Do Transit Fares Hurt the Poor? The Use of Weekly and Monthly Passes in New York City

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Abstract

Using detailed transit card data, we document that many commuters, especially those in low-income neighborhoods, purchase weekly (7-day) unlimited-ride passes repeatedly for long periods of time (at least 11 months) on the New York City public transit system. As a monthly (30-day) pass costs less than an equivalent set of weekly passes, these commuters spend 15 percent ($20) more each month on transit fare than they would have with monthly passes while receiving the same level and quality of transit services. Exploiting fare hikes in December 2010 and March 2013 as natural experiments, we provide evidence of this significant overpayment consistent with these commuters being unable to spend a large amount of money at one time on monthly passes. Alternative mechanisms such as time-inconsistent preferences and job instability alone are unlikely to explain the observed behaviors of recurring weekly pass commuters. Low-income commuters could benefit significantly from a monthly fare cap, which does not require a lump-sum payment and allows transit riders to travel for free for the rest of the month after they meet the fare equivalent of a monthly pass.

Keywords: Public Transport, Liquidity Constraints, Transit Fare, Overpayment
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1 Introduction

Public transportation can help people save money. Maintaining and driving a car require fuel, regular check-ups, insurance, taxes, repairs and more, which are expensive and time-consuming. Subways and buses offer a cheap and affordable way to commute to work and other destinations amid a gas price surge (Glaeser et al., 2008; Holzer et al., 2003; Pathak et al., 2017). In particular, for low-income people who cannot afford personal vehicles, public transit is the only low-cost way to find and commute to higher-paying jobs.

However, in this paper, we document that many commuters, especially those from disadvantaged neighborhoods, appear to make suboptimal fare purchase decisions. Specifically, with transit card (MetroCard) data from June 2009 to December 2016 in New York City, we identify more than 100,000 commuters that purchase a weekly fare MetroCard every week and continue this purchase pattern for more than 11 months.[1] As a monthly (30-day) pass costs roughly the same as three and a half weekly (7-day) passes, these commuters spend 15 percent ($20) more each month on transit fare than they would have with monthly passes while receiving the same level and quality of transit services. We examine this significant overpayment for transit fares and test alternative explanations of this behavior.

To examine this puzzling fare purchase behavior, we compare recurring weekly and monthly pass commuters because a monthly pass is the only close substitute for multiple weekly passes. Specifically, we analyze commuters that purchase a weekly unlimited-ride MetroCard every week for at least 11 months with those that purchase a monthly unlimited-ride MetroCard every 30 days for at least 11 months.

We argue that the most likely explanation of the purchase behavior of repeated seven-day pass commuters is their inability to spend a large amount of money at one time on monthly passes. A monthly pass is the least expensive option per trip for frequent riders of public transit, but the most expensive in absolute terms (e.g., $112 in March 2013) and requires the highest one-time upfront payment. Low-income commuters may not afford a monthly pass, opting instead to buy weekly fares that

[1] While a cutoff point of 11-month may seem arbitrary, we decided to focus on 11 months to filter out seasonal workers and other unusual subpopulations. They may purchase multiple weekly passes for idiosyncratic reasons, despite the option of monthly fares.

are cheaper per pass, but much costlier in the long term (per month).

We provide evidence to support this explanation. With the help of transaction-level MetroCard data from January 2013 to May 2015, we identify the most preferred (used) subway station for each commuter based on their commuting patterns (Huang et al., 2018; Zhou and Long, 2014). We label these stations as "home" stations. We document that home stations of repeat weekly pass commuters are predominately in low-income neighborhoods, while home stations of recurring monthly pass commuters are largely in more affluent areas. Besides, recurring weekly fare sales mainly come from cash or debit card payments. In contrast, the repeated monthly fare sales largely come from credit card payments. Smaller, more frequent transactions in low-income areas with non-credit card payments are consistent with constrained consumers.

In addition, we use fare increases on December 30, 2010 and March 3rd, 2013, as natural experiments to provide further evidence on this explanation. In both fare hikes, the costs of repeat weekly pass usage increased relative to monthly passes. As such, unconstrained commuters should prefer monthly passes even more after the fare increases. However, we observe a significant increase in weekly pass purchases with a decline in monthly pass purchases, suggesting that constrained commuters are sensitive to the total price of monthly passes and are not able to afford these passes with a large upfront lump-sum payment.

While our findings are consistent with repeat weekly pass purchases driven by financially constrained commuters, there are other potential reasons for the recurring weekly fare use. We provide empirical evidence on four alternative explanations: discrepancies in awareness, job insecurity, the prospective of losing a monthly pass, and time inconsistency.[2]

We then conduct back-of-the-envelope calculations to estimate the magnitude of overpayment from recurring weekly fare commuters. From March 2013 to March 2015, a monthly (30-day) pass costs $112 and a weekly (7-day) pass costs $30, recurring weekly pass commuters spend $20 more each month on transit fare than they would have with monthly passes. With 100,000 repeated weekly fare commuters on average each month, this translates to commuters, especially low-income ones, paying

[2]See Section 6 for more details.

an extra \$24 million for transit fares on an annual basis, a substantial overpayment.[3]

Meanwhile, in 2013, each seven-day unlimited ride MetroCard cost \$30 and the minimum wage in New York City was only \$8.75 per hour. A transit dependent family of four with two working parents earning the minimum wage spends 5 to 10 percent more of their after-tax and after-rent income on recurring weekly transit fares than they would have on monthly passes. This substantial portion of income could have been used for other necessities such as food and medical care or saved for important long-term investments in areas like education and childcare.

Given the economic magnitude and population involved in the repeated seven-day pass purchases, our results are directly relevant to ongoing policy debates about the equity impacts of fare structures in public transit system.[4] Numerous news pieces and policy reports have provided anecdotal evidence that many low-income commuters cannot afford the high upfront costs of monthly passes in many cities across the world such as London (Vesty, 2018), Philadelphia (The Pew Charitable Trusts, 2019), Seattle (Cohen, 2016), and Toronto (Tranjan, 2016). Our findings corroborate the anecdotal evidence and show that the fare structure may disadvantage low-income riders. Besides, these findings shed light on public transit fare structure. Public transit authorities in many cities only offer daily and/or weekly fare cap to frequent riders.[5] These fare caps do not essentially help low-income riders as many of them are already recurring weekly pass commuters. Instead, low-income riders will benefit significantly from a monthly fare capping program,[6] which does not require a lump-sum payment and gives riders unlimited free rides for the rest of the month after they meet the fare equivalent of a monthly pass.[7]

[3]Regular MetroCards are thin plastic cards and are not personalized nor registered to a single user. If a MetroCard is lost or damaged and discarded by a rider, this card will vanish from the data set. Thus, when we relax the time requirement to include MetroCards that have recurring weekly fare sales of nine months or more and then disappear from the data set, the number of repeated weekly pass commuters increase to more than 180,000. Using the same methodology as above, our estimates imply that these commuters pay an extra \$43 million a year for public transit.

[4]An important policy objective for the public transport systems in many cities such as London (Mayor of London, 2018), Berlin (Senate Department for the Environment, Transport and Climate Protection, 2018), New York (New York City Department of Transportation 2016), Los Angeles (Los Angeles Department of City Planning, 2016), Vancouver (City of Vancouver, 2012), Chicago (Regional Transportation Authority, 2017) is to provide public transport as an affordable alternative transit mode to the inhabitants of their respective cities, especially low-income residents with no access to a car.

[5]For instance, with the public transit system in London, a rider can ride free for the rest of the week after reaching the equivalent of a weekly pass fare using the same device or bank card in a calendar week.

[6]As the duration of tourist trips is usually short (Montaño et al., 2019), visitors would most likely not take enough rides to trigger a monthly cap.

[7]Meanwhile, studies suggest that poverty-related concerns consume mental resources, leaving less for other tasks (Mani

Our study contributes to three strands of literature. First, this study adds to the literature measuring the impacts of public transportation on poverty alleviation. Existing studies report that public transportation is crucial for hundreds of millions of people around the world to escape poverty (Brueckner and Rosenthal, 2009; Chetty and Hendren, 2018; Pathak et al., 2017; Glaeser et al., 2008). For example, Pathak et. al (2016) suggest that access to transit in underserved areas can plausibly expand residential opportunities for the poor and reduce spatial inequities in urban centers. We contribute to this literature by showing that fare structures with high upfront costs of unlimited passes may hurt low-income riders who could not take full advantage of the available fare discounts.

Second, this study also contributes to the literature on liquidity constraints. This concept has been used to explain food consumption (Zeldes, 1989), savings (Deaton, 1991), consumption using credit cards (Gross and Souleles, 2002), consumer bankruptcy (Gross et al., 2014), post-secondary schooling (Carneiro and Heckman, 2002), and firm investment behaviour (Audretsch and Elston, 2002). This phenomenon has been reported but not yet been thoroughly examined in the context of public transport. Previous studies are either qualitative, based on surveys with limited samples, or use transit card purchase data for a short period.[8] Little is known about the prevalence of recurring weekly pass commuters. More importantly, existing studies could not disentangle the effect of financial constraints from that of job insecurity and other confounding factors. This paper is the first to systematically document a large number of repeated weekly pass commuters and provide evidence on financial constraints as one leading explanation of this behavior.

Third, this study also contributes to a large literature on optimal pricing policies for public transit system. So far, most empirical studies on optimal fare structures focus on the demand elasticity of

et al., 2013). With a monthly fare cap, low-income earners no longer have to worry about overpayment for transit fares, saving them mental resources for other more important tasks such as education and job training.

[8]For instance, Hickey et al. (2010) used transit data from New York City and found that more weekly unlimited ride MetroCards are registered at subway stations located in low-income neighborhoods than in wealthy neighborhoods, in which monthly unlimited ride MetroCards were more popular. Verbich and El-Geneidy (2017) expanded on Hickey et al. (2010) and used one month transit card (OPUS) sales data from Montreal. They found that more monthly passes were sold in more affluent neighborhoods and that more weekly passes were sold in less affluent neighborhoods. They also found that three or more weekly passes were more likely to be purchased in low-income neighborhoods in Montreal, even though a monthly pass cost roughly the same as three weekly passes. Bondemark et al. (2021) used National Travel Survey from Sweden and observed that low-income commuters may be dissuaded from purchasing monthly passes and instead rely on more expensive pay-per-ride tickets.

rides in response to fare increases (Vickrey, 1955, 1963; Palma and Lindsey, 2007; Small and Verhoef, 2007; Tirachinia and Henshera, 2012; Jong and Gunn, 2001; Chen et al., 2011; Davis, 2021). Much less is known about the impacts of unlimited ride weekly or monthly transit cards (Graham and Mulley, 2012; Verbich and El-Geneidy, 2017; Hickey et al., 2010; Bondemark et al., 2021). Using the administrative data for all transit cards of public transport users in New York City during the years 2009–2016, we show that individuals residing in low-income neighborhoods are more likely to purchase weekly passes repeatedly and for long periods of time. Thus, they spend more on transit fares compared with those residing in wealthy neighborhoods potentially because of high upfront costs of monthly passes.

The remainder of the paper is organized as follows. Section 2 gives a brief introduction to the public transit system in New York City. Section 3 describes main features of data sets used in the empirical analysis. To motivate certain choices in our empirical exercise, we provide descriptive statistics on commuters in Section 4. Section 4.3 and 5 describe our main estimation method and results. Section 6 considers other potential mechanisms that might explain the results. Section 7 performs back-of-the-envelop welfare analysis. Section 8 concludes the paper.

2 Background

This paper studies the public transit system in New York city, a system owned by the government of New York City and operated by the New York City Transit Authority (NYCTA). The NYCTA is the busiest and largest transit system in North America. It operates two systems. The first system is New York City Bus, an extensive bus network serving all boroughs of New York City. The second system is New York City Subway, a rapid transit network with 28 different lines (routes) and 424 stations located throughout four boroughs (Manhattan, Brooklyn, Queens, and the Bronx) of New York City. It covers 665 miles (1,070 kilometers) of track and serves more than 8 million passenger-trips per day. About 70 percent of people in New York City, especially low-income workers, commute to work by subways and buses. As the design of mass transit and the percentage of transit commuters in New York City is comparable to that of many other big cities, such as London, Paris, and Tokyo, our analysis of the fare purchase behavior and underlying mechanisms are relevant for research and policy debates on fare equity and affordability of public transport in metropolitan areas around the world.

The MetroCard is a thin refillable plastic card on which a rider electronically loads fares. Various types of MetroCards are available for purchase. There are two types of value-based cards: pay-per-ride MetroCards and single-ride tickets. The pay-per-ride MetroCard carries a real dollar value that decreases every time the user takes the subway or bus (hence "pay per ride").[9] Single-ride tickets cost 25 cents more than the base subway and bus fare on MetroCards. They must be used within two hours of purchase to ride a subway or bus.[10] Also, there are two types of time-based passes: 7-day unlimited-ride pass and 30-day unlimited-ride pass. Unlimited-ride passes allow users to ride the subway and buses as often as they want in a 7- or 30-day window after these passes are activated.

