PLANNING FOR NEW FARE PAYMENT SYSTEMS: AN EQUITY ANALYSIS OF SMARTPHONE, CREDIT CARD, AND POTENTIAL MOBILE TICKETING ADOPTION BY BUS RIDERS IN NASSAU COUNTY

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ABSTRACT

Transit agencies are rapidly deploying new fare payment systems, and many of these systems rely on passenger-provided technologies, such as mobile phones. Mobile ticketing systems typically utilize tickets that are purchased and validated on smartphones; however, not all transit riders have smartphones or other electronic payment media needed to make a mobile payment. Subsequently, transit agencies want to understand rider adoption of smartphones, credit/debit cards, and other electronic payment media when planning for deployment of mobile ticketing systems. Therefore, the objective of this research is to assess access to mobile payments across different socioeconomic groups. The methodology is a case study of Nassau Inter-County Express (NICE) bus system, where two passenger surveys about smartphone, credit card, and potential mobile ticketing adoption were conducted. Binary logit was used to analyze smartphone, credit/debit card and potential mobile ticketing adoption across different socioeconomic groups using the survey data. The model results suggest that younger riders are more likely to have smartphones, while older, more affluent riders are more likely to have credit/debit cards. Based on a stated survey question about potential mobile ticketing use, early adopters of mobile payments are likely to be younger riders. These findings may help inform other transit agencies on the suitability of mobile ticketing in their markets and influence stakeholders prepared to make large capital investments in new fare collection systems.

INTRODUCTION

In the last few years, there has been a push toward utilizing new fare payment technologies in the transit industry, particularly mobile ticketing systems in which riders pay their transit fare directly on their smartphones using a credit card, debit card, or other electronic payment *(1, 2).* Since 2012, numerous transit providers in the United States have deployed mobile ticketing systems, and many other agencies are in various stages of planning and procurement. As shown in Figure 1, the New York Waterway first launched a mobile ticketing application in early 2012, and this was followed by Boston's commuter rail later that year (*1).* In 2013, New Jersey Transit, DART in Dallas, NCTD in San Diego, and TriMet in Portland deployed mobile ticketing applications (*1, 3)*. The next year (2014) included mobile ticketing launches at CapMetro in Austin, NICTD in Indiana, NICE Bus in Nassau County, NY, and the Comet Bus in Columbia, South Carolina (*1, 4).* Since the beginning of 2015, numerous additional transit providers (VRE, MUNI, CTA and NORTA) have already launched mobile ticketing (*1, 5).*

This movement toward mobile ticketing is occurring for many reasons. Mobile payments linked to credit/debit cards can reduce the number of cash transactions at ticket windows and onboard trains or buses, which can potentially reduce operational costs and simplify the fare collection process for transit providers. They also provide transit agencies with valuable planning data that are currently not available in cash-based systems (i.e., disaggregate origin and destination information). Furthermore, mobile payments can improve the rider experience by replacing prepayment at ticket windows or vending machines, which typically require some amount of waiting in line, thereby saving passengers travel time. In addition, smartphone applications can provide transit customers with a comprehensive payment and information platform, including account management capabilities, transit service alerts, and real-time vehicle location/arrival information.

Many of the aforementioned benefits of mobile ticketing rely on the fact that transit riders utilize their personal devices (namely smartphones) to purchase tickets. However, public transportation providers have diverse rider constituencies, and subsequently, not all transit riders have smartphones. Therefore, it is critical for transit agencies who are planning or deploying mobile ticketing systems to understand passenger adoption of smartphones and the other electronic payment media (such as credit/debit cards) that are needed to make purchase mobile tickets for reasons of equity.

