Public transport vouchers to enhance ridership: addressing mental accounting bias in frequent public transport users

Santiago Gómez Cardona (santiago.gomez@maastrichtuniversity.nl) (corresponding autor)

University College Maastricht, Faculty of Science and Engineering, Maastricht University, Maastricht, Netherlands.
ORCID number: 0000-0001-7073-3128

Luis Angel Guzmán García (la.guzman@uniandes.edu.co)

Departamento de Ingeniería Civil y Ambiental, Grupo de Sostenibilidad Urbana y Regional, SUR, Universidad de los Andes, Bogotá, Colombia
ORCID number: 0000-0002-6487-7579

Jorge Luis Ochoa Rincón (jl.ochoa@uniandes.edu.co)

Departamento de Ingeniería Civil y Ambiental, Grupo de Sostenibilidad Urbana y Regional, SUR, Universidad de los Andes, Bogotá, Colombia

ABSTRACT

The extensive adoption of intelligent travel cards has significantly enhanced the flexibility of pricing mechanisms in public transport. The incorporation of this technology has streamlined the process of targeting subsidies toward the most vulnerable commuters. In this study, we analyze the impact of a monthly voucher, which is loaded onto the travel cards of frequent users, on the utilization of public transport services. A controlled field experiment was conducted within the Integrated Public Transport System in Bogotá, Colombia, encompassing a participant pool of 1,607 individuals. We present empirical evidence of the presence of Mental Accounting Bias within the context of transport voucher utilization. Specifically, we show that individuals who received the transport voucher increased their usage of public transport, subsequently leading to a higher ridership rate. This use increment can be attributed not solely to the added income resulting from the voucher's value but also to a response generated by a perceived increase of the available transport budget. This phenomenon underscores the prevalence of mental accounting bias among the participants. To demonstrate the presence of this cognitive bias, our research employs three distinct methodological approaches, each leveraging different sets of evidence collected during the experiment. This paper is the first empirical exploration of the Mental Accounting Bias within the domain of public transport. The potential for inducing Mental Accounting Bias through transport vouchers can be crucial for policies aimed at increasing public transport ridership.

Keywords: public transport, transport voucher, mental account bias, demand subsidies; Bogotá

Public transport vouchers to enhance ridership: addressing mental accounting bias in frequent public transport users

ABSTRACT

The extensive adoption of intelligent travel cards has significantly enhanced the flexibility of pricing mechanisms in public transport. The incorporation of this technology has streamlined the process of targeting subsidies toward the most vulnerable commuters. In this study, we analyze the impact of a monthly voucher, which is loaded onto the travel cards of frequent users, on the utilization of public transport services. A controlled field experiment was conducted within the Integrated Public Transport System in Bogotá, Colombia, encompassing a participant pool of 1,607 individuals. We present empirical evidence of the presence of Mental Accounting Bias within the context of transport voucher utilization. Specifically, we show that individuals who received the transport voucher increased their usage of public transport, subsequently leading to a higher ridership rate. This use increment can be attributed not solely to the added income resulting from the voucher's value but also to a response generated by a perceived increase of the available transport budget. This phenomenon underscores the prevalence of mental accounting bias among the participants. To demonstrate the presence of this cognitive bias, our research employs three distinct methodological approaches, each leveraging different sets of evidence collected during the experiment. This paper is the first empirical exploration of the Mental Accounting Bias within the domain of public transport. The potential for inducing Mental Accounting Bias through transport vouchers can be crucial for policies aimed at increasing public transport ridership.

Keywords: public transport, transport voucher, mental account bias, demand subsidies; Bogotá

1. INTRODUCTION

Despite the many benefits of public transport usage and its role in improving the quality of life (Hybel and Mulalic, 2022), many people still choose to use other less sustainable transport modes. In contexts like Latin America, one reason for this is the lack of affordability of public transport for a large part of the population combined with poor level of service. The financial burden of transport expenditure for the poorest exceeds 25% of their income in half of the cities in the region (Falavigna and Hernandez, 2016; Rivas et al., 2018). This can be a strong factor explaining the lack of access to vulnerable social groups (Guzman et al., 2018), who also tend to be less mobile than wealthier groups and often live in peripheral zones (Tiznado-Aitken et al., 2023). This reduces the potential of public transport as a provider of accessibility across the income spectrum: low-income households do not use it enough, due to access costs and higher-income groups reduce its usage privileging other less sustainable transport modes. In this scenario, subsidies to public transport are the main instrument used to increase ridership and improve public transport attractivity. Cities across Latin America have implemented several types of subsidies, whether supply-side or demand-side subsidies, using different targeting mechanisms.

However, public transport subsidies do not always have the desired effects. Depending on the context, subsidies can be regressive, as is the case in Los Angeles (Iseki and Taylor, 2010), lose their effectiveness in terms of public transport usage (Guzman and Hessel, 2022), or not effective as a redistributive policy (Börjesson et al., 2020). Therefore, how these subsidies are targeted or delivered can be a determining factor in their effectiveness. The existing evidence in the integrated public transport system (SITP in Spanish) of Bogotá, Colombia, demonstrated that the effect of the pro-poor subsidy scheme has been decreasing over time until it becomes ineffective (Guzman and Hessel, 2022). The current subsidy mechanism consists of a 28% fare reduction per trip for a maximum of 30 trips per month. We tested a new way of delivering targeted subsidies to incentivize SITP use through a large-scale randomized controlled field experiment. This alternative way to deliver the targeted subsidy was a monthly cash transfer to users' personalized travel cards, which works as a transport voucher. These subsidies proved effective, boosting ridership expenditures by +7.7% compared to the control group.