The MetroCard has three features that facilitate our empirical analysis and allow us to examine repeat use of weekly passes. First, except for cash payments for bus tickets,[11] MetroCard was the only payment method allowed for subway and bus rides during our study time period, June 2009 to December 2016. The universal use of MetroCard helps us to identify the prevalence of recurring weekly fare purchases. In contrast, transit systems in many cities allow various payment methods. For instance, commuters in Chicago can purchase and load a weekly or monthly pass to their transit card (Ventra Card) or to their contactless bankcard. As such, analysis of only reloadable transit card data may not capture the universe of transit fare and pass purchases in these cities.

Second, unlike some other cities, New York City did not have fare zones during the study period. The base fare of each subway or bus ride is the same regardless of the destination or length of the ride. During the time period studied in this paper, the base fare of a ride is $2.50. Correspondingly, there is only one price for weekly ($30) and monthly pass ($112). As a result, monthly fare is the only close substitute to multiple weekly fares. This simple fare structure makes it much easier for us to identify repeat weekly pass purchases, calculate the total amount of overpayment by recurring weekly

[9] The minimum purchase on a new pay-per-ride MetroCard is the fare of a round trip (currently $5.50). No minimum purchase is required for refill transactions. Riders can load any amount of money on the card.

[10] Single-ride tickets are available for sale only through vending machines in subway stations. They can only be purchased using cash. Single-ride tickets are only valid for one transfer bus to bus, not valid for subway to bus transfers.

[11] Cash payments for bus tickets account for less than 0.5% of total passenger trips.

pass commuters, and explore the underlying mechanisms.

Third, unlimited ride passes always expire exactly at midnight on the 7th or 30th day after activation, regardless of the time a commuter activated the card on the first day. For example, if a weekly pass is activated on Monday morning, it will expire Sunday night at midnight. If a weekly pass is activated Monday evening at 11:30pm, it still expires Sunday night at midnight, thus, effectively it can be used for six days and 30 minutes only. Hence, it is most efficient to use a new unlimited ride pass as early in the day as possible and use it for all rides in the following six days. This ubiquitous midnight expiration of passes allows us to examine some mechanisms which can be driving pass purchase behavior.

3 Data

In this section, we present the main features of the data sets used in this study. This paper documents the behavior of recurring weekly pass commuters using three data sets: MetroCard fare purchase data, ride data, and the American Community Survey data.

3.1 Transit Card Data

The MetroCard fare purchase and ride data sets were provided to us by the New York City Transit Authority. The transaction-level fare data cover all fare purchases from March 1, 2013 to May 31, 2015.[12] Each observation includes information on MetroCard number, the balance of the card before the purchase, the type of tickets purchased and loaded on to the card (pay-per-ride, single ticket, weekly or monthly pass), the payment amount, the station at which the purchase was made, the date and time of the purchase, and the method of payment (cash, debit or credit cards). The station-level fare data include the total number of fare purchases each week from June 2009 to December 2016, broken out for various types of MetroCards.[13] The transaction-level ride data cover all subway and

[12] This dataset includes deposit transactions from the New York City Subway rapid transit system, New York City Transit buses, and the partner agencies.

[13] Pay-per-ride, 7-day-unlimited, 30-day-unlimited, 7-day-unlimited Express, single-ride, reduced-fare seniors and disabled, etc.

bus rides from March 1, 2013 to May 31, 2015.[14] Each observation includes information on the type of fare used (pay-per-ride, single ticket, weekly or monthly pass), the subway station of entry or bus route for the ride, as well as the date and time of entry. The station-level ride data include the total number of subway and bus trips riders made each week as they entered each station of the New York City Subway, PATH, AirTrain JFK and Roosevelt Island Tram from June 2009 to December 31, 2016, broken out for various types of MetroCards.

As mentioned in the background section, the MetroCard was the primary payment method for the New York City subways and buses over our sample period. Each MetroCard has a unique card number (i.e., travel ID), which allows us to track individual fare purchase and travel behavior over time. A total of 43,835,397 fare purchases and 3,703,397,385 rides were completed from March 1st, 2013 to May 31, 2015. These transactions originated from 28,942,582 unique MetroCards and took place both at subway stations and bus stops. Note that these transactions include all types of MetroCards. For this study, we identify repeated weekly pass commuters as individuals who purchase a 7-day unlimited ride MetroCard every week and continue this purchase pattern for more than 11 months. Since monthly fare is the only close substitute for multiple weekly fares, we focus on the comparison of repeat weekly and monthly pass commuters in the empirical analysis and correspondingly identify repeated monthly pass commuters as riders who purchase a 30-day unlimited ride MetroCard every 30 days and continue this pattern for more than 11 months. Cutting the data in this way leaves us with a sample of 9,415,409 MetroCard IDs as repeated weekly fare commuters and 4,925,253 MetroCard IDs as repeated monthly fare commuters, respectively. For each of these IDs we have at least 11 months of observations.

Throughout this paper, we employ a rather strict definition of the concept of a "repeated weekly or monthly pass commuter" as we require them to purchase passes in a very consistent manner. Consequently, we exclude individuals who purchase recurring weekly or monthly fares for less than 11 months. We also drop irregular weekly pass commuters: riders that purchase and use weekly passes for a few weeks, have a gap of at least one or two weeks with no transit rides or only sporadic pay-per-ride trips, then resume the purchase and use of weekly passes for some weeks, and so on. Similar to

[14]This data set includes information on rides and transactions from the New York City Subway rapid transit system, New York City Transit buses, and the partner agencies.

reloadable transit cards used by the public transit agencies in many other cities, regular MetroCards are not personalized nor registered to a single user. As such, we miss repeated weekly or monthly pass commuters who use multiple MetroCards across different weeks or months as well. Given the size of our data, these misses still leave substantial sample sizes. Moreover, if anything, this strict selection procedure implies that the estimates reported below are a lower bound, as we focus only on commuters who adhered to recurring weekly or monthly pass purchases for a long period of time.

3.2 Neighborhood Income Data

In addition to the MetroCard data, we also use census tract data from the American Community Survey 5-Year Data (2011-2015). Many studies show that socioeconomic characteristics are strong predictors of transit card purchase patterns in a cross section (Graham and Mulley, 2012; Hickey et al., 2010; Verbich and El-Geneidy, 2017; Bondemark et al., 2021). In particular, the previous literature has documented that low-income riders, or riders in poorer neighborhoods are more likely to purchase weekly passes and pay-per-ride tickets instead of monthly passes, which are more common in more affluent neighborhoods.

Following the literature, we link socioeconomic measures to transit commuters and assess how these factors, especially income, could explain the recurring pass purchase behavior. Because the NYCTA does not collect personal- or household-level information of transit riders or link such data to MetroCard purchases and uses, we use neighborhood-level variables as proxies for demographics of transit riders instead. In particular, we use the median household income, population, the number of households, and the unemployment rate for each census tract in New York City from the 2011-2015 ACS 5-year estimates.

To calcualate neighborhood demographics at the station level, we generated a 1000-meter (1-km) network buffer around the centroid of every subway station using the street network of New York City. These buffers are intersected with census tracts to assign median household income within the buffer around each station, and the contribution of each census tract was weighted based on area. The percentage of unemployed residents was also calculated with the same method. Unemployed residents may be prone to purchase weekly passes due to the uncertainty of travel or inability to afford a monthly pass. A similar procedure was used to calculate population and the number of household within the buffer as well. Table 1 presents the summary statistics of these socioeconomic measures within the buffers around subway stations.

Table 1: Summary Statistics of Socioeconomic Measures

Variables	Median	Mean	Std. dev.	Min	Max
Median Household Income ($)	49,362	56,728	24,736	21,615	125,581
Population	4,023	4,239	1,127	2,226	8,826
Households	1,529	1,750	683	671	4,678
Unemployed (%)	0.06	0.07	0.03	0	0
# of Lines Passing through Stations	2	2	1	1	5

Summary statistics at the station (N = 470) level

4 Descriptive Statistics and Preliminary Evidence

4.1 Descriptive Statistics

We start by providing some descriptive statistics of weekly and monthly pass use based on the data on the whole population of New York City public transit riders. These statistics are used to motivate certain choices that we make in the empirical analysis that is to follow. Figure 1 displays the monthly sales of weekly and monthly passes at different stations across the city in May 2014. Circle-sizes correspond to relative size of sales. Major hub stations and stations at the airports are omitted because of the non-residential nature of the surrounding areas and potential outliers due to tourist purchases. During our sample period, from March 2013 to May 2015, the monthly sales of weekly and monthly fares at different stations followed a standard pattern, as displayed in Figure 1 for May 2014. The figure shows that more weekly passes are sold in stations located in low-income neighborhoods such as Harlem and South Bronx. Sales of monthly passes, on the other hand, are more concentrated in stations in more affluent neighborhoods like Upper West Side and Chelsea. These spatial variations are consistent with the existing studies that find weekly passes are more likely to be purchased in low-income neighbourhoods (Bondemark et al., 2021; Hickey et al., 2010; Verbich and El-Geneidy, 2017).

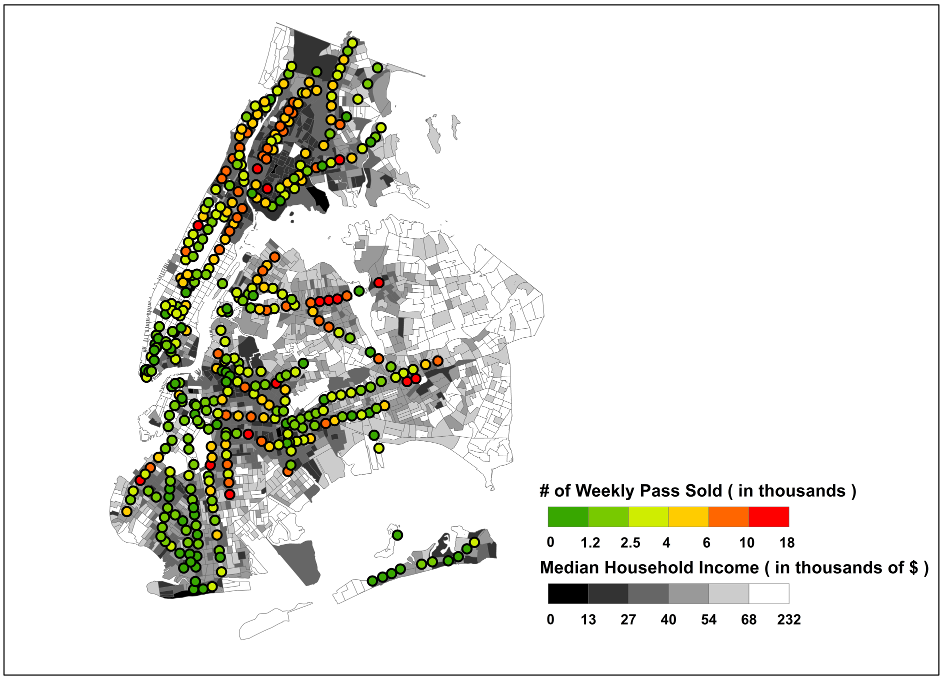
One important caveat to consider is that purchases of weekly and monthly passes at different locations may come from the same rider. As shown in Table 2, from March 2013 to May 2015, an average of 1,652,452 weekly passes and 589,136 monthly passes are sold monthly. These sales originated from only about 523,549 and 228,388 unique travel IDs (card numbers), respectively, indicating that many riders purchase multiple unlimited-ride passes. Meanwhile, more than 28.23 percent of travel IDs have bought weekly or monthly passes at different stations. When riders that live in low-income neighborhoods purchase unlimited-ride passes in wealthy neighborhoods such as stations around workplaces, our analysis of the impacts of socioeconomic characteristics on sales of weekly and monthly passes simply based on purchase locations may represent attenuated behavioral responses.