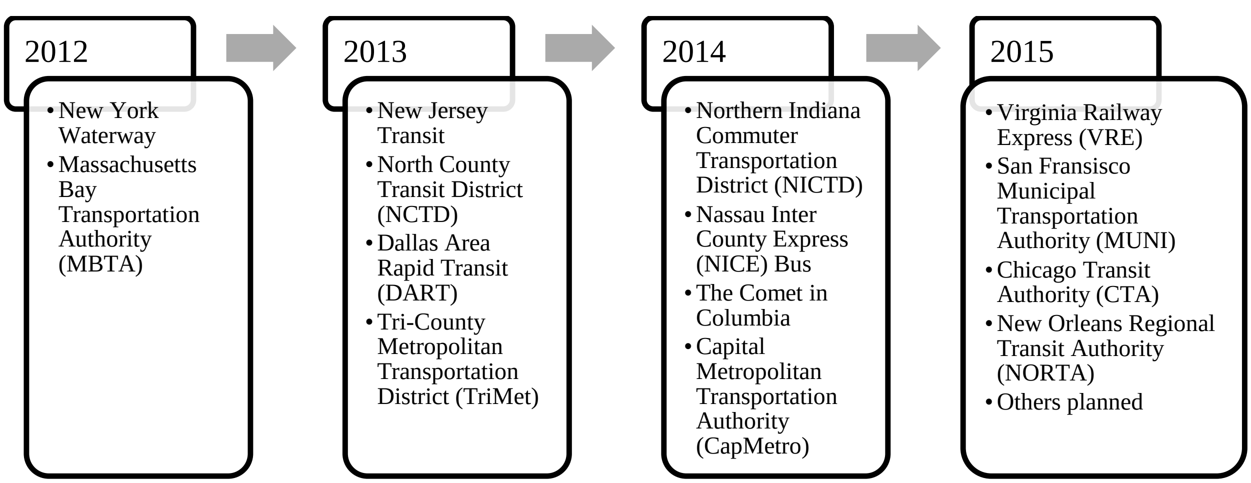

FIGURE 1 Timeline of Mobile Ticketing Launch in American Transit Systems.

OBJECTIVE

The objective of this research is to assess socioeconomic trends of bus riders who are capable of and interested in using mobile ticketing through a case study of the Nassau Inter-County Express (NICE) bus system on Long Island, New York, which is the first bus-only transit system to deploy mobile ticketing in the United States. This study focuses on smartphone and credit/debit card adoption rates, as well as potential interest in mobile ticketing. System-wide onboard survey data and a small, targeted web-based survey were used in a discrete choice modeling framework to assess equity in socioeconomic trends.

PRIOR RESEARCH

Given that mobile ticketing is a recent innovation in transit fare collection, there is limited literature available concerning this new payment medium. One noteworthy study of transit mobile ticketing examined potential adoption of mobile payments by commuter rail riders prior to the launch on the Massachusetts Bay Transportation Authority (MBTA)'s commuter rail system in 2012. Researchers conducted an onboard paper survey of more than 900 riders on two commuter rail lines in Boston, and the survey questionnaire included questions about smartphone adoption (76% of survey respondents used smartphones). After briefly explaining how mobile ticketing would work on the commuter rail in the future, survey respondents were asked how likely they were to utilize mobile ticketing if it were available. This stated preference survey question was used to create a statistical model to forecast future demand system-wide, and the model revealed that approximately 26% of riders were very likely to adopt mobile ticketing on Boston's commuter rail. The research also showed that commuter rail riders in the Boston area were predominately white, high-income, and employed *(6)*.

Another relevant prior study investigated smartphone adoption rates in the context of providing real-time information with the St. Louis Metro bus and light rail system *(7)*. The goal was to determine whether real-time information delivered through smartphone applications ("apps") would be accessible to all demographic groups. Based on survey data collected in 2012, the researchers found that about 70% of St. Louis Metro bus and light rail riders had smartphones, which was higher than the national average at the time. They also discovered that certain socioeconomic groups were less likely to own smartphones, such as riders over 40 years old.

While the prior research informed this study, neither paper is fully applicable. In the case of Boston, the commuter rail demographics are quite different than those of the riders of NICE and other typical American bus systems. Regarding the study of St. Louis, the research did not investigate mobile ticketing, but instead focused on real-time information and smartphone adoption. Therefore, further research pertaining to adoption to smartphones and payment technologies is deemed necessary to inform the fare collection planning process currently happening at many American transit agencies, and the following study of NICE bus aims to fill this gap in the literature.

BACKGROUND ON NASSAU INTER-COUNTY EXPRESS (NICE) BUS

This study analyzes the potential for a mobile ticketing program at NICE, the bus transit system in Nassau County, New York. Nassau County is a suburban county on Long Island, located immediately east of New York City, with a population of over 1.3 million people. It is among the wealthiest counties in the United States with over 48% of households having an annual income of over $100,000. It is a predominately white county with about 75% of Nassau County residents identifying as white. In contrast, NICE bus riders tend to have lower household income levels and are more likely to identify as African American or Latino. Only 3% of NICE bus riders have an annual income of over $100,000 and close to 70% have an annual income of under $35,000. About 75% of riders identify as African American or Latino *(8).*

NICE is a public-private operating partnership between Nassau County and Veolia Transportation. Veolia manages all aspects of the transit system under contract to the county. NICE serves about 100,000 riders daily in Queens, Nassau and Suffolk counties. NICE operates 52 fixed routes with a fleet of 300 buses (*9*).