In this paper, we demonstrate that this subsidy delivery method leverages the users' cognitive biases nudging them to increase their weekly trips by using the transport voucher more than should be expected. When users receive the voucher on their travel cards, they engage with SITP more frequently than they would if the money were not designated for that specific purpose. In particular, the voucher triggers a cognitive bias known as Mental Accounting Bias. Transferring cash directly to the travel cards increases the public transport mental spending account, thereby stimulating greater spending (in terms of usage) on the SITP.

This paper addressed the need to provide evidence on the non-fully rational behavior of public transport users. Specifically, it shows how behavioral traits can produce a deviation from classical consumer behavior in the population aggregate, thereby becoming potential targets of policy interventions. The current literature has posed the question of the potential impact of behavioral traits, in general, and of Mental Accounting Bias (MAB henceforth), in specific (Garcia-Sierra et al., 2015; Metcalfe and Dolan, 2012). This research adds to the evidence on behavioral traits, in general, and is the first to provide empirical support for the relevance of MAB in public transport behavior and policy pricing design. Drawing on the principles of MAB theory, this paper demonstrates for participants engaged in the experiment: i) Public transport expenses are larger when financed through transport vouchers in comparison to the utilization of travelers' funds; ii) The additional expenditure on public transport surpasses what it would be if the voucher were uniquely perceived as an increase of income; and iii) The allocation of a grocery voucher does not exert any discernible influence on public transport expenditures[1]. In the absence of MAB, the latter outcome would theoretically not hold, as the impact of a grocery voucher should be equal to that of a transport voucher. This empirical evidence validates the applicability of the MAB theory within this specific context, thereby establishing a foundation for the formulation of public policies rooted in cognitive biases.

[1] Participants in the control group were given a grocery voucher for having participated throughout the experiment.

2. MENTAL ACCOUNT BIAS: BACKGROUND AND DEFINITIONS

Over the past few decades, research in the field of behavioral economics has extensively documented systematic deviations from the principles of standard consumer behavior theory (Thaler, 2018). According to this theory, the issuance of a voucher should be equivalent to an increment in income (Bradford and Shaviro, 1999). Stated in a transport-related context, the increase in the number of trips taken by a commuter, consequent to receiving an income increase, should be comparable to the increase observed when they receive cash loaded onto their travel card. Nevertheless, commuters do not consistently behave themselves as standard economic agents, due to cognitive biases that have been extensively observed across diverse scenarios. One such deviation is Mental Account Bias, described originally by Thaler (1985).

2.1 A mental accounting bias definition

The Mental Accounting Bias (MAB) encompasses a wide array of behaviors explicable through the notion that consumers allocate their expenses across distinct mental ‘accounts’ (Thaler, 2008, 1999, 1985). The creation of these categorical budget divisions simplifies spending decisions, yet overlooks the interchangeable nature of money (i.e., money fungibility), consequently resulting in inefficiencies (Thaler, 1999; Zhang and Sussman, 2018). Such inefficiencies manifest when decisions arise concerning goods or services that belong to different mental accounts, frequently culminating in excessive consumption of certain items. A typical illustration of MAB arises when consumers receive a voucher to utilize in a store they frequently patronize. A rational approach involves spending the voucher for usual purchases, thereby liberating funds for a desirable or more profitable use. Hence, the value of the voucher isn’t confined to the store’s product assortment but is essentially incorporated into the consumer’s general budget. This implies that the utilization of the voucher should be the same if an equivalent value were given in cash.

In the context of MAB, vouchers are used for additional consumption that surpasses usual purchases. In such instances, consumers exhibit behavior as if the voucher's value will be an increase to the budget specific for that store, rather than an increase in their total expenditure budget. As a standard economic agent, the voucher should be used for regular purchases, and personal funds can be reserved for alternate purposes, obviating the

necessity to restrict expenditures to the store. Consequently, the exclusive utilization of the voucher for additional in-store consumption is categorized as a cognitive bias.

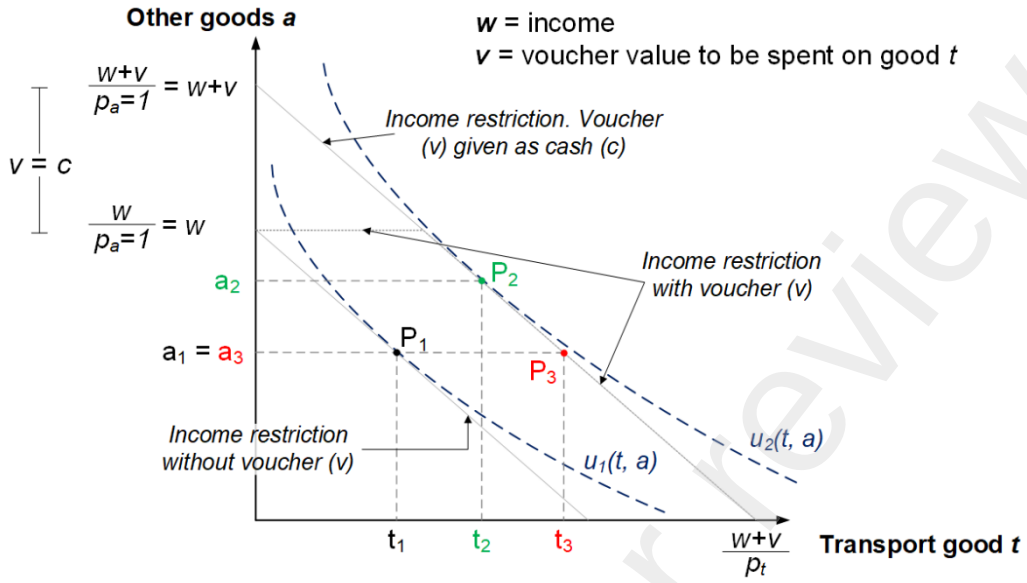
A substantial body of literature addresses the phenomenon of MAB. While the present paper centers its focus on MAB as it emerges from the utilization of transport vouchers, it is important to note that MAB holds implications across multiple domains. To get a recent review of the subject, interested readers are directed to the analysis by Zhang and Sussman (2018). Numerous studies have effectively illustrated the effects of MAB through controlled laboratory experiments. By subjecting participants to precisely structured choice scenarios within a controlled environment, researchers have been able to discern variations in behavior resulting from the introduction of distinct procedures, thereby facilitating bias identification (Cherry, 2001). Moreover, compelling evidence highlights that the impacts of MAB are discernible in the typical behavior of consumers in diverse contexts. This observation suggests that MAB carries tangible real-world consequences extending beyond controlled experimental environments. Milkman and Beshears (2009) present evidence derived from the employment of a grocery voucher, whose findings align with those of the present study. Particularly noteworthy is the extensive investigation concerning the US Food Stamp Program (Hastings and Shapiro, 2018), fuel consumption dynamics (Hastings and Shapiro, 2013), and tax rebates (Feldman, 2010). These empirical studies demonstrate that, within their specific contexts, the receipt of a voucher or analogous instruments encourages increased consumption of associated goods and services. This increased consumption is larger than expected, deviating from consumers' usual behavior. Importantly, in all the cited cases, the presence of MAB biased consumer choices, as its absence would lead individuals to select an alternate bundle of goods and services more aligned with their preferences.