Table 2: Summary Statistics for Weekly and Monthly Passes

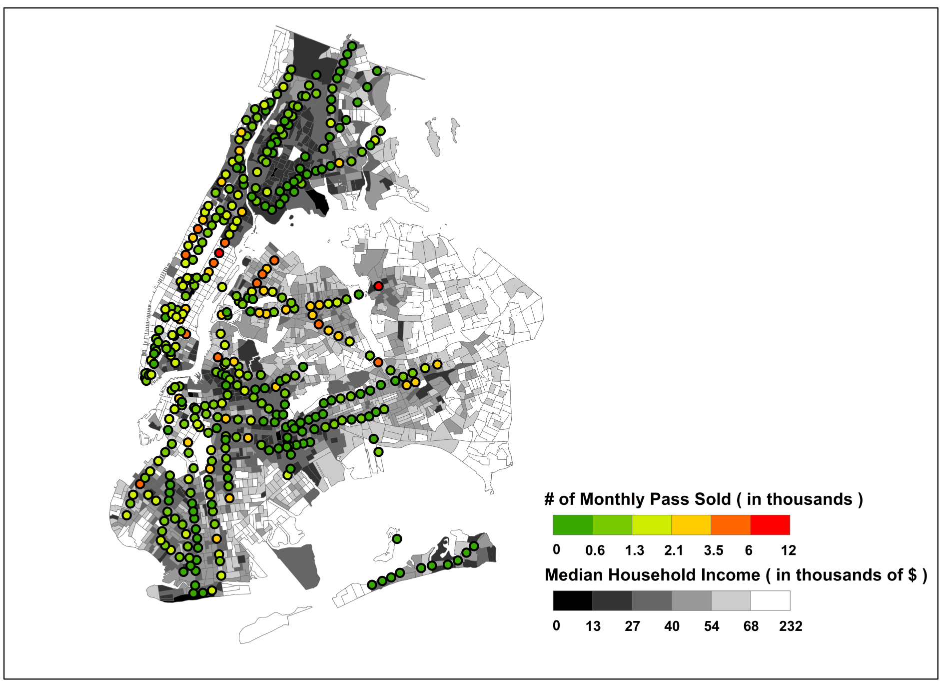
Variables	Median	Mean	Std. dev.	Min	Max
Panel A: All Passes					
Weekly					
# of pass sold per month	1,766,214	1,652,452	415,472	391,372	2,427,826
# of unique travel IDs	594,388	523,549	192,184	135,852	939,349
Monthly					
# of pass sold per month	610,751	589,136	137,954	143,686	880,701
# of unique travel IDs	229,605	228,388	108,256	55,685	605,011
Panel B: Repeated Pass Commuters					
Weekly					
# of trips taken per week	17.8	16.2	7.23	12	25
# of repeated pass commuters per month	392,700	348,719	142,426	64,479	759,980
Monthly					
# of trips taken per week	15.3	14.9	6.92	11	23
# of repeated pass commuters per month	187,152	182,417	70,001	33,728	395,366

The sample is obtained from the transaction-level MetroCard purchase and swipe data during the period from March 2013 to May 2015. Panel A includes all weekly and monthly passes purchased and corresponding travel IDs, while panel B includes only repeated weekly and monthly passes. Columns 1-5 shows the median, mean, standard deviation, minimum, and maximum of selected variables in each subsample, respectively.

Figure 1: Stations of Weekly and Monthly Pass Purchases in May 2014



(a) Weekly Pass Commuters



(b) Monthly Pass Commuters

Figure 1a plots the number of 7-day unlimited-ride passes sold in each subway stations in May 2014. Figure 1b plots the number of 30-day unlimited-ride passes sold in each subway stations in May 2014.

4.2 Defining Home Stations

Prior studies analyzing transit fare inequities and recurring weekly fare purchases have not reached a consensus on how to address the issue of pass purchases at different stations. Verbich and El-Geneidy (2017) chose to exclude all travel IDs that bought multiple weekly passes at different locations and only use IDs that made repeated purchases at a single point of sale in their main empirical analysis. While overcoming the aforementioned issue, this approach led to a small sample size and might not be informative of the overall recurring weekly fare sales. Bondemark et al. (2021), on the other hand, use individual data from the Swedish National Travel Survey. Although this survey data has direct background information such as income and employment status, it has a small sample size and lacks detailed information on transit purchases and trips, which prevents a clean comparative analysis of fare purchases and travel patterns between non-monthly and monthly pass commuters.

With the data on the universe of actual trip records on the New York City subways and buses for each MetroCard, we offer advantages over earlier contributions in overcoming these potential biases. Specifically, we use actual travel patterns to identify subway stations most frequently used for each repeat weekly or monthly pass commuter. We label these stations as home stations. Table 2 shows that the median repeat weekly pass commuter is observed in the data set for 12.1 months and take an average of 14 trips per week. Meanwhile, each repeat weekly or monthly pass commuter takes at least 12 trips each week with stable commuting patterns. As the MTA subway fares are not distance dependent, the system only stores the station where a passenger enters the subway with no information on exit locations.[15] We use the following rules to identify a recurring weekly or monthly pass commuter's home subway station h:

(1) Station h is the first entry station in a weekday that the server records.

(2) Station h is the first entry station of a pair of entry stations that appear at least five times a week on the same recurring monthly or weekly MetroCard.

[15] As MTA bus trips only record route information and do not store data on location for each individual boarding a bus, we could not identify home stations for commuters whose working days start with a bus ride. We thus exclude these recurring pass commuters from the analysis on income strata and fare purchase patterns.

(3) Boarding time at the first entry station h and boarding time at the second entry station in the pair of entry stations in (2) are at least 7 hours apart.

(4) There is not a third entry station recorded between boarding time at the first entry station and boarding time at the second entry station in the pair of entry stations in (2).

4.3 Preliminary Results

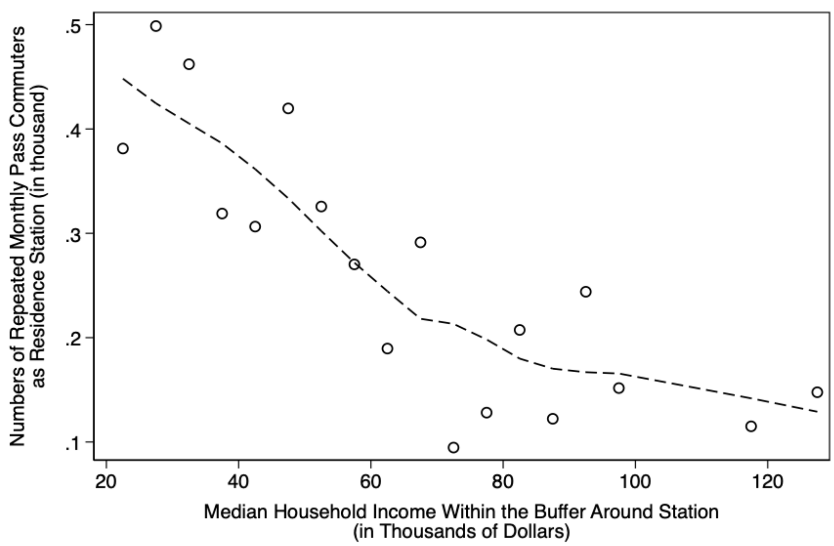
As we describe above, socioeconomic characteristics such as income are important predictors of the sales of weekly and monthly passes. Thus, after identifying home stations of repeat weekly and monthly pass commuters, we first analyze the relationship between median household income within the 1-km buffer around the station and the number of repeat weekly and monthly pass commuters in each subway station in Figure 2. This figure shows a negative relationship between neighborhood income and recurring weekly fare sales: subway stations in neighborhoods with lower median household incomes have larger numbers of recurring weekly pass commuters as home stations. In contrast, there is a positive relationship between income and recurring monthly fare sales. Subway stations in more affluent areas have larger numbers of recurring monthly pass commuters as home stations. Figure 3 presents the spatial patterns of home stations according to the number of repeat weekly and monthly pass commuters. This figure shows patterns similar to Figure 2. Home stations of repeat weekly pass commuters are predominately in low-income neighborhoods such as South Bronx and Harlem in Manhattan, while home stations of recurring monthly pass commuters are mostly in more affluent neighborhoods.

Then, we run the following regression for recurring weekly and monthly pass commuters separately and compare the resulting coefficients:

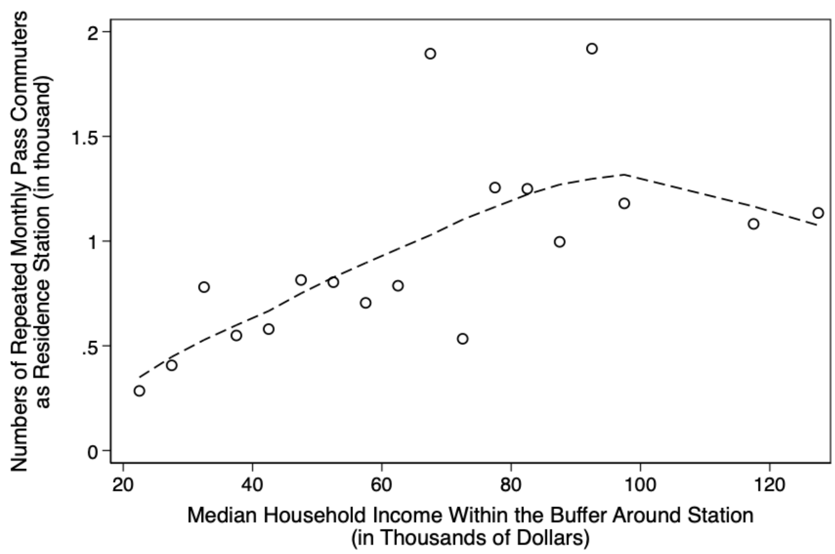
$$\begin{aligned} ln(Num_{jt}) =& \alpha + \theta ln(Income_j) + \tau ln(Pop_j) + \gamma HH_j + \mu Unemp_j \\ &+ \delta Line_j + \epsilon_{jt}, \end{aligned} \tag{1}$$

where $ln(Num_{jt})$ is the natural logarithm of the number of repeat weekly or monthly pass commuters with station j as home station in month t; $Income_j$ is the average median household income within

Figure 2: The Number of Recurring Pass Commuters and Average Median Household Incomes Around Home Stations



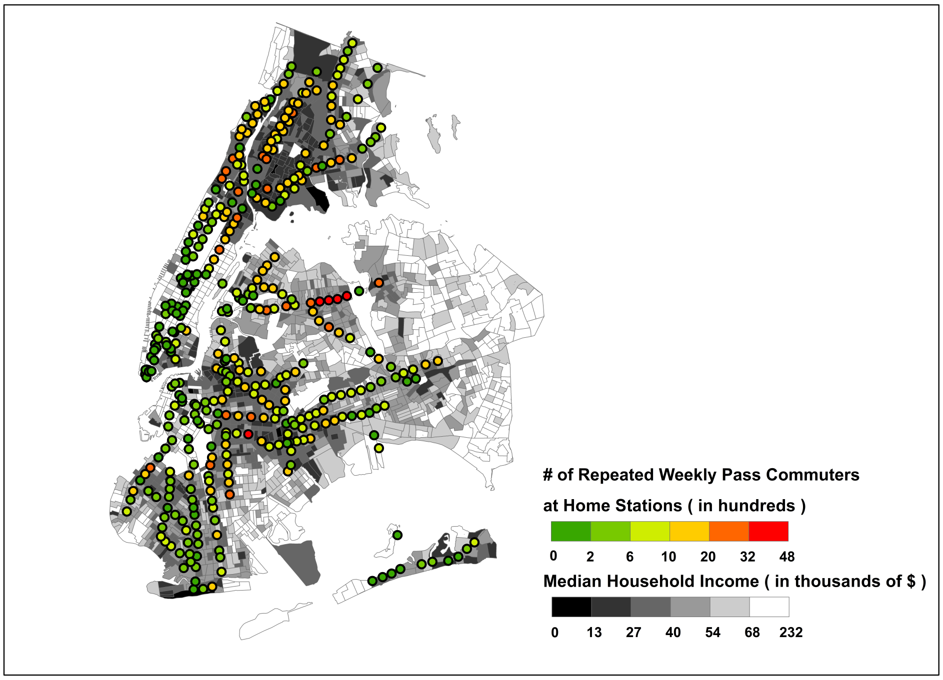
(a) Repeated Weekly Pass Commuters



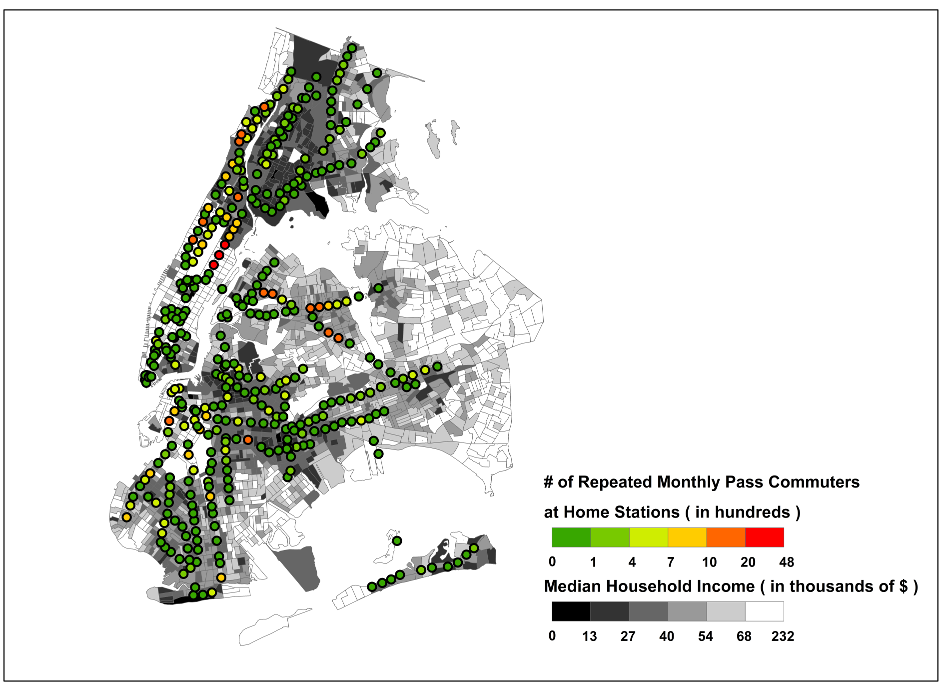
(b) Repeated Monthly Pass Commuters

Figure 2a plots the number of recurring weekly pass commuters at each home station on the y-axis and the average median household income (in thousand of dollars) within the buffer of each home station on the x-axis. Figure 2b plots the number of recurring monthly pass commuters at each home station on the y-axis and the average median household income within the buffer of each home station on the x-axis.