NICE uses a farebox-validated payment scheme. Riders can prepay using their MetroCard, a magnetic stripe card from New York City's Metropolitan Transportation Authority (MTA), or pay using exact change on board. Fare media is solely issued by the MTA, so NICE is unable to make significant changes to the payment network and had limited ability to independently set fare policy. For example, there are limited points of sale for the MetroCard in Nassau County, and NICE is unable to deploy additional units. Despite its shortcomings, NICE must continue to support the MetroCard as close to 25% of NICE riders transfer into the MTA system daily, and the MetroCard is the only feasible way to ensure free inter-system transfers. While the MTA has announced plans to deploy a new fare system, current plans suggest the MetroCard may be in place until 2020 (*10*). Considering the issues noted above, as well as old magnetic stripe fareboxes approaching the end of their useful life, NICE sought to offer passengers an alternative.

In early 2014, NICE decided to pilot a visual mobile ticketing program as a potential stopgap measure until stakeholders felt confident investing in a more robust deployment. The program had minimal up-front costs as it did not required onboard hardware, and the vendor would be paid through a small percentage of mobile ticketing transactions. Implementation took less than six months from contract signing to deployment, with beta testing beginning in late April 2014, and full rollout occurring in early June 2014. This initial deployment used visual mobile tickets, where bus drivers visually inspect a smartphone screen and then click the farebox to record the boarding. Passengers could still pay with existing fare media, including the MTA's MetroCard and cash.

In the current mobile ticketing program, riders prepay for mobile tickets, which can be used immediately or stored for later use. Currently, only pay-per-ride tickets are available, although they can be purchased in bundles of 1, 4, 6, 8, 12 and 20 tickets (see left screenshot in Figure 1). Given equity and Title VI concerns involved with a smartphone payment solution, mobile tickets were priced to match existing MetroCard fares. NICE also chose not to eliminate any existing payment choices or offer special pricing that would only be available to smartphone owners. Similarly, riders who purchase a bundle of 20 mobile tickets receive 1 free ticket to match the 5% bonus MetroCard riders are awarded when they add money to their fare cards.

To use a mobile ticket, a rider pushes 'use ticket' just prior to boarding (see middle screenshot in Figure 1). This activation starts a countdown clock on the screen and also displays a secure, flashing visual element in the form of a color and word of the day (see right screenshot in Figure 1). Prior to departing on their daily run, drivers check the color and word of the day at a monitor by the dispatch window. When a passenger boards with a mobile ticket, the driver pushes a mobile boarding button on the farebox to capture data within the legacy fare collection software. Passengers have two hours and fifteen minutes from the moment of activation to ride and transfer within the NICE bus system.

While NICE has experienced no major issues since deployment and required no new onboard infrastructure, the mobile ticketing program is heavily reliant on drivers properly inspecting tickets. NICE is looking to improve the system by deploying innovative multi-format readers, and NICE has already installed a test unit on one vehicle. These readers are format agnostic; they are capable of accepting barcodes, contactless bank cards, proximity smartcards (e.g., student or employer ID cards), and emerging payment technologies such as Bluetooth Low Energy.

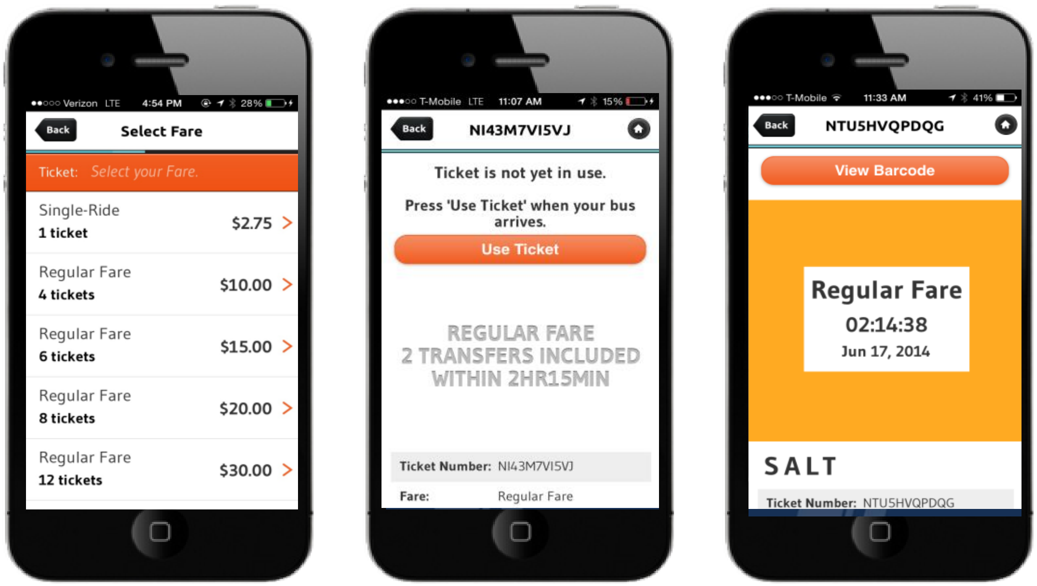

FIGURE 2 Demonstration Screenshots of NICE Mobile Ticketing Application.