There is a lack of research concerning the role of MAB in the field of public transport. Previous scholarly references accentuate the potential for MAB to induce inequitable comparisons between variable costs associated with private and public transport (Garcia-Sierra et al., 2015; Metcalfe and Dolan, 2012). It is noteworthy that these assertions are grounded in evidence from domains other than transport, and lack direct empirical justification within this sector. To the best of our knowledge, there is an absence of discussion regarding the potential utility of transport vouchers, harnessed through the lens of MAB, as a valuable instrument for shaping transport policy frameworks.

2.2. A simple model of mental accounts

Before discussing the methods employed to detect MAB in our case study, it is imperative to introduce a formalized representation of MAB within the framework of optimal consumer behavior. This formalization assumes that transport serves as another commodity within the consumption basket, as depicted in Figure 1. MAB, in this context, can be interpreted as the consumer's selection of a goods basket that fails to maximize utility. To comprehend MAB and its associated implications, we adopt the structured framework proposed by Farhi and Gabaix (2020). This framework entails a modification of the classical consumer problem of determining optimal quantities of goods to maximize their utility.

This approach starts with the classical problem of utility maximization. A consumer with a budget of w faces price p_t for good t, and price p_a for good a. There is a Cobb-Douglas parametrization of the consumer's utility function ($u(a,t)=a^{\alpha}\cdot t^{\gamma}$, with $\alpha+\gamma=1$), and the standard income restriction ($p_a \cdot a + p_t \cdot t \leq w$), Farhi and Gabaix (2020) introduce a parameter $\beta \in [0, 1-\gamma]$ that characterizes the level of MAB. The consumption choice under MAB results from biased utility maximization (see Appendix 1. Supplentary Materials for further details). Figure 1 provides a graphical representation of the problem, showing the optimal solutions that maximize utility and the suboptimal choice under the influence of MAB.



The price of other goods (*a*) is standardized to one (1). This implies that income can be directly read out of the Y-axis.

Figure 1. Utility maximization under MAB

Given the conditions defined in Figure 1, the consumer chooses quantities of the goods that maximize their utility. This is represented by the point P_1. Note that this is the highest reachable utility under the budgetary restriction, i.e., the point where the budget line is tangent to the highest reachable utility function (u_1). This is a standard result in consumer theory. Due to the Cobb-Douglas utility function, the consumer spends a fixed proportion of their income on each good, a proportion γ for good *t*, and a proportion α for good *a*. This is equivalent to:

$$t_1 = \frac{\gamma \cdot w}{p_t},\ a_1 = \frac{\alpha \cdot w}{p_a} \quad (1)$$

In this context, we present two distinct categories of monetary transfers. The initial category involves a cash transfer denoted as *c*, which is assumed to lack the capacity to induce MAB behavior. Thus, it is classified as a non-MAB-inducing transfer. The following category encompasses a voucher labeled as *v*, and it is posited to induce MAB behavior, thereby qualifying as an MAB-inducing transfer.

2.2.1 Choice with a non-MAB-inducing transfer

Firstly, let us first analyze the non-MAB-inducing transfer. Upon the implementation of a cash transfer with a value denoted as *c*, the income restriction changes, leading to an increment by the value equivalent to the cash transfer. It now takes the form $p_a \cdot a + p_t \cdot t \leq w+c$. The optimal quantities can be promptly obtained through the revision of Eq. (1) considering the updated budget now available ($w+c$):

$$t_2 = \frac{\gamma \cdot (w+c)}{p_t},\ a_2 = \frac{\alpha \cdot (w+c)}{p_a} \tag{2}$$

In Figure 1, the revised income restriction is illustrated by a dashed gray line, while the newly updated choice is denoted as point P_2. With the increase of the available budget, the consumer can achieve a higher utility curve that was previously unreachable in the absence of the cash transfer (the voucher).