Figure 3: Home Stations of Repeat Weekly and Monthly Pass Commuters



(a) Repeated Weekly Pass Commuters



(b) Repeated Monthly Pass Commuters

Figure 3a plots the number of repeated weekly pass commuters with station j as residence station from March 2013 to May 2015. Figure 3b plots the number of repeated monthly pass commuters with station j as residence station from March 2013 to May 2015.

the buffer of the home station j; Pop_j, HH_j, $Unemp_j$ are population, the number of households, and percent of residents who are unemployed within the buffer of the home station j, respectively; $Line_j$ is the number of transit lines going through home station j. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station.

The results are reported in Appendix Table 11, using different control variables in each specification. The regressions for repeat weekly pass commuters are reported in Columns (1) - (3), and the regressions for repeat monthly pass commuters are reported in Columns (4) - (6). The baseline specification in Columns (1) and (4) control for neighborhood median household income, population, and the number of households around each home station. In line with Figure 2 and 3, the coefficient of median household income is negative and statistically significant for recurring weekly pass commuters, suggesting that stations in neighborhoods with lower median household incomes have larger numbers of recurring weekly pass commuters as home stations.

We then check the robustness of this initial result by making two adjustments to the base specification. First, as unemployed residents may be prone to purchase weekly passes due to the uncertainty of travel or inability to afford a monthly pass, Column (2) includes the percentage of local residents who are unemployed within the buffer of each home station as an additional control variable. The addition of the unemployment rate increases the estimates to -260.4 and the effect remains statistically significant. Meanwhile, the estimated coefficient of unemployment rate is negative and statistically significant at 0.1%, indicating that an increase in unemployed residents residing in the neighborhood is expected to decrease the number of repeat weekly and monthly pass commuters.

Second, to further address a possible bias from the size of the stations, our preferred specification in Column (3) builds on the model in Column (2) by adding the number of transit lines that pass through each home station. The effect of the median household income and unemployment rate remain highly similar. Purchase patterns observed in Figure 2a and 3a as well as Table 11 suggest that repeat weekly fare commuters predominantly live in low-income neighborhoods.

With detailed transaction-level information, we also analyze the share of a commuter's fare purchases that occur on each day of the week and on each day of the month. We show purchase shares by day of the week in the top panel of Figure 4 among recurring weekly pass commuters, purchase shares constantly decrease from Mondays to Thursdays and then increase visibly on Fridays. Purchase shares are more evenly distributed for recurring monthly pass commuters. The F-statistic for the test that purchase shares are equal across days in the second half of the week (Wednesday–Saturday) is 488.05 for recurring weekly pass commuters and 4.39 for recurring monthly pass commuters. The observed higher shares of recurring weekly pass purchases on Fridays may suggest that lower income individuals purchase passes after they collect their weekly paychecks on Fridays. As such, they are likely to purchase a weekly pass on Fridays to guarantee commuting trips to work in the upcoming seven days.

Purchase shares by day of the month are presented in the bottom panel of Figure 4. Relatively large spikes in purchase shares on the first six days of the month are evident for recurring monthly pass commuters. The pattern of the first week of month purchases disappears almost completely for repeat weekly pass commuters.

The Survey of Consumer Finances (SCF) indicates that it is primarily the poor who use non-credit payments in the US (Bricker et al., 2014; Brueckner and Rosenthal, 2009). To test whether this is true in the case of repeated weekly pass commuters, we examine differences in payment methods (cash, debit card, versus credit card) between recurring monthly and weekly fare purchases. As shown in Figure 5, the recurring weekly fare purchases mainly came from non-credit payments: more than 50 percent of recurring weekly fares were paid by cash and another 30 percent were paid by debit card. In contrast, the repeated monthly fare purchases largely came from credit card payments with 15 percent were paid by cash.

To confirm the payment patterns observed in Figure 5, we modify equation (1) to include a non-credit payment indicator as independent variable and use a dummy variable for recurring weekly fare sales as dependent variable. We show the estimated marginal effects in Table 3. The baseline specification in Column (1) controls for neighborhood median household income, population, number of households, unemployment rate, and the number of subway lines that pass through each station. Consistent with Figure 5, the estimated coefficient of $Non-credit$ is 0.42 and significant at the 0.1% level, indicating that repeated weekly pass commuters are 42% more likely to pay for transit fare by

Figure 4: Heterogeneity for Purchases of Repeated Weekly and Monthly Pass Commuters

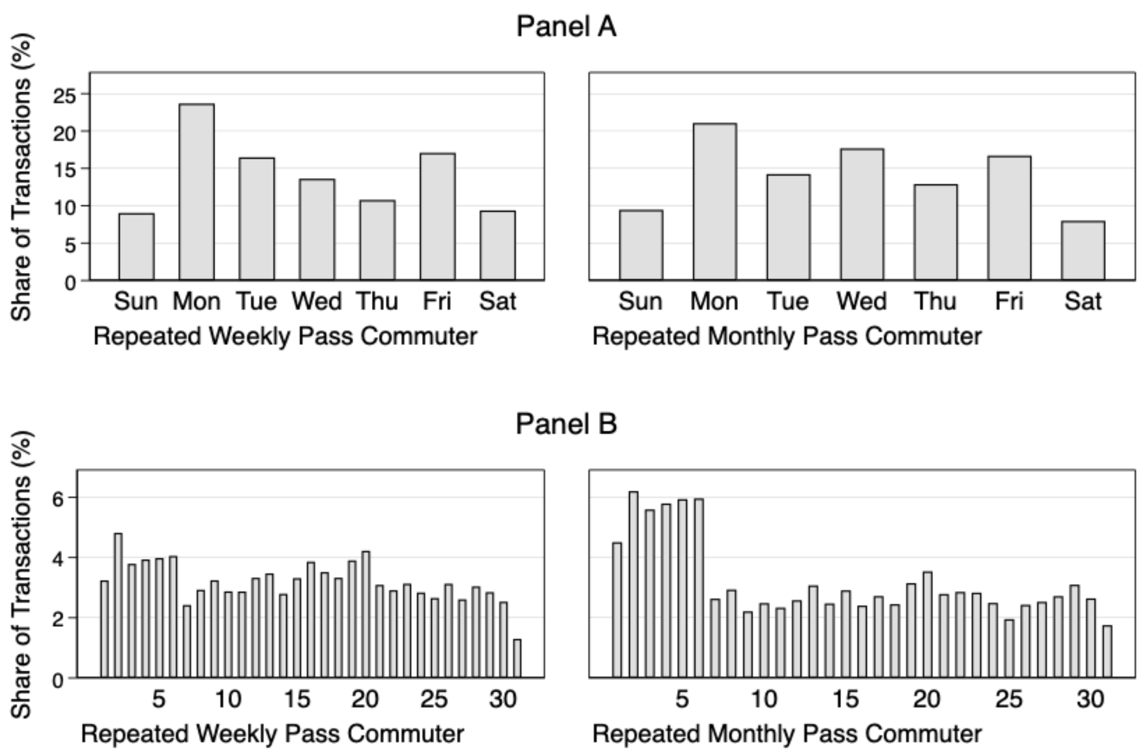
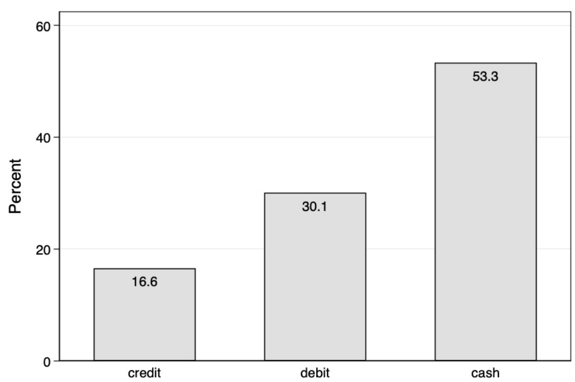
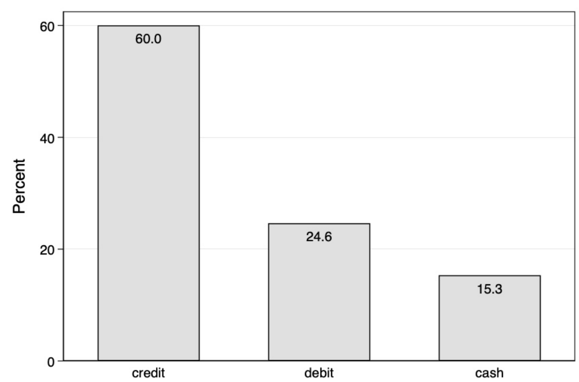


Figure 4 shows the purchase share of repeated weekly and monthly pass commuters on each day of the week (panel A) and day of the month (panel B).

Figure 5: Purchase Shares of Repeated Weekly and Monthly Pass Commuters by Payment Methods



(a) Repeated Weekly Pass Commuters



(b) Repeated Monthly Pass Commuters

Figure 5 plots the histogram for recurring weekly and monthly fare sales by different payment methods (cash, debit card, and credit card). Figure 5a plots the histogram for recurring weekly fare sales by different payment methods. Figure 5b plots the histogram for recurring monthly fare sales by different payment methods.

cash or debit card than recurring monthly fare commuters.

Table 3: Determinants of Weekly Fare Purchases For Repeated Pass Commuters

	(1)	(2)	(3)
Non-credit	0.416***	0.416***	0.411***
	(1,006.50)	(1,007.71)	(998.22)
ln(Income)	-0.062***	-0.061***	-0.061***
	(-61.51)	(-61.45)	(-60.99)
ln(Population)	0.197***	0.195***	0.192***
	(117.24)	(116.53)	(115.09)
ln(Households)	-0.197***	-0.196***	-0.193***
	(-135.15)	(-134.30)	(-132.68)
Unemployed	1.838***	1.830***	1.816***
	(150.05)	(149.55)	(149.04)
# of Lines	0.006***	0.006***	0.006***
Passing through Stations	(24.99)	(25.10)	(25.19)
Day of the Week FE	Yes	Yes	Yes
Day of the Month FE	No	No	Yes
Month FE	No	Yes	Yes
Year FE	No	No	Yes
Observations	2,407,111	2,407,111	2,407,111
R^2	0.254	0.255	0.261

This table shows the regression results for equation 1. The sample is obtained from the transaction-level MetroCard purchase and swipe data during the period from March 2013 to May 2015. The dependant variable in Columns 1-3 is a dummy variable for recurring weekly fare sales. The baseline specification in columns 1 includes non-credit purchases, the average median household income, population, the number of households, and percent of residents who are unemployed within the buffer of home stations. Column 2 builds on the specification in Column 1 by adding day of the week and day of the month fixed effects as additional control variables. Our preferred specification in Column 3 builds on the model in column 2 by adding month and year fixed effects. Robust standard errors in parentheses. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

If riders' payment patterns are different across different months of the year or if different types of riders purchase at different times of the year, any variations in the time of data collection could affect the regression results. To account for this possibility, our preferred specification in Column (3) includes month, year, day of the week, and day of the month fixed effects. As with the other control variables, the inclusion of these fixed effects has little impact on the estimated effect of the non-credit payment method.

To summarize, we find that repeat weekly pass purchases are more prevalent in lower income neighborhoods, while riders in higher income neighborhoods buy repeat monthly passes. We also find that repeat weekly pass purchases are more likely to be made with cash or a debit card (as opposite to a credit card). In addition, we find that there is an increase in repeat weekly pass purchases on Fridays, when low income workers often receive their paychecks. Taken together, these results may suggest that riders in low-income neighborhoods may face difficulty buying a monthly pass which is the least expensive option per trip, but the most expensive in absolute dollar terms ($112) and requires the highest upfront cost. Low-income commuters may be unable to spend a large amount at one time for a monthly pass and instead repeatedly rely on more expensive weekly fares. They buy with cash and debit cards, thus unable to use credit to pay for their passes. Also, some commuters in low-income neighborhoods purchase weekly passes on Fridays, when many of them receive paychecks and have more liquidity.