DATA COLLECTION

In order to prepare for the mobile ticketing program, survey data were collected to understand the potential adoption and equity of mobile ticketing. Two separate surveys were conducted prior to the initial pilot program of mobile ticketing that began in June 2014. The first was a system-wide paper survey conducted onboard buses in the fall of 2013, which was intended for general planning purposes, but specifically included a question about smartphone adoption levels. The second survey was a smaller-sized web-based survey conducted in February 2014 that focused primarily on fare payment and mobile ticketing. The following paragraphs delineate the methods used to collect the responses to these two surveys.

Survey 1: Onboard System-wide Survey

A third party firm collected the data through an onboard survey. Surveys were collected on all NICE bus routes during a two week period from October 19, 2013 until October 30, 2013. The firm used a stratified random sampling methodology to collect data that accurately represented NICE ridership. Prior to data collection, a sampling target was calculated for each route reflective of average daily ridership provide by NICE. The third party firm then created response targets for each route to ensure a confidence level of 95 percent and a +/- 10 percent margin of error (based on daily average ridership by route).

Survey Content and Sample Size

The onboard survey was designed to capture travel patterns and behavior, including where people are traveling to and from; how they access transit service; when they travel, how they travel to their final destination; frequency of use; trip purpose; trip length; and other travel modes they use. These questions were used for standard planning purposes. In preparation for the upcoming mobile ticketing program, the survey included a question on smartphone adoption. Last, the survey also captured rider demographics, including race, gender, ethnicity, income, and employment and student status.

All customers boarding the surveyed routes were given the opportunity to take the survey, and a total of 9,430 responses were received. Of these 9,430 respondents, 7,951 answered the smartphone adoption question.

Survey 2: Web-based Mobile Ticketing Survey

In mid-February 2014, NICE conducted a web-based survey that was designed by the authors of this paper. The goal of this survey was to understand the fare payment and technology habits of riders, as well as the likelihood that they would adopt mobile ticketing. Survey responses were collected from February 11, 2014 through March 3, 2014. The survey was posted on the homepage of the NICE website, advertised regularly through NICE social media accounts, and emailed to a list serve of over 2,000 riders accessed through the NICE customer service database. Riders were incentivized to take the survey; ten respondents were randomly chosen to win 30-day MetroCards valued at $112.

Survey Content and Sample Size

The web-based survey was designed to capture technology adoption and fare payments habits that would inform the upcoming mobile ticketing program. The survey asked about current fare payment choices, smartphone and bankcard adoption, frequency of mobile payment use at merchants (e.g. Starbucks), desire to use mobile ticketing for NICE buses, and demographics.

Potential respondents clicked on the survey link approximately 1,900 times. NICE collected a total of 978 responses, of which 942 were considered valid. Respondents were required to respond to the smartphone and mobile ticketing questions in order to submit the survey.

ANALYSIS

The following analysis is divided into two sections. The first section presents results from the system-wide survey to assess adoption of smartphones by NICE bus riders and identify trends between different socioeconomic groups. The second section assesses the small-scale web-based survey of NICE bus riders aimed at understanding the adoption potential of mobile ticketing.

Analysis of the System-wide Survey

This section presents an analysis of the system-wide survey of NICE bus riders, in which all respondents were asked if they have a smartphone. A cross-tabulation of this question was done to show differences in the socioeconomic status as they relate to smartphone ownership, and the results are shown in Table 1 for the 7,951 respondents who answered this question.