2.2.2 Choice with a MAB-inducing transfer

Next, let us examine a scenario involving a transfer that induces MAB. Introducing a voucher valued at *v*, the income restriction is changed, shifting it from *w* to $w+v$. Consequently, a new basket with higher quantities of goods can be chosen. The income constraint constraint is altered with the inclusion of voucher *v* with the same monetary value as cash *c* (see Figure 1). Within this revised context, the optimal choice of basket remains in P_2. As observed before (Eq. 2), the precise values can be determined by adjusting the available budget by adding the voucher's value:

$$t_2 = \frac{\gamma \cdot (w+v)}{p_t},\ a_2 = \frac{\alpha \cdot (w+v)}{p_a} \tag{3}$$

If a consumer chooses P_2 in this scenario, their utility is maximized. It is crucial to observe that, in this instance, the consumer would allocate a portion of the voucher towards additional goods *t*. Nonetheless, this income increase would equate to receiving a cash transfer of equivalent value, as demonstrated by Eq. (3) and Eq. (2), which are essentially the same.

However, the selection under MAB will be different. It implies an overconsumption of the good linked with the voucher (good *t*) and an underconsumption of the alternative one (good

a). This circumstance is illustrated in Figure 1 as denoted by point P_3. In this scenario, the consumer solely increases the consumption of good *t* while maintaining the level of consumption of good *a* unchanged from before the delivery of the voucher. The choice exemplified in basket P_3 is defined according to the framework of Farhi and Gabaix (2020) (see Supplementary Material (Model extension) for more details):

$$t_3 = \frac{\gamma \cdot (w + c) + \beta \cdot v}{p_t},\ a_3 = \frac{\alpha \cdot (w + v) - \beta \cdot v}{p_a} \quad (4)$$

Note that if $\beta=0$, then Eq. (4) reduces to Eq. (3). In this case, there is no MAB bias. If $\beta=1-\gamma$, the maximum possible is reached, then Eq. (4) transforms to[2]:

$$t_3 = \frac{\gamma \cdot w + v}{p_t},\ a_3 = \frac{\alpha \cdot w}{p_a} \quad (5)$$

This is the scenario outlined in point P_3. When the MAB is at its maximum, the consumer utilizes the complete value of the voucher to acquire additional units of the good *t*. Since the voucher is designated specifically for use with the good *t*, consumers treat it as a dedicated budget for that particular good. This corresponds to an adjustment of $\gamma \cdot w$, the pre-voucher budget for good *t*, by adding the value of the voucher, thereby resulting in $\gamma \cdot w + v$. In other words, the consumer establishes a new budget intended for the good *t* and conducts themselves accordingly. Note that the consumer disregards the opportunity to allocate a portion of the transferred resources to enhance the consumption of good *a*.

The intermediate values are admissible within this conceptual framework. This situation arises when $0 < \beta < 1-\gamma$, representing scenarios in which the consumer does not spend the complete value of the voucher for the good *t*. Nevertheless, they still consume a greater amount of transport (trips, good *t*) and a lesser quantity of the alternative good *a* than would be considered optimal. This is shown in Eq. (6) but it is not shown in Figure 1:

[2] Note that $(w+c)+(1-\gamma)\cdot v = \gamma \cdot w+\gamma \cdot v+v-\gamma \cdot v = \gamma \cdot w+v$. And that $\alpha \cdot (w+v)-(1-\gamma)\cdot v = \alpha \cdot w+\alpha \cdot v-v+\gamma \cdot v = \alpha \cdot w+(\alpha+\gamma)\cdot v-v = \alpha \cdot w$; with the last step due to the fact that in a Cobb-Douglas utility is $\alpha+\gamma=1$.

$$t_{3b} > t_2 = \frac{\gamma \cdot (w+v)}{p_t},\ a_{3b} < a_2 = \frac{\alpha \cdot (w+v)}{p_a} \quad (6)$$

2.2.3 Marginal propensities to consume

A valuable method for representing the changes between a cash transfer that does not induce MAB and one that does induce MAB is by considering the concept of Marginal Propensities to Consume (MPC). These propensities are defined as the proportion of money spent on goods relative to the value of the transferred resources, specifically referring to the latest income received. This last income is either cash or a voucher. In this paper, our exclusive focus is on the consumption of transport good *t*. Determining this MPC is straightforward, as it corresponds mathematically to the derivative of transport goods' costs. For the cash transfer, the cost function is expressed as follows:

$$t_2 \cdot p_t = \gamma \cdot (w+c) \quad (7)$$

And the corresponding marginal propensity to consume from the cash transfer is:

$$MPC_c = \partial \frac{t_2 \cdot p_t}{\partial c} = \partial \frac{\gamma \cdot (w+c)}{\partial c} = \gamma \quad (8)$$

For the voucher, the cost function is:

$$t_3 \cdot p_t = \gamma \cdot (w+v) + \beta \cdot v \quad (9)$$

And the corresponding marginal propensity to consume from the voucher is:

$$MPC_v = \partial \frac{t_3 \cdot p_t}{\partial v} = \partial \frac{\gamma \cdot (w+v) + \beta \cdot v}{\partial v} = \gamma + \beta \quad (10)$$

The fact that the β terms define the level of MAB can be readily seen in the difference between both marginal propensities to consume (MPC_v *and* MPC_c). When $\beta=0$, there is no MAB, and both marginal propensities are the same $MPC_v = MPC_c = \gamma$. When $\beta > 0$, there is MAB, and MPC_v is larger than MPC_c, $MPC_v > MPC_c$.