5 Fare Increases and Weekly Pass Purchasing Behavior

In this section, we use fare increases on December 30th, 2010 and March 3rd, 2013, which changed relative costs of weekly and monthly passes, to provide further evidence on fare purchase behavior of constrained riders. For this analysis, we expand our data to include MetroCard sales data from June 2009 to December 2016.[16]

5.1 Details of Fare Changes and Testable Hypotheses

Table 4 lists the details of fare information from June 2009 to March 2015. Column 1 presents the fare schedule from June 28, 2009 to December 29, 2010. The base subway and bus fare was $2.25. The weekly and monthly passes were $27 and $89, respectively. Column 2 lists the fare hike at the end of 2010. On December 30, 2010, the 7-day pass increased to $29 and the 30-day pass increased to $104. There was no change in base subway and bus fares, but the cost of a single-ride ticket went to $2.50.

[16] Data before March 2013 do not allow us to reliably link pass purchases over time, hence we did not use it in the previous Section.

Column 3 shows the fare hike in 2013. On March 3, 2013, the base subway and bus fare increased from \$2.25 to \$2.50. The cost of a 7-day pass increased to \$30. The cost of a 30-day pass increased to \$112. The price of a single-ride ticket increased to \$2.75.

As Columns (1) - (4) of Table 12 in Appendix show, in December 2010, the switching point between pay-per-ride (PPR) and 7-day pass remained the same at 14 trips. An unconstrained rider with fewer than 14 trips per week should prefer PPR, while a rider with 14 or more rides per week would prefer a weekly pass. Similar calculations for PPR and 30-day pass in Columns (1) - (4) of Table 13 in Appendix, show that the switching point moved from 46 rides before the fare change to 50 rides after the policy change. The cost of a monthly pass is lower than an equivalent in weekly passes before and after the 2010 fare changes.[17]

Table 4: Fare Increases in 2010 - 2015

Date	(1) Jun 28, 2009 - Dec 29, 2010	(2) Dec 30, 2010 - Mar 2, 2013	(3) Mar 3, 2013 - Mar 21, 2015
Base fare (\$)	2.25	2.25	2.50
7-day-unlimited (\$)	27	29	30
30-day-unlimited (\$)	89	104	112
Single-ride tickets (\$)	2.25	2.50	2.75

Notes: Table 4 summarizes fare increases in December 2010 - March 2015.

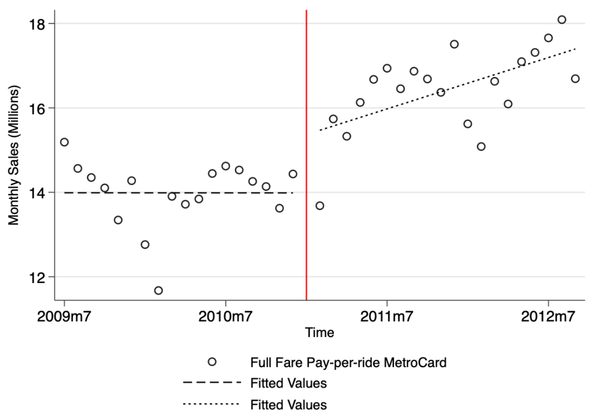
After December 30, 2010, there could be an incentive to switch from a monthly pass to PPR for riders with fewer than 50 trips, but there is no incentive for unconstrained commuters to switch to weekly passes after the fare changes. The calculation can be different for a constrained commuter because the cost of the monthly pass increased from \$89 to \$104. If there are constrained riders who could not afford the new higher price of monthly passes, we may expect them to switch from monthly to weekly passes after the fare increases.

As Columns (3) - (6) of Appendix Table 12 show, the switching point from PPR to a weekly pass decreased from 14 to 13 trips after the 2013 fare increases. In addition, Columns (3) - (6) of Appendix Table 13 indicate the threshold between PPR and monthly pass decreased from 50 to 48 rides. How-

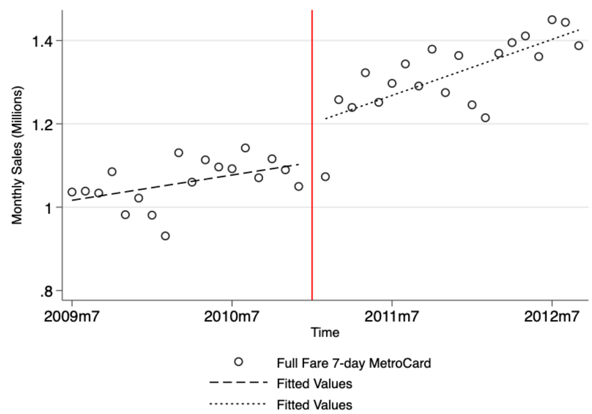
[17] The equivalent price of the weekly pass is multiplied by 4.286 to match the 30-day pass. The converted weekly pass price is \$115.72 compared to the monthly pass price \$89 before the fare increases, and \$124.29 compared to \$104 after.

ever, it is still better to purchase a monthly pass ($112) compared with an equivalent in weekly passes ($128.58) after the fare increases as it was before the increase ($104 versus $124.29, respectively). Similar to the 2010 fare increases, unconstrained commuters should prefer monthly passes to weekly passes, while a constrained rider may find it harder to save for a higher price of a monthly pass.

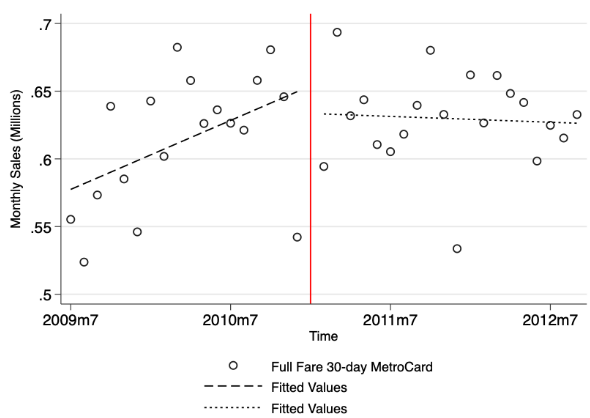
Figure 6: **Pay-per-ride, Weekly and Monthly Pass Purchases After 2010 Fare Increases**



(a) Pay-per-ride



(b) 7-Day Pass



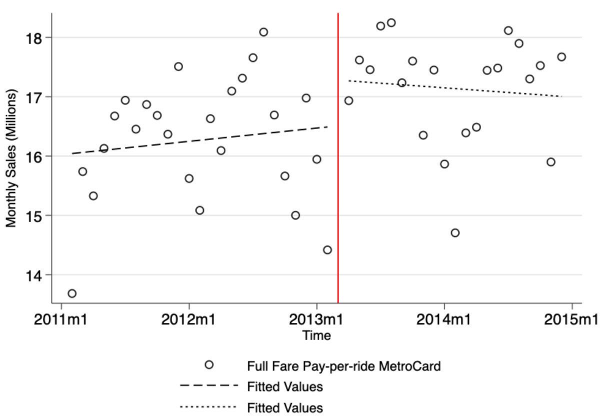
(c) 30-Day Pass

Notes: Figure 6 shows the number of PPR rides systemwide for each week in June 2010 - December 2011, as well as weekly and monthly pass purchases for each month in June 2009 - September 2012. The dashed and dotted lines represent linear trends fitted to these data.

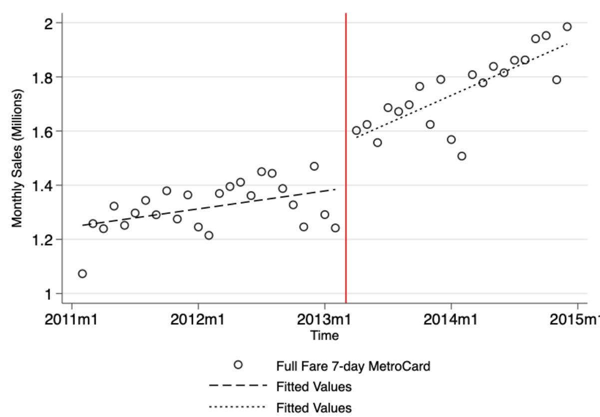
5.2 Results for Aggregate Sales

To examine how relative costs of different fare options affect their sales, we first plot PPR, weekly and monthly pass purchases by month before and after the 2010 fare increases in Figure 6. This figure shows a significant increase in PPR purchases, a small decline in monthly pass purchases, and a significant increase in weekly pass purchases. As we outlined in the previous paragraph, an unconstrained consumer should not switch from monthly to weekly passes after the fare increases. But, a constrained rider may prefer a weekly pass which is less expensive up front, but more expensive in the long term.

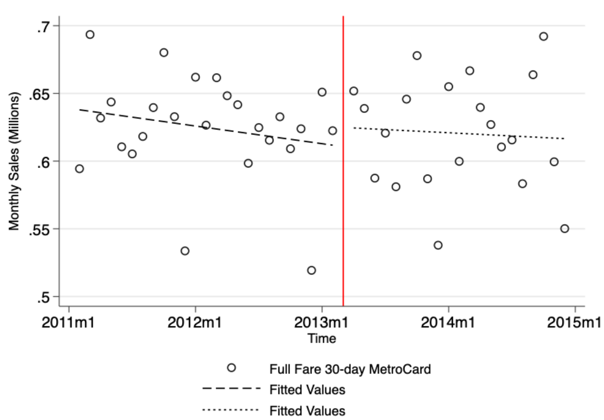
Figure 7: **Pay-per-Ride, Weekly and Monthly Pass Purchases After 2013 Fare Increases**



(a) Pay-per-ride



(b) 7-Day Pass



(c) 30-Day Pass

Notes: Figure 7 shows the number of PPR rides systemwide for each week in January 2011 - December 2014, as well as weekly and monthly pass purchases for each month in January 2011 - December 2014. The dashed and dotted lines represent linear trends fitted to these data.

Figure 7 shows changes in PPR, weekly and monthly pass purchases after the 2013 fare increases. Similar to Figure 6, we observe a large increase in weekly pass purchases after the fare hike, but no change in monthly pass purchases. This finding is consistent with constrained commuters switching to weekly passes after monthly passes became more expensive in up front (from \$104 before to \$112 after).

We also examine this hypothesis more formally and estimate the following model using monthly data on PPR, weekly, and monthly passes purchases:

$$Y_t = \beta + \gamma \mathbb{1}\{t \geq t_0\} + a(t) + X_t + u_t, \tag{2}$$

where t represents time, Y_t is PPR, weekly and monthly sales at time t, t_0 is the distinct cutoff point (e.g., December 30, 2010), $a(.)$ is a flexible function of time, X is a set of controls including day-of-week and month-of-year fixed effects. We cluster standard errors at month level, allowing for arbitrary correlation in error terms over time for a given month. The coefficient of interest is γ which measures the effect of the new fares on PPR, weekly and monthly pass sales.

Table 5 summarizes our results for estimating Equation (2) on the data before and after the 2010 fare increases. Column 2 shows that the fare hike increased purchases of weekly passes by 0.1 million per month and decreased purchases of monthly passes by 0.04 million per month. These results suggest riders purchase more weekly passes, which have a lower cost per unit, but higher costs over the long term, after the price of a monthly pass increased.

Table 6 shows results for the effect of the 2013 fare increases on PPR, weekly, and monthly pass purchases. Unconstrained commuters are still incentivized to prefer monthly passes to weekly passes after the fare increases. However, we observe a decline in sales of monthly passes and an increase in sales of weekly passes. This opposite effect suggests that constrained riders again switch from more cost-efficient monthly passes to less efficient weekly passes.

Since riders have three fare options (PPR, weekly and monthly passes) and consider them simultaneously, we rerun these regressions with a fractional Logit model which allows us to compute the effects

Table 5: **The Effect of 2010 Fare Increases on Monthly Purchases of PPR, Weekly and Monthly Pass**

	Pay-per-ride	Weekly Passes	Monthly Passes
After	1.701***	0.099***	-0.039***
	(0.359)	(0.031)	(0.012)
Time Trend	0.042**	0.008***	0.002***
	(0.017)	(0.001)	(0.001)
Month FE	Yes	Yes	Yes
Observations	39	39	39
R^2	0.953	0.973	0.801

Notes: Table 5 presents the results of estimating model in Equation (2) for each type of fare after the 2010 fare increase. The data consist of system-wide monthly counts of PPR, weekly and monthly pass purchases. $After$ is an indicator variable equal to 1 after the fare increase.