TABLE 1 Smartphone Cross-tab from the NICE Bus System-wide Survey Data

		Yes Smartphone		**No Smartphone**		**All Riders**	
		Count	*% Row*	Count	*% Row*	Count	*% Column*
	All Respondents	*5,337*	*67%*	*2,613*	*33%*	*7,950*	*100%*
Age	Under 16	35	71%	14	29%	49	1%
	Age 16-18	429	79%	112	21%	541	7%
	Age 19-24	1,537	85%	261	15%	1,798	23%
	Age 25-44	1,998	73%	755	27%	2,753	35%
	Age 45-64	1,036	49%	1,072	51%	2,108	27%
	Age 65+	116	33%	234	67%	350	4%
	N/A	186	53%	165	47%	351	4%
Employ-ment Status	Full-time	2,497	70%	1,094	30%	3,591	45%
	Part-time	1,756	72%	669	28%	2,425	31%
	Retired	130	42%	180	58%	310	4%
	Not employed	794	62%	493	38%	1,287	16%
	N/A	160	47%	177	53%	337	4%
Gender	Male	2,082	72%	807	28%	2,889	36%
	Female	2,731	65%	1,455	35%	4,186	53%
	N/A	524	60%	351	40%	875	11%
Ethnicity*	Hispanic/Latino	1,404	70%	605	30%	2,009	25%
	White	504	56%	392	44%	896	11%
	Asian	362	66%	184	34%	546	7%
	Black/African	2,307	70%	1,001	30%	3,308	42%
	American Indian/Alaskan	45	48%	48	52%	93	1%
	Hawaiian/Pacific	35	69%	16	31%	51	1%
	Other / Multiple races	287	79%	75	21%	362	5%
	N/A	393	57%	292	43%	685	9%
Annual Household Income	Less than $15,000	1,578	63%	924	37%	2,502	31%
	$15,000 to $24,999	488	71%	203	29%	691	9%
	$25,000 to $34,999	972	71%	403	29%	1,375	17%
	$35,000 to $49,999	483	74%	173	26%	656	8%
	$50,000 to $74,999	627	74%	218	26%	845	11%
	$75,000 to $99,999	250	76%	77	24%	327	4%
	$100,000 or more	179	84%	33	16%	212	3%
	N/A	760	57%	582	43%	1,342	17%
Student	Full-time	1,434	84%	268	16%	1,702	21%
	Part-time	728	78%	210	22%	938	12%
	Not a student	2,759	62%	1,713	38%	4,472	56%
	N/A	416	50%	422	50%	838	11%

Note: All numbers and percentages rounded to the nearest whole number.

**Riders could select all that apply.*

Binary Logit Model of Smartphone Adoption

Next, the system-wide survey data were used in a discrete choice model to determine the extent to which different socioeconomic characteristics, such as age, annual income, and ethnicity, related to the use of smartphones. A binary logit model was specified for riders having a smartphone versus not having a smartphone, and it was estimated using the open source statistical program R *(11)*. All of the independent variables in the logit model were binary and set equal to one if the respondent fell into that category. For each category, a reference variable was defined, and the coefficients were interpreted relative to that reference category. Respondents who refused to answer a question were excluded, which reduced the total sample size to 5,345 participants. The results of the binary logit models are shown in Table 2 and discussed in the following paragraph.

The alternative specific constant in the model for smartphone use has a positive, significant coefficient of 0.97, which indicates that, all else being equal, NICE bus riders choose to have a smartphone. Each variable in the first category, annual household income, is positive and significant. This suggests that bus riders with higher incomes are more likely to have smartphones than those with lower incomes (less than $25,000 per year). The ethnicity category was evaluated with a reference variable of white; since all of the other categories are positive and significant, it can be concluded that minority groups may be more likely to have a smartphone than whites. The positive, significant coefficient of the male variable implies that male bus riders may be more likely than females to have smartphones. For the age category, the negative coefficients of those ages 25 to 44 and age 45 and older suggest that they are less likely to have smartphones than riders under 25 years old. In the employment category, being retired was weakly significant ($p<0.1$) and the category for unemployed was very significant; both had negative coefficients, which implies that retired and unemployed riders are less likely to have a smartphone than riders who are employed full-time. The student variable had a positive significant coefficient, so students may be more likely to have a smartphone than those who are not students. Last, the overall goodness of fit was good, as is indicated by a pseudo R-squared of 0.44.

TABLE 2 Smartphone Binary Logit Model from the NICE Bus System-wide Survey Data

	Independent Variable	**Coefficient**	**(Standard Error)**
	Alternative Specific Constant	0.97^{***}	(0.14)
Annual Household Income	Less than $25,000	(reference)	
	$25,000 to $49,999	0.35^{***}	-0.08
	$50,000 to $74,999	0.30^{***}	(0.11)
	$75,000 or more	0.66^{***}	(0.14)
Ethnicity	White	(reference)	
	Hispanic/Latino	0.39^{***}	(0.11)
	Black/African American	0.55^{***}	(0.10)
	All Other (including multiple)	0.29^{**}	(0.12)
Gender	Female	(reference)	
	Male	0.32^{***}	(0.07)
Age	Age 24 and under	(reference)	
	Age 25-44	-0.53^{***}	(0.10)
	Age 45 and over	-1.66^{***}	(0.10)
Employment Status	Full-time	(reference)	
	Part-time	-0.09	(0.08)
	Retired	-0.31^{*}	(0.17)
	Not employed	-0.62^{***}	(0.10)
Student	Not a student	(reference)	
	Student (full or part-time)	0.50^{***}	(0.09)
Summary Statistics	AIC	5635.84	
	BIC	5728.02	
	Log Likelihood	-2803.92	
	Deviance	5607.84	
	McFadden's Pseudo R^2	0.4432	
	Number of Observations	5345	

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Analysis of the Mobile Ticketing Survey

This section presents an evaluation of the mobile ticketing survey responses. First, the survey data were analyzed by cross-tabulation to provide description statistics. Table 3 shows the results of the cross-tabulation for NICE bus riders who have smartphones (first set of columns) and for those who have credit or debit cards (second set of columns). The third set of columns show participants' responses to a stated preference question asking if they would like to use mobile ticketing once it becomes available (yes/no). It is important to note that this survey was not collected via probability sampling, and therefore, the descriptive statistics are not be generalizable to all NICE bus riders.