2.2.4 Restriction condition for the equality of cash and voucher

The preceding discussion on MAB-induced transfers applies in all instances in which the voucher's value is sufficiently low to enable the attainment of the optimal basket. This is delineated in Figure 1, where the optimal basket (P_2) is situated along the descending

segment of the income constraint, which includes the voucher (v). This situation is possible as the voucher's value is either equal or less than the cost of the optimal quantity of the good to which it is attached:

$$v \leq t_2 = \frac{\gamma \cdot (w + v)}{p_t} \tag{11}$$

Consequently, any voucher whose value falls short of or is equal to the expenditure incurred on goods before the voucher's introduction will also fulfill this criterion.

$$v \leq t_1 = \frac{\gamma \cdot w}{p_t} < t_2 = \frac{\gamma \cdot (w + v)}{p_t} \tag{12}$$

This holds particularly true for vouchers in this case, as their values are lower than the monthly expenses borne by the participants in the experiment.

3. CASE STUDY AND INTERVENTION DESIGN

From a public transport policy perspective, the presence of cognitive bias could be a useful tool to improve public transport attractiveness and increase ridership. Thus, we present a brief description of the case study and the design of our field-controlled experiment.

3.1 The Bogotá's SITP

Bogotá has one of Latin America's most extensive public transport systems, with more than 3.85 million daily trips. The current system relies on a BRT system with dedicated lanes and stations, that constitute the backbone component of the system. Additionally, regular buses share road space with traffic, and recently, the first line of a cable car system has been operating since late 2018 (Guzman et al., 2023). These subsystems compose the Integrated Public Transport System of Bogotá (SITP) which is the most common motorized transport mode for the lower and middle-income level Bogotá inhabitants.

Currently, the SITP works with a flat fare, corresponding to 2,950 Colombian pesos (COP), approximately 0.65 USD for the BRT component, and 2,750 COP (0.61 USD) for the regular bus component. The SITP exclusively works with a travel card that allows the use of all services without having to pay for separate tickets. This travel card is named *tullave plus*. There are two card types: personalized and anonymous. Users must charge their cards with

money, as available credit to be spent in the SITP. For every trip, a user must validate their travel card; at this moment, the value of one trip is subtracted from the available credit on the card. Credit in the card is registered in COP and cannot be transformed into cash, it can only be used on SITP trips, and it does not have an expiration date. A personalized travel card is needed to be able to access transfer discounts and is also required to make use of targeted subsidies such as fare discounts.

The current targeted pro-poor subsidies work as a fare discount for people classified as low-income under government regulations. This subsidy initiative was initially introduced in 2013, offering prices set at 60% of the regular fare for individuals above the age of 16 exhibiting a low-income status. The structure of this subsidy has evolved over time and presently entails a pricing scheme equivalent to 72% of the full fare for low-income populations. There is also a limit of 30 trips per month imposed, alongside a requirement of meeting a certain threshold of lower income to qualify for participation in the subsidy program. Currently, the SITP has not managed to regain its ridership levels from before the pandemic. Furthermore, the existing pro-poor subsidy, which takes the form of a fare discount, is no longer effective in encouraging the utilization of public transport (Guzman and Hessel, 2022).

3.2 Experimental design

In 2021, we conducted an experimental field intervention aimed at testing an alternative for providing transport subsidies to users of the SITP. The intervention involved granting a monthly cash transfer to a subset of frequent users for four months. Specifically, a randomized sample consisting of 1,607 SITP users possessing personalized travel cards was selected from a larger population of approximately 176,000 frequent SITP users who were not benefiting from any subsidies. Among the selected participants, 807 individuals were designated to receive a monthly cash transfer onto their travel cards (the voucher), while the remaining 801 individuals were allocated to a control group. The recipients of the cash transfer were further divided into two subgroups: one receiving a higher amount (referred to as group A) amounting to 28,000 COP (equivalent to 7.5 USD), and another receiving a lower amount (referred to as group B) of 21,000 COP (equivalent to 5.6 USD).

It is important to note that the random assignment of participants to these groups ensures their statistical equivalence. This randomization enables us to attribute any observed

disparities in SITP usage to the causal impact of the monthly voucher. Importantly, it should be emphasized that the voucher, upon receipt, can solely be utilized for the purchase of public transport tickets; direct cash withdrawal is not an option. Any unused funds remain stored on the recipient's travel card for future transport-related expenses.

Individualized travel card usage data was gathered throughout the entire duration of 2021 – before, during, and after the implementation of the intervention. Complementary data was also acquired within this timeframe, encompassing a household baseline survey, subsequent weekly follow-ups, and a concluding survey at the end line. The survey information was gathered through face-to-face interviews conducted in March, April, and November. This intervention was initiated in May and concluded in September. For participants in the control group who were not allocated the transport voucher, an alternative participation incentive in the form of a grocery voucher amounting to 30,000 COP (8 USD) was provided at the culmination of the intervention. Comprehensive data was collected concerning the utilization and redemption of these vouchers.

As observed, we put forth the hypothesis that the vouchers will be utilized to facilitate additional consumption of SITP trips beyond the expected usage. In other words, these effects exhibit a more pronounced SITP use compared to the scenario where MAB is absent (the effects will surpass what would be expected if the participants were solely reacting rationally to the income increments indicated by the voucher, and using it as they would use cash). To accomplish this, we previously offered a more comprehensive explication of how to comprehend MAB. Subsequently, we present three distinct methodological approaches derived from the theoretical framework. Lastly, we present the outcomes of implementing these approaches, accompanied by their respective analysis and discussion.

4. METHODS

Under the influence of the MAB, participants receiving an MAB-inducing transfer (in the form of a voucher) are expected to exhibit a greater increase in SITP usage compared to participants receiving a non-MAB-inducing transfer (in the form of cash). However, it is noteworthy that our experimental design did not incorporate an alternative treatment, such as providing cash directly to individuals, to provide explicit and quantifiable evidence regarding the differential impact of the same monetary amount distributed through varying

means to participants. Instead, we employed a three-pronged strategy to provide evidence of MAB among regular users of the SITP in Bogotá. These methodologies were devised to discern indications of MAB within participants' emerging SITP-expenditure patterns as a response to the voucher.