Table 6: **The Effect of 2013 Fare Increases on Monthly Purchases of PPR, Weekly and Monthly Pass**

	Pay-per-ride	Weekly Passes	Monthly Passes
After	0.105	0.082**	-0.021*
	(0.178)	(0.034)	(0.010)
Time Trend	0.018**	0.013***	0.000*
	(0.008)	(0.001)	(0.000)
Month FE	Yes	Yes	Yes
Observations	44	44	44
R^2	0.886	0.974	0.867

Notes: Table 6 presents the results of estimating model in Equation (2) for each type of fare after the 2013 fare increase. The data consist of system-wide monthly counts of PPR, weekly and monthly pass purchases. $After$ is an indicator variable equal to 1 after the fare increase.

of a fare increase on relative shares of these three fare options. Tables 7 and 8 summarize these results.[18] These tables show that after both fare hikes, commuters decreased purchases of monthly passes (by 3 and 1.3 percent) and increased purchases of weekly passes (1.6 and 4.5 percent, respectively).

Table 7: The Effect of the December 2010 Fare Hike on Fare Purchases

	Pay-per-ride	7-day	30-day
Post	0.014***	0.016***	-0.030***
Population	-0.000***	0.000***	-0.000
# of households	-0.000***	-0.000***	0.000***
Unemployed (%)	0.500***	1.455***	-1.955***
# of Lines	-0.003***	0.007***	-0.004***
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	11,634	11,634	11,634

This Table shows the regression result for the percentage change of pay-per-ride, weekly, and monthly pass purchases for each month using the fractional multinomial logit model after the December 30, 2010 fare increases. We use the station-level monthly purchases data during the period from June 2010 to December 2011.

5.3 Downgrading from Monthly to Weekly Passes after the 2010 and 2013 Fare Increases

While in the previous section, we examined the aggregate sales of PPR, weekly and monthly passes after the fare increases, in this section we consider individual card data and examine whether riders downgrade from monthly to weekly passes after the fare changes. This is the most direct evidence of commuters switching from purchasing monthly to weekly passes after the increase in upfront costs of monthly passes. For this analysis, we use card-level data which is only available before and after the 2013 fare increase.

We present our results in Figure 8. This figure shows the number of commuters who downgraded from monthly to weekly passes and continued purchasing them for at least 7 weeks (panel a) and at least 10 weeks (panel b). We also plot these numbers by home stations' income level. These figures

[18] We use fare purchase data at the station-month level to implement these analyses.

Table 8: The Effect of the December 2013 Fare Hike on Pass Use

	Pay-per-ride	7-day	30-day
Post	-0.032***	0.045***	-0.013***
Population	-0.000***	0.000***	0.000
# of households	0.000***	-0.000***	0.000***
Unemployed (%)	0.236***	1.656***	-1.891***
# of lines	-0.004***	0.007***	-0.003***
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	11,634	11,634	11,634

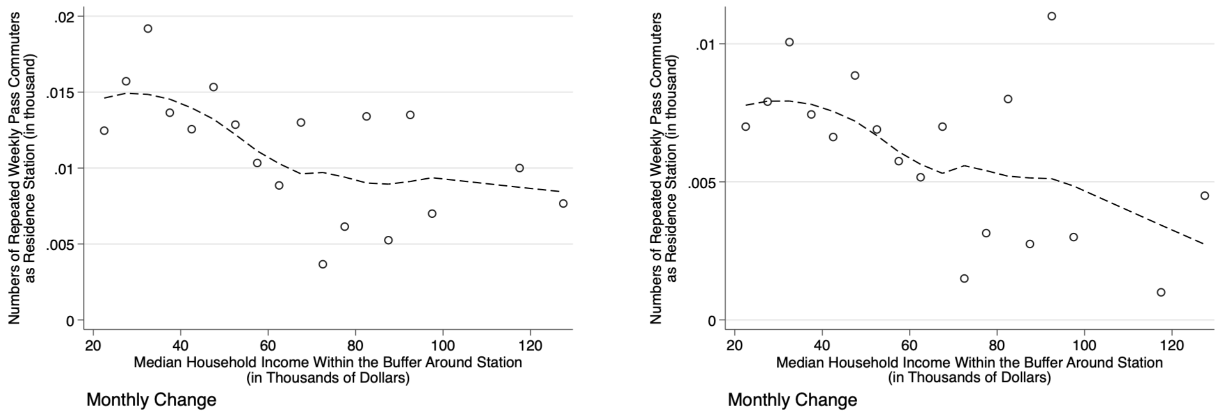
This Table shows the regression result for the percentage change of pay-per-ride, weekly, and monthly pass ridership for each month using the fractional multinomial logit model after the March 3, 2013 fare increases. We use the station-level monthly purchases data during the period from January 2011 to December 2014.

show that more monthly-pass riders in low income neighborhoods switched to weekly passes after the 2013 fare increase than riders in high-income neighborhoods.

5.4 Summary of Results Based on Fare Increases

To summarize, in this section, we use fare changes in 2010 and 2013 to estimate the effect of high fixed costs of monthly passes on switching between monthly and weekly passes. As fare changes are plausibly exogenous to individual commuters, our estimates are less likely to be affected by unobserved factors which may drive commuters in low income neighborhoods to purchase weekly passes instead of monthly passes. Both fare changes increased upfront costs of monthly passes, but did not make them more expensive than an equivalent combination of weekly passes. Thus, we argue that weekly pass purchases should not increase after these fare changes for unconstrained commuters. However, constrained riders may switch from monthly passes to weekly passes, if they do not have enough funds for a large-ticket monthly pass purchase. Our results in this section show evidence of this behavior.

Figure 8: Home Stations of Monthly Commuters who Downgraded to Recurring Weekly Passes After the 2013 Fare Increases



(a) At Least 7 Weeks

(b) At Least 10 Weeks

Figures 8a - 8b are based on card-level purchase data from January to April 2013. 8a plots the home stations of commuters who purchased a monthly pass in February 2013 and downgraded to recurring weekly passes for at least 7 weeks after the fare hike on March 2, 2013. 8b plots the home stations of commuters who purchased a monthly pass in February 2013 and downgraded to recurring weekly passes for at least 10 weeks after the fare hike on March 2, 2013.

6 Alternative Mechanisms

While our findings are consistent with some commuters being unable to afford high upfront cost monthly passes, there are a number of other reasons why these commuters purchase a weekly pass every week and continue this purchase pattern for a long time. In this section, we provide empirical evidence on four potential alternative explanations: discrepancies in awareness, job instability, the fear of losing a monthly pass, and time inconsistency.

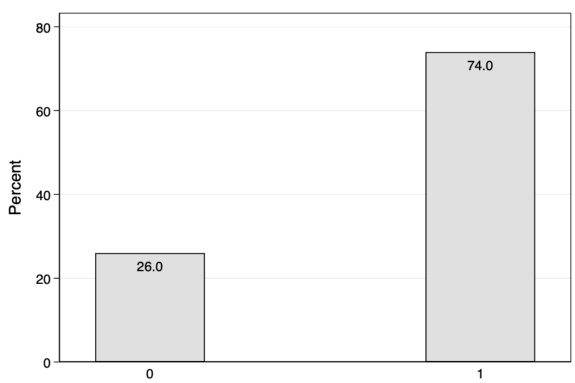
6.1 Discrepancies in Awareness

There may be some concern that recurring weekly fare commuters are not aware of the existence of monthly passes. As shown in Appendix Figure 12, weekly and monthly passes are two default choices presented right next to each other on interactive screens of MetroCard vending machines. Riders can always see the information about 30-day passes when they purchase 7-day passes. Thus, the observed recurring weekly fare sales are not likely driven primarily by discrepancies in awareness.

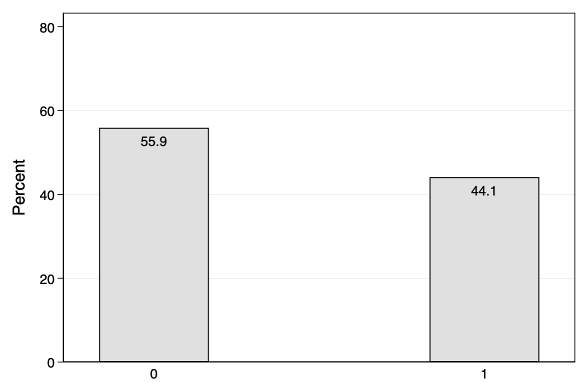
6.2 The Fear of Losing a Monthly Pass

Another possibility is that some commuters may worry about losing an expensive monthly pass, choosing instead to rely on less expensive weekly passes. To evaluate the potential influence of this factor, we examine the purchasing behavior of riders with multiple weekly passes on the same MetroCard. The card allows riders to load and store two unlimited-ride passes at the same time. The two passes will sequentially stack on the card, with the second pass becoming active following the expiration of the first pass and can be used on the card. As shown in Figure 9, we find that about 75 percent of recurring weekly pass commuters have loaded two weekly passes at the same time across different months. Meanwhile, over 40 percent of recurring weekly pass commuters have added a second weekly pass to their cards before the first one expires.

Figure 9: Portions of Commuters with Sequential Stacks of Weekly Passes



(a) Same-day Purchase



(b) Preload Purchase

Figure 9a plots the portion of repeated weekly fare commuters that have purchased two weekly passes at the same time. Figure 9b plots the portion of repeated weekly fare commuters that have preloaded a second weekly pass before the first one expires.

To generate testable predictions beyond those implied by the portion of commuters with two weekly passes held on their MetroCards at the same time, we modify equation (1) to use a dummy variable indicating whether repeated weekly fare commuters have sequentially stacked two weekly passes on the same MetroCard as dependent variable. Meanwhile, we use the same set of independent variables including the average median household income, population, number of households, and percent of residents who are unemployed within the buffer of home stations as in Table 11. This approach is based, in part, on the supposition that repeat weekly fare commuters with higher incomes are less constrained and more likely afford to preload a second weekly pass to their cards before the first one expires to avoid the inconvenience of waiting in line to purchase weekly passes during the rush hours or missing a train in station.

Table 9 reports the results. The regressions for purchases of two weekly passes at the same time are reported in Columns (1) - (3), and the regressions for the preloads of a second weekly pass before the first one expires are reported in Columns (4) - (6). The baseline specification in Columns (1) and (4) control for median household income, population, and the number of households within the buffer of residence stations. In line with our expectations, the coefficient of median household income around home stations is positive and statistically significant, suggesting that repeat weekly fare commuters with residence stations in higher-income neighborhoods are more likely to load a second weekly pass at the same time as the first pass or before the first pass expires. Columns (2) and (5) include the percentage of local residents who are unemployed within the buffer of home stations as an additional control variable. The estimated effect of the median household income remains robust after controlling for unemployment rates. Meanwhile, the coefficient of unemployment rate is negative and statistically significant, suggesting that home stations with higher unemployment rates record fewer preloads of a second weekly pass among repeated weekly pass commuters. Our preferred specification in Column (3) builds on the model in Column (2) by adding the number of transit lines that pass through each home station. The effect of the median household income and unemployment rate remain highly similar after considering the size of home stations.

Overall, the findings in Table 9 and Figure 9 confirm that a majority of recurring weekly pass commuters have loaded two weekly passes at the same time across different months and often preload a second weekly pass before the first one expires. If commuters are concerned about losing an unlimited-ride pass, they would only load a new pass after the current one expires. Thus, concerns about losing a monthly pass cannot fully explain the recurring weekly pass sales.