Next, the mobile ticketing survey data were used in a discrete choice modeling framework to determine the extent to which different socioeconomic characteristics, such as age, annual income, and ethnicity, related to the use of smartphones, credit/debit cards, and potential use of mobile ticketing. Three binary logit models were specified, and all models were estimated using the open source statistical program R *(11)*. The first model was for riders having a smartphone versus not having a smartphone, and the second was for NICE bus riders having a credit/debit card versus not having one. The third model is for those who would like to use mobile ticketing versus those riders who stated that they do not want to use mobile ticketing.

All of the independent variables in the logit models were binary and set equal to one if the respondent fell into that category. For each category, a reference variable was defined, and the coefficients were interpreted relative to that reference category. Respondents who refused to answer a question were excluded, which reduced the total sample size to 851 participants. The results of the binary logit models are shown in Table 4 and discussed in the following paragraphs.

Model 1: Smartphones

The alternative specific constant in the first model for smartphone use had a positive, significant coefficient of 1.97, which indicates that, all else being equal, NICE bus riders choose to have a smartphone. The first set of categorical variables, annual household income, only had one moderately significant variable (p<0.1), which suggests that respondents in households with the highest income levels ($75,000 or more) may be more likely to have a smartphone. The ethnicity variable was evaluated with a reference group of white individuals, and the positive, significant coefficients of African Americans and Hispanics suggest that those groups may be more likely to have smartphones than Caucasian bus riders. For the age category, the only statistically significant variable was for respondents age 45 and older; the negative coefficient suggests that older bus riders are less likely have a smartphone. Similarly, the employment category had negative, significant coefficients for individuals who were retired or not employed, which can be interpreted as those individuals being less likely to have smartphones than bus riders who are employed full-time. The variable for students had a positive, significant coefficient, which suggests that they are more likely to have smartphones than those who are not students. Last, the gender variables were not significant, and the overall goodness of fit was moderate, as is indicated by a pseudo R-squared of 0.28.

Model 2: Credit/Debit Cards

In the binary logit model for use of credit/debit cards, the alternative specific constant had a positive, significant coefficient of 1.85; this suggests that NICE bus riders choose to have credit/debit cards when holding all else equal. All variables in the first category, annual household income, were positive and significant. Therefore, riders in households with higher income levels may be more likely to have credit or debit cards than those in household with income levels less than $25,000 per year. Both age variables were positive and significant, suggesting that bus riders over age 25 are more likely to have credit or debit cards than those under 25 years of age. In the employment category, the coefficient for those who were not employed had a negative, significant coefficient, which can be interpreted as those without jobs being less likely to have a credit or debit card compared to those who are employed full-time. Additionally, the student variable had a positive significant coefficient, which was surprising since younger respondents appeared less likely to have credit/debit cards those older respondents. Last, the ethnicity and gender variables were not significant, and the overall goodness of fit was moderate (pseudo R-squared of 0.31).

Model 3: Stated Use of Mobile Ticketing

The third binary logit model was for the stated use of mobile ticketing. The alternative specific constant was weakly significant (p<0.1), and the positive value suggests that, holding all else equal, survey respondents would like to use mobile ticketing. The coefficient for the gender variable representing men was positive and significant, which suggests that men may be more likely to use mobile ticketing than women. For the age category, the variable for those age 45 and older had a negative coefficient that was significant, indicating that older bus riders may be less likely to adopt mobile ticketing. Similarly, in the employment status category, the variable for retired respondents had a negative coefficient, indicating that retirees may therefore be less likely to use mobile ticketing than those who are employed full-time. The variable for students had a positive, significant coefficient; students may be somewhat more likely to adopt mobile ticketing than non-students. None of the variables in the income or ethnicity categories were statistically significant in this model. Last, the overall goodness of fit was somewhat low (pseudo R-squared of 0.16) compared to the other two models.