The initial proposed approach entails an examination of the temporal pattern of SITP expenditures in the weeks after the delivery of the voucher. This first approach aims to analyze temporal fluctuations in SITP usage and investigate whether these variations align with the presence of MAB. The second approach relies on the premise that in the context of MAB, the Marginal Propensity to Consume public transport from the voucher (MPCv) exceeds that from additional cash income (MPCc), as presented earlier (Section 2.2). We seek to measure the difference between these two MPCs utilizing the data acquired during the experiment. The third approach delves into the response to vouchers not specifically designated for public transport. In the presence of MAB, it is postulated that any alternative voucher, such as a grocery voucher, should exert a lesser influence on public transport usage compared to a voucher expressly designed for public transport. We empirically test this hypothesis by inspecting the behavior of control group participants who received a grocery voucher upon the conclusion of the experiment.

4.1 Temporal fluctuations in SITP ridership

This approach initiates with the recognition that participants recharge their travel cards with the necessary funds to cover their weekly expenditures on the SITP and that the value of the provided vouchers exceeds the average cost of a week's usage. Once a voucher becomes active, individuals in the treatment group can cease adding funds to their travel cards until the voucher is exhausted. Subsequently, they can revert to utilizing their budget. If there is an absence of MAB and the fungibility of money is respected, there should be no disparity in the resource utilization between trips financed by the voucher and those supported by the participant's budget. Vouchers are delivered monthly and are pre-announced. Consequently, participants can plan their weekly trips based on their overall financial plan, which encompasses both personal resources and the voucher.

Under these circumstances, if participants were to receive a transfer that does not induce MAB, they would likely exhibit consistent spending on their weekly SITP trips in the weeks

after its receipt. This pattern would also be evident in their response to the voucher if participants were unaffected by MAB. Essentially, this indicates that participants treat the voucher and cash as interchangeable, aligning their behavior with Eq. (3). It is noteworthy that this enables participants to save money in the first half of the month by refraining from utilizing their regular income for transport expenses. Consequently, in the latter half of the month, these savings facilitate continued SITP usage. As a result, weekly ridership should be equivalent in both the first and second halves of the month.

Conversely, when participants are subject to the influence of MAB, differential reactions would manifest between trips funded by their budget and those funded with the voucher. Again, participants initially expend the voucher and subsequently, when it is depleted, employ their own funds to continue using the transport system. In the presence of MAB, the voucher stimulates higher expenditures on public transport in comparison to other forms of supplementary income. This implies that public transport expenses are elevated in the initial part of the month when participants utilize the voucher, as opposed to the final part of the month when they use their income. To examine differential expenditure patterns in the weeks following voucher distribution, we employ the following model:

$$\mathrm{Y}_{it} = \gamma_i + \lambda_t + \sum_p \beta_p \mathbf{T}_i^p + \tau \cdot \mathbf{P}_i + \epsilon_{it} \quad (13)$$

Where Y_{it} refers to the outcome variables from participant i in the week t. Two are of interest: i) expenditures in SITP from the travel card use; and ii) money recharges to the travel card. γ_i are fixed effects of individuals, accounting for the fact the average SITP use is not the same for every participant. λ_t refers to week-fixed effects, accounting for factors such as holiday seasons, weekends, and strikes, which can affect the overall performance and use of the SITP during different moments in time. The central element of this model is the utilization of the p subindex, which indicates the elapsed time in weeks since the activation of a specific voucher. In the week of the voucher's activation, this value is set to 1. Subsequently, in the week following activation, it increments to 2, and this sequential pattern continues. The value resets to 1 upon the activation of another voucher for the same participant, which typically occurs in the subsequent month. This subindex assumes a value of 0 before the initial voucher activation and remains at 0 for four weeks following the final

voucher activation. Furthermore, it retains a value of 0 for any period of participants in the control group.

A set of dummy variables, denoted as T_i^p, is used to indicate whether a specific week for a given participant corresponds to week 1, week 2, and so forth. This serves as the basis for estimating the impact of each of these periods on the treatment, as indicated by the coefficients β_p. The dummy variable P_i is employed to mark the period following the treatment and controls for any disparities between the treatment and control groups after the treatment ended.

The β_p coefficients provide a measure of disparities between the treatment and control groups in terms of SITP expenditures due to the voucher. Additionally, they allow for an examination of shifts in the pattern of adding funds to travel cards (recharging). This enables us to identify whether alterations in SITP expenditures align with changes in the recharge patterns of the participants. As participants gradually exhaust the balance on their travel cards after receiving a voucher, we anticipate observing changes in their recharge patterns. If participants remain unaffected by the MAB, their patterns of public transport expenditure are likely to remain unaltered. However, if participants are influenced by the MAB, the weeks following voucher activation should display increased expenditures alongside reduced levels of recharge.