Table 9: Determinants of Sequential Stacks of Weekly Passes

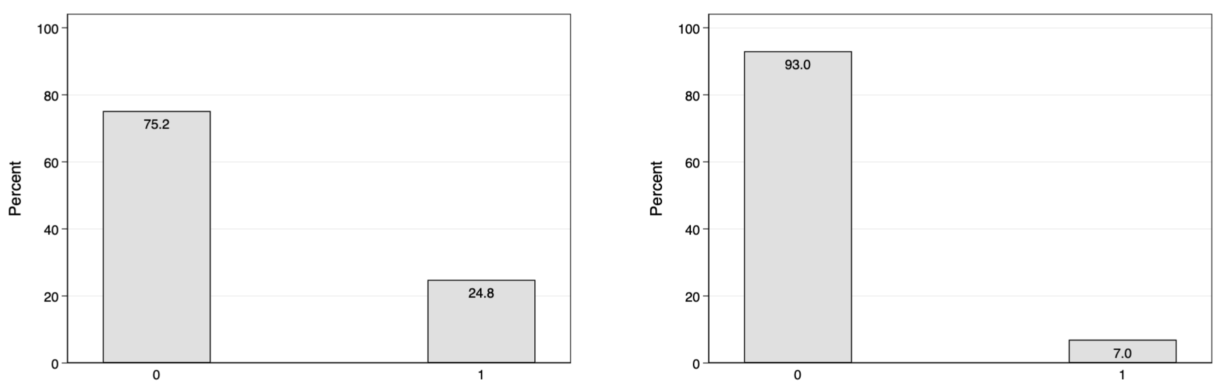
	Same-day Purchases of Two Weekly Passes			Preloads of Weekly Passes		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Income)	0.015**	0.011	0.011	0.092***	0.620***	0.617***
	(3.06)	(1.57)	(1.59)	(4.38)	(19.66)	(19.58)
ln(Population)	0.013	0.012	0.007	-0.568***	-0.333***	-0.251***
	(1.07)	(0.94)	(0.56)	(-10.44)	(-6.02)	(-4.42)
ln(Households)	-0.007	-0.006	-0.002	0.251***	0.012	-0.050
	(-0.71)	(-0.54)	(-0.21)	(5.56)	(0.25)	(-1.05)
Unemployed		-0.048	-0.048		7.654***	7.654***
		(-0.62)	(-0.62)		(22.40)	(22.40)
# of Lines			-0.003			0.060***
Passing through Stations			(-1.53)			(6.22)
Observations	106,639	106,639	106,639	106,639	106,639	106,639
R^2	0.000	0.000	0.000	0.002	0.007	0.007

This table shows the regression results for equation 1. The sample is obtained from the transaction-level recurring weekly pass sales during the period from March 2013 to May 2015. The dependant variable in Columns 1-3 is a dummy variable indicating whether repeated weekly fare commuters have purchased two weekly passes at the same time. The dependant variable in Columns 4-6 is a dummy variable indicating whether repeated weekly fare commuters have preloaded a second weekly pass before the current pass expires. The baseline specification in columns 1 and 4 includes only the average median household income, population, and the number of households within the buffer of home stations. Columns 2 and 5 build on this specification by adding percent of residents who are unemployed within the buffer of home stations as additional control variable. Our preferred specification in Columns 3 and 6 builds on the model in column 2 by adding the number of transit lines that pass through each home station. Robust standard errors in parentheses. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

6.3 Time Inconsistent Preferences

Previous studies suggest that people with lower incomes have higher discount rates (Harrison et al., 2002; Shapiro, 2005). If poorer transit commuters have very high discount rates, they may be better off buying weekly instead of monthly passes. To address this concern, we examine same-day pay-per-ride fare purchases among repeated weekly pass commuters. The unlimited-ride cards are valid from the first use of the card until midnight on the 7th or 30th day. For repeated pass commuters, it is best to first use a new unlimited ride pass as early in the day as possible before taking any rides and use it for all rides in the following seven or thirty days. However, as shown in Figure 10, we find that, after the last seven-day pass expired at midnight the day before, more than 25 percent of repeated weekly pass commuters have bought and used a pay-per-ride ticket for the first trip of the day before purchasing another seven-day fare card later in the same day. These commuters not only pay \$2.75 more for transit fare but also get to effectively use the weekly pass only for 6 days and a few hours. Conversely, only 7 percent of repeated monthly pass commuters have used a pay-per-ride ticket and a thirty-day fare pass on the same day.

Figure 10: Portions of Repeated Pass Commuters with Same-day Pay-per-ride Purchases



(a) Repeated Weekly Pass Commuters

(b) Repeated Monthly Pass Commuters

Figure 10a plots the portion of repeated weekly fare commuters that have purchased and used a pay-per-ride ticket for the first trip of the day before purchasing another seven-day fare card later in the same day. Figure 10b plots the portion of repeated monthly fare commuters that have purchased and used a pay-per-ride ticket for the first trip of the day before purchasing another seven-day fare card later in the same day.

To validate the observations in Figure 10, we run the following regression:

$$\begin{aligned} PPR_i = &\lambda_0 + \lambda_1 Weekly_i + \theta ln(Income_j) + \tau ln(Pop_j) + \gamma HH_j \\ &+ \mu Unemp_j + \delta Line_j + \epsilon_{jt}, \end{aligned} \tag{3}$$

PPR_i is an indicator that equals one if a repeated pass commuter has made same-day pay-per-ride fare purchases and zero otherwise; $Weekly_i$ is an indicator that equals one for repeated weekly pass commuters and zero for recurring monthly pass commuters; $Income_j$ is the average median household income within the buffer of home station j; Pop_j, HH_j, $Unemp_j$ are population, the number of households, and percent of residents who are unemployed within the buffer of home station j, respectively; $Line_j$ is the number of transit lines going through home station j. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station.

The results are reported in Table 10. Column (1) displays the estimated effect of recurring weekly fare sales on same-day pay-per-ride purchases, using median household income, population, and the number of households within the buffer of residence stations as control variables. Consistent with the visual evidence in Figure 10, recurring weekly pass commuters are 17.3 percent more likely to use a pay-per-ride ticket and an unlimited-ride pass on the same day than recurring monthly pass commuters. Meanwhile, the coefficient of $Income$, the median household income within the buffer around home stations, is negative and statistically significant, implying that repeated pass commuters with same-day pay-per-ride fare purchases are more likely to live in low-income neighborhood. Columns (2) and (3) include the percentage of local residents who are unemployed within the buffer of home stations and the number of transit lines that pass through each home station as additional control variables, respectively. The estimated effect of the recurring weekly fare sales and the neighborhood median household income remain highly similar, confirming the robustness of our estimates.

To further evaluate the influence of socioeconomic characteristics on same-day pay-per-ride ticket purchases, we restrict our sample to the recurring weekly pass commuters. Columns (4) - (6) in Table 10 present the results. The estimated coefficient for median household income around home stations

Table 10: Determinants of Same-day Pay-per-ride Purchases for Repeated Pass Commuters

	All Repeated Pass Commuters			Repeated Weekly Pass Commuters		
	(1)	(2)	(3)	(4)	(5)	(6)
Weekly	0.173***	0.172***	0.172***			
	(108.64)	(108.22)	(108.20)			
ln(Income)	-0.036***	-0.026***	-0.027***	-0.052***	-0.044***	-0.044***
	(-13.76)	(-6.88)	(-7.00)	(-11.12)	(-6.24)	(-6.30)
ln(Population)	-0.060***	-0.055***	-0.050***	-0.091***	-0.087***	-0.076***
	(-8.52)	(-7.56)	(-6.54)	(-7.49)	(-7.07)	(-5.95)
ln(Households)	0.059***	0.052***	0.048***	0.088***	0.084***	0.075***
	(9.87)	(8.44)	(7.41)	(8.70)	(8.11)	(7.10)
Unemployed		0.170***	0.172***		0.116	0.117
		(3.53)	(3.58)		(1.53)	(1.53)
# of Lines			0.003*			0.009***
Passing through Stations			(2.33)			(4.01)
Observations	227,162	227,162	227,162	106,639	106,639	106,639
R^2	0.059	0.059	0.059	0.001	0.001	0.001

This table shows the regression results for equation 3. The sample is obtained from the transaction-level recurring weekly and monthly pass sales during the period from March 2013 to May 2015. The dependant variable in Columns 1-3 is an indicator that equals one if a repeated weekly or monthly pass commuter has made same-day pay-per-ride fare purchases and zero otherwise. The dependant variable in Columns 4-6 is an indicator that equals one if a repeated weekly fare commuter has made same-day pay-per-ride fare purchases and zero otherwise. The baseline specification in columns 1 and 4 includes only the average median household income, population, and the number of households within the buffer of home stations. Columns 2 and 5 build on this specification by adding percent of residents who are unemployed within the buffer of home stations as additional control variable. Our preferred specification in Columns 3 and 6 builds on the model in columns 2 and 5 by adding the number of transit lines that pass through each home station. Robust standard errors in parentheses. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

is again negative and statistically significant at 0.1% level, strengthening our finding that repeat weekly pass commuters with same-day pay-per-ride fare purchases are more likely to live in low-income neighborhood.

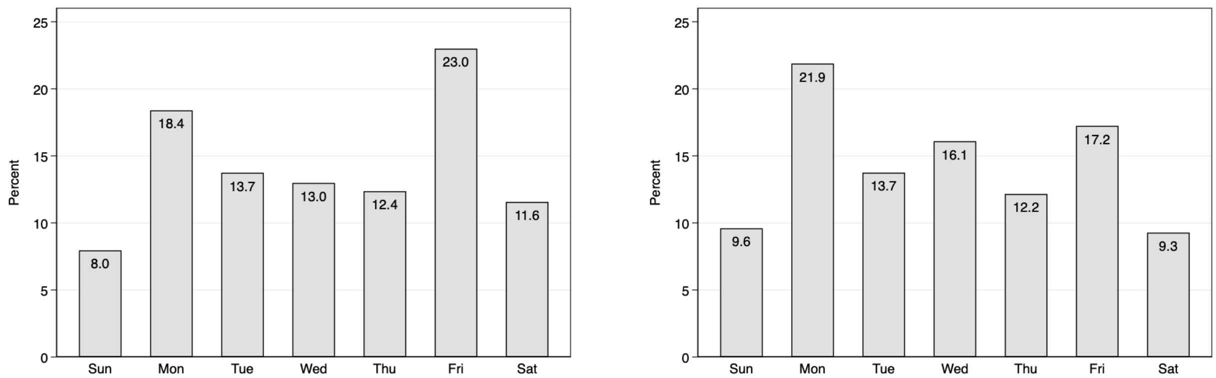
Altogether, the results in Figure 10 and Table 10 imply that many repeat weekly pass commuters purchase and use a pay-per-ride ticket for the first ride in the morning before purchasing another seven-day pass later in the same day. A high discount rate could not explain the prevalence of same-day pay-per-ride purchases among recurring weekly pass commuters as these people pay $2.75 more for transit fare and get to use the weekly pass for a much shorter period of time. Hence, time inconsistency cannot fully account for the observed recurring weekly fare sales.

Meanwhile, these findings are in line with low-income commuters unable to afford high upfront costs of passes. Poorer households usually receive weekly wages. They are likely to run out of money right before the next paycheck arrives and have to purchase and use a pay-per-ride ticket to get to work in the morning of a payday. To support this explanation, we document that higher shares of these same-day pay-per-ride purchases occur on Fridays for repeat weekly pass commuters. As shown in Figure 11a, more than 20 percent of same-day pay-per-ride purchases occur on Fridays. Purchase shares are more evenly distributed for repeated monthly pass commuters. We see little evidence of significant increases of same-day pay-per-ride purchases on Fridays. This finding offers further evidence on how constrained consumers may not be able to purchase even weekly passes in some periods.

6.4 Job Instability

Transit riders with unstable or seasonal jobs may opt for weekly passes because they do not take enough rides to justify the purchase of a monthly unlimited pass. These jobs are marked with high job turnover and frequent periods of joblessness (Kalleberg, 2018; Keith-Jennings and Chaudhry, 2018; Walther, 2019). Indeed, we observe a considerate number of irregular weekly pass riders in our data. These riders purchase and use weekly passes for a few weeks, have a gap of at least one or two weeks with no transit rides or only sporadic pay-per-ride trips, and then resume the purchase and use of weekly passes for some weeks. Higher portions of irregular weekly fare sales are registered at subway stations

Figure 11: Heterogeneity of Same-day Pay-per-ride Purchases for Repeated Pass Commuters



(a) Repeated Weekly Pass Commuters

(b) Repeated Monthly Pass Commuters

Figure 11a shows the purchase share of same-day pay-per-ride tickets for repeated weekly pass commuters on each day of the week. Figure 11b shows the purchase share of same-day pay-per-ride tickets for repeated monthly pass commuters on each day of the week.

located in low-income neighborhoods than in more affluent neighborhoods. These purchase patterns are consistent with job instability and frequent periods of joblessness. However, because we exclude cards with irregular weekly pass purchases and focus on cards for more than 11 months of consecutive weekly pass purchases, job instability is unlikely to explain our findings. In addition, as we show in Section 5, job insecurity could not explain the significant increase in weekly pass purchases and downgrading of commuters from monthly to weekly passes after the fare changes in December 2010 and March 2013.

7 Economic Costs of Repeat Weekly Passes

To understand the economic magnitude of our results, we conduct back-of-the-envelope calculations to estimate the total costs of recurring weekly fare purchases for transit commuters. During our sample period, a monthly (30-day) pass cost $112 and a weekly (7-day) pass cost $30, recurring weekly pass commuters spent $20 more each month on transit fare than they would have with monthly passes while receiving the same level and quality of transit services. With 100,000 repeated weekly fare commuters on average each month, this translates to commuters, especially low-income ones, paying an extra

$24 million for transit fares on an annual basis, a substantial overpayment. Regular MetroCards are thin plastic cards and are not personalized nor registered to a single user. If a MetroCard is lost or damaged and discarded by a rider, this card will vanish from the data set. Thus, when we relax the time requirement to include MetroCards that have recurring weekly fare sales of nine months or more and then disappear from the data set, the number of repeated weekly pass commuters increase to more than 180,000. Using the same methodology as above, our estimates imply that these commuters pay an extra $43 million a year for transit costs. When we further relax the time requirement to include MetroCards that have recurring weekly fare sales of six months or more and then disappear from the data set, the number of repeated weekly pass commuters increase to more than 220,000. Using the same methodology as above, our estimates imply that these commuters pay an extra $52 million per year in transit costs.