TABLE 3 Socioeconomic Status of Smartphone, Credit/Debit Card and Mobile Ticketing

Mobile Ticketing Survey		**Do you have a smartphone?**				**Do you have a credit/debit card?**				**Do you want to use mobile ticketing?**				**All Respondents**	
		Yes		**No**		**Yes**		**No**		**Yes**		**No**			
Category*	**Independent Variable**	Count	*% Row*	Count	*% Row*	Count	*% Row*	Count	*% Row*	Count	*% Row*	Count	*% Row*	Count	*% Column*
	All Respondents	*808*	*86%*	*134*	*14%*	*871*	*92%*	*71*	*8%*	*608*	*65%*	*334*	*35%*	*942*	*100%*
Age	Age 24 and under	239	94%	15	6%	219	86%	35	14%	191	75%	63	25%	254	27%
	Age 25-44	398	91%	38	9%	411	94%	25	6%	302	69%	134	31%	436	46%
	Age 45-64	157	69%	71	31%	218	96%	10	4%	106	46%	122	54%	228	24%
	Age 65+	8	47%	9	53%	17	100%	0	0%	6	35%	11	65%	17	2%
	No Answer	6	86%	1	14%	6	86%	1	14%	3	43%	4	57%	7	1%
Employment Status	Full-time	449	87%	65	13%	497	97%	17	3%	326	63%	188	37%	514	55%
	Part-time	232	91%	24	9%	241	94%	15	6%	186	73%	70	27%	256	27%
	Retired	12	48%	13	52%	25	100%	0	0%	10	40%	15	60%	25	3%
	Not employed	105	78%	30	22%	97	72%	38	28%	81	60%	54	40%	135	14%
	No Answer	10	83%	2	17%	11	92%	1	8%	5	42%	7	58%	12	1%
Gender	Male	404	85%	69	15%	433	92%	40	8%	320	68%	153	32%	473	50%
	Female	397	86%	64	14%	430	93%	31	7%	284	62%	177	38%	461	49%
	No Answer	7	88%	1	13%	8	100%	0	0%	4	50%	4	50%	8	1%
Ethnicity**	Hispanic/Latino	122	92%	11	8%	121	91%	12	9%	95	71%	38	29%	133	14%
	Black/African American	239	94%	16	6%	236	93%	19	7%	176	69%	79	31%	255	27%
	White	249	76%	78	24%	302	92%	25	8%	192	59%	135	41%	327	35%
	All Other (with mixed)	159	88%	21	12%	167	93%	13	7%	117	65%	63	35%	180	19%
	No Answer	39	83%	8	17%	45	96%	2	4%	28	60%	19	40%	47	5%
Annual Household Income	Less than $25,000	300	85%	54	15%	308	87%	46	13%	236	67%	118	33%	354	38%
	$25,000 to $49,999	226	87%	33	13%	248	96%	11	4%	180	69%	79	31%	259	27%
	$50,000 to $74,999	109	87%	16	13%	124	99%	1	1%	76	61%	49	39%	125	13%
	$75,000 or more	132	88%	18	12%	144	96%	6	4%	97	65%	53	35%	150	16%
	No Answer	41	76%	13	24%	47	87%	7	13%	19	35%	35	65%	54	6%
Student	Full-time	183	96%	8	4%	169	88%	22	12%	151	79%	40	21%	191	20%
	Part-time	79	94%	5	6%	80	95%	4	5%	58	69%	26	31%	84	9%
	Not a student	535	82%	117	18%	608	93%	44	7%	395	61%	257	39%	652	69%
	No Answer	11	73%	4	27%	14	93%	1	7%	4	27%	11	73%	15	2%

**Riders could select all that apply. Multiple selections combined with Other.*
***All numbers and percentages rounded to the nearest whole number.*

TABLE 4 Binary Logit Models from the Mobile Ticketing Survey

Category	Independent Variable	Model 1: Smartphone	Model 2: Credit Card Credit/Debit Card	Model 3: Mobile Ticketing
	Alternative Specific Constant	1.97***	1.85***	0.58*
		(0.46)	(0.51)	(0.30)
Annual Household Income	Less than \$25,000	(reference)	(reference)	(reference)
	\$25,000 to \$49,999	0.14	1.08***	0.24
		(0.29)	(0.39)	(0.20)
	\$50,000 to \$74,999	0.37	2.46**	-0.09
		(0.37)	(1.04)	(0.25)
	\$75,000 or more	0.60*	0.82*	0.06
		(0.36)	(0.49)	(0.23)
Ethnicity	White	(reference)	(reference)	(reference)
	Hispanic/Latino	0.71*	-0.32	0.16
		(0.37)	(0.42)	(0.24)
	Black/African American	0.98***	0.36	0.13
		(0.31)	(0.40)	(0.20)
	All Other (including multiple)	0.51	0.2	-0.03
		(0.31)	(0.41)	(0.21)
Gender	Female	(reference)	(reference)	(reference)
	Male	0.13	-0.23	0.39**
		(0.22)	(0.30)	(0.15)
Age	Age 24 and under	(reference)	(reference)	(reference)
	Age 25-44	-0.28	0.72**	-0.07
		(0.39)	(0.36)	(0.22)
	Age 45 and over	-1.59***	1.36***	-0.92***
		(0.39)	(0.50)	(0.25)
Employ-ment Status	Full-time	(reference)	(reference)	(reference)
	Part-time	-0.13	-0.07	0.18
		(0.33)	(0.44)	(0.22)
	Retired	-0.90*	14.11	-0.44
		(0.53)	(880.32)	(0.50)
	Not employed	-1.07***	-2.09***	-0.43*
		(0.34)	(0.39)	(0.25)
Student	Not a student	(reference)	(reference)	(reference)
	Student (full or part-time)	1.09***	0.83**	0.40*
		(0.39)	(0.38)	(0.22)
Summary Statistics	AIC	582.82	373.22	1051.37
	BIC	649.27	439.67	1117.82
	Log Likelihood	-277.41	-172.61	-511.68
	Deviance	554.82	345.22	1023.37
	McFadden's Pseudo R^2	0.2849	0.3146	0.1649
	Number of Observations	851	851	851