4.2 The Marginal Propensity to Consume public transport

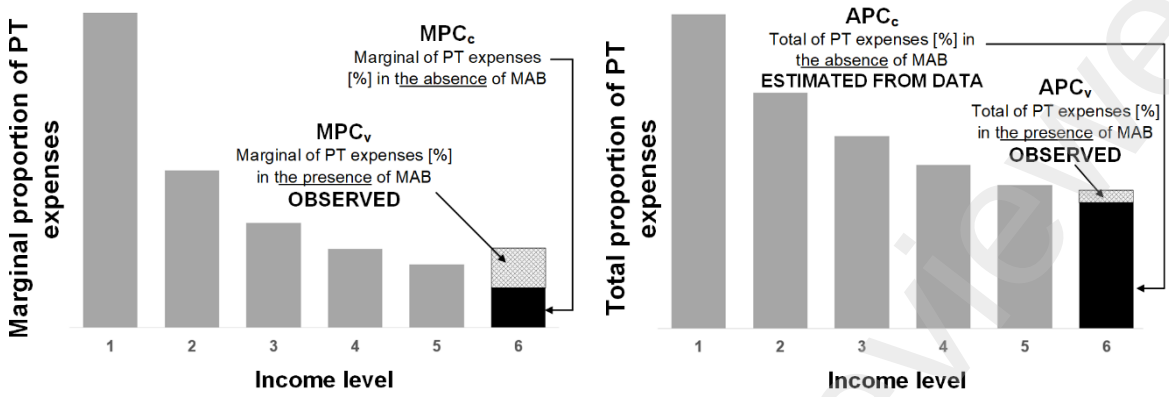
The preceding methodological approach relies on the identification of expenditure patterns over time. In contrast, this approach focuses on the allocation of the proportion of money from the voucher that participants allocate towards additional trips. As previously stated, due to the influence of MAB, participants may not fully expend the entire voucher value on additional trips. Importantly, with MAB in place, the expenditures on these additional trips exceed those made when an equivalent cash value is provided. This discrepancy can be quantified through the concept of the Marginal Propensity to Consume (PMC) public transport. Under MAB, we obtain:

$$\mathrm{MPC}_c = \gamma \; < \gamma + \beta = \mathrm{MPC}_v \tag{14}$$

Based on the obtained results, the primary objective is to empirically demonstrate that MPC_v surpasses MPC_c. In our experiment, the quantification of MPC_v is achievable through direct measurement by observing the additional travel expenses accrued by participants within the treatment groups relative to the voucher's value. Conversely, MPC_c is not directly measurable due to the absence of cash transfers in the intervention. To overcome this limitation, we employ an analytical approach centered on the calculation of Average Propensities to Consume (APC). This metric is defined as the total expenditure on trips relative to the total available budget, where the total available budget encompasses regular income plus the voucher when present.

Figure 2 illustrates how a divergence in Marginal Propensities to Consume ($MPC_v > MPC_c$) manifests as a disparity in the corresponding observed Average Propensities to Consume ($APC_v > APC_c$). We have chosen this alternative methodology since, despite the unobservability of MPC_c, we leverage the experimental dataset to compare APC_v against APC_c. The available evidence suggests that expenditures on public transport in Bogotá do not exhibit a constant *MPC* across different income levels (Guzman and Oviedo, 2018). As income levels increase, initial increments in public transport spending are observed, albeit at a diminishing rate. Subsequently, these expenditures start to decline as individuals with higher incomes shift towards other transport alternatives. This pattern indicates that the proportion of income allocated to public transport diminishes with rising incomes (Graham et al., 2009; Rivas et al., 2018). Both the *MPC* and the *APC* demonstrate a consistent reduction as income levels rise.

Figure 2 schematics are utilized to visually clarify this relationship. Here, the graph on the left depicts the *MPC* to consume public transport of six individuals with six income levels (where level 1 is the individual with the lowest income). This graph illustrates the *MPC* according to income level. The income of the all individuals comes from their regular earnings, while the sixth individual receives a cash transfer in addition. The graph on the right displays the *APC* across the same income level. *APC* can be viewed as an aggregation of all the *MPCs* up to a specific income level.



436

437 **Figure 2. Schematic representation of comparison measures to identify the presence of MAB**

438

439 Let us consider the individual in the sixth income level. If they receive a non-MAB-inducing
440 transfer, such as cash, their new MPC_c will align with the one represented by the solid black
441 bar in the left graph. Conversely, if the transfer is MAB-inducing, like a voucher, the MPC_v
442 will be represented by the crosshatch pattern bar on the left graph. The presence of MAB
443 results in a higher *MPC*. We can directly observe the MPC_v associated with a voucher, but
444 we lack a direct measure of *MPCv* for a non-MAB-inducing transfer.

445 When shifting our focus to *APC* instead of *MPC*, our attention turns to the scenarios depicted
446 on the right side of Figure 2. *APC* essentially computes the new *MPC* for the sixth individual
447 and averages it with all the preceding *MPCs* (from the first to fifth individuals). As before, if
448 the participants receive a non-MAB-inducing transfer, such as cash, their new APC_c will be
449 represented by the solid black bar on the right graph. Conversely, if the transfer is MAB-
450 inducing, like a voucher, the APC_v will be represented by the blue lines pattern bar on the
451 right.

452 Since the first five *MPCs* remain consistent in both scenarios, the relationship concerning
453 the response to the cash transfer persists, with $APC_v > APC_c$, although the disparity is not
454 as pronounced as in the $MPC_v > MPC_c$ case. Note that is feasible to derive estimates for
455 both APC_v and APC_c. APC_v can be directly estimated from the data. To approximate APC_c,
456 we consider as a control an individual whose income is equivalent to that of a treated
457 individual including the voucher value.

It would be desirable to compare a participant with an income level w_x who receives a voucher v to another participant with the same income level w_x who receives cash c. In this scenario, the income for both participants will be identical: $w_x + v = w_x + c$. As we do not have a cash transfer, we instead compare a participant with income level w_x who receives a voucher against another participant with income level w_y, ensuring that $w_x + v = w_y$. Since cash is non-MAB-inducing, the *APC* levels are equivalent between the participant who receives the cash transfer and the participant already at a higher income level.