In 2013, each seven-day unlimited ride MetroCard cost $30 and the minimum wage in New York City was only $8.75 per hour. A transit dependent family of four with two working parents earning the minimum wage spends 5 to 10 percent more of their after-tax and after-rent income on recurring weekly transit fares than they would have on monthly passes. This substantial portion of income could have been used for other necessities such as food and medical care or saved for important long-term investment in areas like education and childcare.

8 Discussions and Conclusions

Using details of transit card data in New York City during the period 2013-2015, we identify a large number of repeated weekly pass commuters who purchase a 7-day unlimited-ride pass every week and continue this purchase pattern for more than 11 months. From March 2013 to May 2015, a monthly (30-day) pass costs $112 and a weekly (7-day) pass costs $30. As such, recurring weekly pass commuters spend 15 percent ($20) more each month on transit fare than they would have with monthly passes while receiving the same level and quality of transit services. With 100,000 repeated weekly fare commuters on average each month, this translates to commuters, especially low-income ones, paying an extra $24 million for transit fares on an annual basis, a substantial overpayment.

We use fare increases in 2010 and 2013 to provide evidence that recurring weekly pass purchases are likely to come from financially constrained commuters. Low-income commuters may be unable to spend a large amount at one time for a monthly fare, opting instead to buy weekly fares that are cheaper in the short-term but much costlier in the long-term. With the help of transaction-level data, we identify the most preferred subway station near each commuter's residence (i.e., home or residence stations) according to individual commuting regularity. Home stations of repeated weekly pass commuters are predominately in low-income neighborhoods. Besides, recurring weekly fare sales mainly came from cash or debit card payments. Small, frequent transactions in low-income areas with non-credit payments are consistent with financial constraints.

We provide empirical evidence on four potential alternative explanations: discrepancies in awareness, job insecurity, the prospective of losing a monthly pass, and time inconsistency. Weekly- and monthly- unlimited ride passes are two default choices next to each other on TouchScreen of MetroCard vending machines. As such, the observed recurring weekly fare sales are not likely driven primarily by discrepancies in awareness of the availability of monthly passes. Meanwhile, recurring weekly pass riders in the data set have consecutive purchases of weekly cards for more than 11 months, showing little signs of job instability or frequent out-of-work periods. In addition, most recurring weekly pass commuters have preloads of a second weekly pass before the first one expires. If commuters are concerned about losing an unlimited-ride pass, they would only load a new pass after the current one expires. Thus, concerns about losing a monthly pass are not likely fully explain the recurring weekly pass sales.

Given the economic costs and populations involved in repeat purchases of weekly passes, our results are directly relevant for ongoing policy debates about the equity impacts of fare structures in public transit system. In the past few decades, policy makers and researchers have advocated the importance of public transport as crucial to escaping poverty. As many low-income people have no access to personal vehicles, they rely on public transit to find and commute to higher-paying jobs that would help them accumulate wealth and escape poverty.

Our findings shed light on public transit fare structures. Public transit authorities in many cities offer a daily and/or weekly fare cap to frequent riders. For instance, with the public transit system in London, a rider can ride free for the rest of the week after reaching the equivalent weekly pass fare using the same device or bank card in a calendar week. A daily or weekly fare may not help low-income riders as many of them are already recurring weekly pass commuters. Instead, low-income riders will benefit significantly from a monthly fare capping program. This feature effectively gives riders the discounted prices available to monthly pass holders without the upfront cost of a pass. Meanwhile, studies suggest that poverty-related concerns consume mental resources, leaving less for other tasks (Mani et al., 2013). With a monthly fare cap, low-income riders no longer have to worry about overpayment for transit fares, saving them mental resources for other more important tasks such as education and job training.

Another possible way to address fare equity concerns is to offer reduced fares to vulnerable commuters. Actually, many transit agencies around the world have offered fare subsidies to low-income riders (Tranjan, 2016; Darling et al., 2021). For instance, through the fair fare program, the MTA provides half-priced weekly and monthly passes for working-age New York City residents earning at or below the federal poverty line (which is $13,590 for a single-person household). However, such a fare subsidy program struggles to reach its full potential. As shown in Figure 3, many repeated weekly pass riders live in neighborhoods with median household income of 200 or 300 percent of the federal poverty measure. They may not maintain an income low enough to qualify for the fair fare program.

Meanwhile, the reduced fare programs for low-income commuters come at a considerable cost, both fiscal and in terms of economic efficiency, and may not be sustainable. Even before the COVID pandemic, transit ridership has dropped significantly and steadily for years in many big cities around the world, such as London, Chicago, and Toronto (Economist, 2018). For example, transit ridership in Los Angeles plunged over 40 percent from 2013 to 2019. With ridership declines and transit revenue shortfalls, there have been more disruptions and reductions in public transit services. The pandemic has exacerbated the issue with a shift to telework. As fare revenue covers on average 40% of transit agencies' operating costs, a sustained or expanded reduced fare program for working-age low-income riders may enlarge budget deficits and spiral into service cuts. Polls of low-income transit riders suggest they would prefer more frequent and reliable service to reduced fares (Transit Center, 2019). Nonetheless, participants of the fare subsidy programs will benefit substantially from a monthly fare capping program, which gives commuters the same discounted prices without the upfront cost of a pass.

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Appendix

Table 11: Determinants of Home Stations for Repeat Pass Commuters

	Weekly Pass Commuter			Monthly Pass Commuter		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Income)	-108.3***	-260.4***	-267.6***	653.7***	117.4	114.7
	(-6.43)	(-11.62)	(-11.94)	(10.00)	(1.33)	(1.30)
ln(Population)	662.3***	633.3***	664.0***	-130.7	-430.1*	-251.0
	(13.84)	(13.42)	(13.97)	(-0.74)	(-2.43)	(-1.35)
ln(Households)	-332.4***	-280.2***	-306.6***	865.3***	1,205.5***	1,046.5***
	(-8.59)	(-7.29)	(-7.91)	(5.98)	(8.23)	(6.71)
Unemployed		-2,524.2***	-2,527.1***		-9,062.3***	-8,842.5***
		(-10.08)	(-10.13)		(-8.74)	(-8.52)
# of Lines			31.10***			83.36**
Passing through Stations			(4.49)			(2.92)
Observations	3,056	3,056	3,056	1,479	1,479	1,479
R^2	0.152	0.179	0.185	0.289	0.324	0.328

This table shows the regression results for equation 1. The sample is obtained from the transaction-level MetroCard purchase and swipe data during the period from March 2013 to May 2015. We identify the station near each repeated weekly or monthly pass commuter's residence (i.e., the residence or home station) according to individual commuting regularity and collapse the data to create a panel at the station-month level for the outcomes in columns 1-6. The dependant variable in Columns 1-3 is the natural logarithm of the number of repeated weekly pass commuters with station j as residence station in month t. The dependant variable in Columns 4-6 is the natural logarithm of the number of repeated weekly pass commuters with station j as residence station in month t. The baseline specification in columns 1 and 4 includes only the average median household income, population, and the number of households within the buffer of home stations. Columns 2 and 5 build on this specification by adding percent of residents who are unemployed within the buffer of home stations as additional control variable. Our preferred specification in Columns 3 and 6 builds on the model in column 2 by adding the number of transit lines that pass through each home station. Robust standard errors in parentheses. We cluster standard errors at the station level, allowing for arbitrary correlation in error terms over time for a given home station. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table 12: Comparison of Costs of Pay-per-ride versus 7-day Pass

Rides	Jun 28, 2009 to Dec 29, 2010 15% bonus for every $8		Dec 30, 2010 to Mar 2, 2013 7% bonus for every $10		Mar 3, 2013 to Mar 21, 2015 5% bonus for every $5		Mar 22, 2015 to Mar 18, 2017 11% bonus for every $5.5	
	(1) PPR	(2) Weekly Pass	(3) PPR	(4) Weekly Pass	(5) PPR	(6) Weekly Pass	(7) PPR	(8) Weekly Pass
1	2.25	27	2.25	29	2.5	30	2.75	31
2	2.25	13.5	2.25	14.5	2.38	15	2.48	15.5
3	2.25	9	2.25	9.67	2.38	10	2.48	10.33
4	1.96	6.75	2.25	7.25	2.38	7.5	2.48	7.75
5	1.96	5.4	2.10	5.8	2.38	6	2.48	6.2
...	...	...	...	...				
11	1.96	2.45	2.10	2.64	2.38	2.73	2.48	2.82
12	1.96	2.25	2.10	2.42	2.38	2.5	2.48	2.58
13	1.96	2.07	2.10	2.23	2.38	2.31	2.48	2.38
14	1.96	1.93	2.10	2.07	2.38	2.14	2.48	2.21

Notes: Table 12 compares the cost of per trip using pay-per-ride versus 7-day-unlimited cards. The red oval circles mark the threshold number of trips needed to switch from pay-per-ride to 30-day-unlimited before versus after the new card fee was implemented.

Table 13: Comparison of Costs of Pay-per-ride versus 30-day Pass

Rides	Jun 28, 2009 to Dec 29, 2010 15% bonus for every $8		Dec 30, 2010 to Mar 2, 2013 7% bonus for every $10		Mar 3, 2013 to Mar 21, 2015 5% bonus for every $5		Mar 22, 2015 to Mar 18, 2017 11% bonus for every $5.5	
	(1) PPR	(2) Monthly Pass	(3) PPR	(4) Monthly Pass	(5) PPR	(6) Monthly Pass	(7) PPR	(8) Monthly Pass
1	2.25	89	2.25	104	2.5	112	2.75	116.5
2	2.25	44.5	2.25	52	2.38	56	2.48	58.25
3	2.25	29.67	2.25	34.67	2.38	37.33	2.48	38.83
4	1.96	22.25	2.25	26	2.38	28	2.48	29.13
5	1.96	17.8	2.10	20.8	2.38	22.4	2.48	23.3
...	...	...	...	...				
45	1.96	1.98	2.10	2.31	2.38	2.49	2.48	2.59
46	1.96	1.93	2.10	2.26	2.38	2.43	2.48	2.53
47	1.96	1.89	2.10	2.21	2.38	2.38	2.48	2.48
48	1.96	1.85	2.10	2.17	2.38	2.33	2.48	2.43
49	1.96	1.82	2.10	2.12	2.38	2.29	2.48	2.38
50	1.96	1.78	2.10	2.08	2.38	2.24	2.48	2.33

Notes: Table 13 compares the cost of per trip using pay-per-ride versus 30-day-unlimited cards. The red oval circles mark the threshold number of trips needed to switch from pay-per-ride to 30-day-unlimited before versus after the new card fee was implemented.

Figure 12: Screen Snapshot on Vending Machine When Purchasing Unlimited-ride Passes

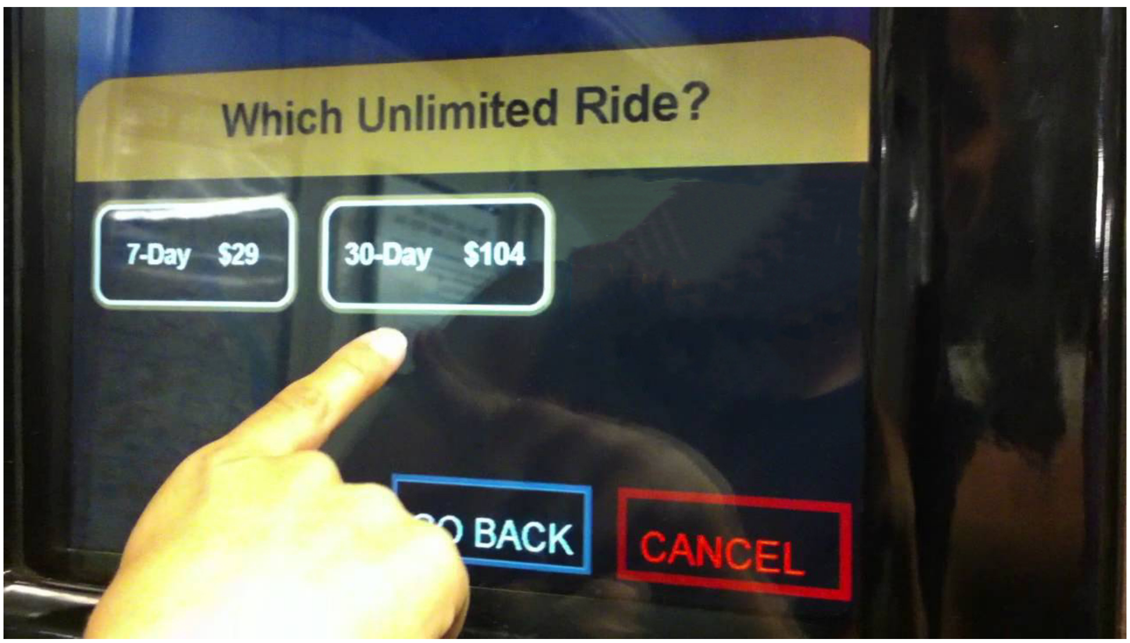

Figure 12 shows the screen snapshot of the MetroCard vending machines when purchasing a weekly or monthly pass.