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; Standard errors shown in parentheses.

COMPARISON

The following is a brief comparison of the insights gathered from the NICE bus system-wide survey, the mobile ticketing-specific web-based survey, and other related research.

First, the smartphone adoption rates and regression results can be directly compared between the two surveys of NICE bus riders. In the system-wide survey, overall smartphone adoption levels were approximately 67%, while in the web-based survey adoption levels were approximately 86%. The web-based survey likely reported a much higher adoption rate because it was conducted using non-probability sampling and was not representative of all bus riders; therefore, the system-wide survey smartphone adoption numbers are relied on to draw conclusions using summary statistics and cross-tabs. 67% is similar to recent research conducted on St. Louis Metro, where approximately 70% of riders had smartphones (*7*). The NICE smartphone adoption results also compared favorably to nationwide smartphone adoption, which was approximately 58% in 2014 when the survey was conducted (*12*).

Second, in both smartphone binary logit models, older riders were less likely to have smartphones than younger riders, while Hispanics/Latinos and African Americans are more likely than white riders to have smartphones. These data are relevant to transit agencies that must ensure certain socioeconomic groups are not disproportionately disadvantaged by a new fare collection program. While certain minority groups are more likely to own smartphones than white riders, which aligns with prior research at St. Louis Metro, higher income riders are still slightly more likely to own smartphones. Nevertheless, as prices of smartphones and data plans drop, there may be a flattening of adoption levels among all income groups. This trend may already have begun; among NICE riders ages 19-24, there is virtually no difference in smartphone adoption levels between various income groups using data from both NICE rider surveys.

Third, in the regression model for credit/debit card adoption, income appears to be the most important indicator. In contrast to smartphone adoption, older people are also more likely to have credit cards or debit cards than younger riders. As a result, transit agencies may want to investigate alternative billing methods for younger riders that do not require credit or debit cards.

Last, about 65% of survey respondents in the small-scale web-based survey indicated that they want to use mobile ticketing, with younger riders showing more interest. It is worth re-mentioning that close to 25% of NICE riders transfer between NICE and the MTA; over 40% of respondents that did not want to use mobile ticketing indicated retaining the free transfer to the MTA was the main reason. Therefore, regional integration could be an important determinant in future fare media choices of passengers.

CONCLUSIONS AND FUTURE RESEARCH

This research demonstrates significant potential for adoption of mobile ticketing at NICE bus, considering the smartphone and credit/debit card adoption rates of riders. In particular, the system-wide onboard survey data revealed that approximately 67% of riders use smartphones, with even higher adoption rates among younger riders. The web-based survey revealed that older riders were more likely to have credit/debit cards, and that younger riders were more interested in using mobile ticketing. Based on comments from the mobile ticketing survey, many NICE bus riders view the new technology positively. For example, one rider stated the following in the comment box at the end of the web-based survey: *"This is a fantastic plan, it will be very convenient and an easy alternative to carrying change-which can be a hassle to get in the first place. Additionally, metro cards are seldom sold in the stores within our communities, I usually* *have to wait until I travel into the city to buy a metro card. I love this app idea, thanks so much!!!"*

Last, there are many avenues for future research that emerged from this analysis. First, because the mobile ticketing program has recently launched on NICE buses, an interesting topic for future research would be to study overall adoption levels and trends in socioeconomic status of the earliest adopters. Second, the mobile ticketing application collects data about where and when NICE bus riders pay their fares, which could be an excellent new data source for future research. Third, it may be interesting to study the impact of mobile ticketing on vehicle dwell times, in a similar fashion to existing research with other fare collection methods (*13*). In summary, there are likely to be many new and interesting areas for future research pertaining to mobile ticketing as this new fare payment technology becomes increasingly common in the transit industry.

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