It is crucial to provide an accurate description of the average propensity to consume public transport as a function of income. To model this relationship, we employ a polynomial fit. Subsequently, we need to determine whether the *APC* is higher for participants who receive the voucher. To evaluate this, we use the following model:

$$\mathrm{Y}_{it} = \lambda_t + \beta_T \cdot \mathbf{T}_{it} + \sum_{\mu} \beta_\mu \mathbf{I}_i^\mu + \mathbf{X} \cdot \beta_{\mathrm{X}} + \epsilon_{it} \qquad (15)$$

T_{it} corresponds to a dummy variable of participant i being treated in the week t. There are no fixed effects, as the model uses income whose value is constant for all participants during the treatment period. We use socioeconomic variables as controls. As the individuals in the treatment and control were randomly chosen, this does not induce estimation bias but can potentially reduce the test's statistical efficiency. Y_{it} refers to the proportion of income used in public transport per week; this uses the data on weekly use of public transport, but also on the reported income. I^μ is the income per person, using reported household income by the participants. Importantly, the income of the participants in the treatment is increased by the value of the voucher during the period in which the voucher was offered. Income remains constant for participants in the control group as they did not receive the transport voucher.

Under this specification, the β_T coefficient represents induced changes in public transport spending that are not due to income increases. Income increases are captured by the β_μ coefficients. If there is an increased expenditure due to the influence of MAB, the β_T coefficient should be positive and larger than zero.

4.3 The response to no public transport vouchers

As previously noted, had an additional treatment group been allocated a voucher-equivalent value transferred to their bank accounts or given in cash, we could have directly assessed the unique impact of receiving the monetary transfer in voucher format. Unfortunately, this particular treatment modality was not implemented. Nevertheless, as described in the case study, participants belonging to the control group were issued vouchers redeemable at grocery stores as an incentive for their participation. Assuming that participants in the treatment group reverted to their pre-treatment behaviors once the intervention concluded, this scenario can be exploited to gather further evidence concerning the existence of MAB in public transport utilization.

The value of the grocery voucher exceeded that of the transport voucher by 7% (USD 8.0 vs. USD 7.5). It is pertinent to note that the value of the grocery voucher falls below the average weekly grocery expenditures for an average household reported for Bogotá. Following the framework presented before, this is equivalent to a cash transfer. Consequently, in the absence of the influence of MAB, both the transport voucher (provided to treatment participants) and the grocery voucher (allocated to control participants) should operate as cash-equivalent increments in the total available resources. Therefore, in this context and the absence of MAB, any shifts in public transport expenses by those receiving the grocery voucher should mirror the changes observed in recipients of the transport voucher. Conversely, under the influence of MAB, a disparity in public transport expenditures between the grocery and transport vouchers should be present.

By comparing the conduct of participants receiving the grocery voucher with that of those who did not, it becomes feasible to find out whether the receipt of the grocery voucher exerts a comparable effect on public transport expenditures, similar to the effect identified for the transport voucher. Specifically, as we possess information regarding the utilization dates of the transport voucher, we will, mirroring our initial approach, reconstruct the temporal behavioral patterns of participants following the redemption of the grocery voucher. We employ the following model.

$$Y_{it} = \gamma_i + \lambda_t + \sum_p \beta_p \mathbf{T}_i^p + \sum_s \beta_s \mathbf{T}_i^g + \epsilon_{it} \quad (16)$$

The expression presented above modifies Eq. (13) by incorporating a set of coefficients. These coefficients serve to capture the behavior of participants in the control group who received and redeemed the grocery voucher. The subindex *s* is used to denote time, which is measured in weeks from the moment the grocery voucher is redeemed. The outcomes in this statistical model will closely resemble those used in the earlier regression (Eq. (13)). Specifically, it focuses on additional SITP expenditures and travel card recharge patterns.

If the MAB influences the grocery budget category, the values of β_s would tend toward either zero or be equivalent to it. Such a result would suggest that participants allocate either all or the majority of the extra income from the grocery voucher to purchasing additional groceries. Consequently, they would reallocate either none or a very small portion of their funds towards additional trips on public transport. Conversely, if MAB is not present in the grocery category, the values of β_s could be positive. However, these values should be smaller than β_p if the transport voucher induces MAB. If neither voucher prompts MAB under any circumstances, the coefficients would be identical. Table A1 in the Supplementary Material offers a visualization of these scenarios.

5. RESULTS

Before deepening into the outcomes of the previously proposed methodologies, it is imperative to underscore the fundamental findings of this field experiment. Providing subsidies to participants in a voucher form on their travel cards yielded a favorable impact on their average use of the SITP system. Notably, there was an average increase of 7.7% in SITP expenditures (travel card use) observed throughout the intervention period for individuals who were recipients of the vouchers. This increase was more pronounced among participants in the A treatment group, recording a growth of 8.4%, in contrast to the 7.0% rise documented for those in the B treatment group. This supplementary expenditure implies that participants allocated 35% of the voucher's value towards additional trips while reserving the remaining sum. This corresponds to 39% of the expenditure for the A treatment group and 31% for the B treatment group.

5.1 SITP use patterns

Figure 3 presents the set of β_p coefficients estimated using the model in Eq. (13). These coefficients, depicted by dots, represent the average weekly changes in SITP expenses (travel card usage in USD) for participants in treatment groups A and B caused by transport vouchers. The figure is divided by vertical dotted lines in five panels, each panel corresponding to a different week (week 1 is when the voucher is transferred and activated).

There is a statistically significant increase in travel card usage (expenses), particularly during the first two weeks. There is still an increase observed but lower by week 3, as shown in the drop of the coefficient values (from 0.45/0.48 to 0.29/0.28, see Figure 3, week 2 and 3, respectively). However, by weeks 4 and 5, this increase is no longer statistically significant. As explained in Section 4.1, this observed pattern contradicts what would typically be expected from consumers who adhere to rational economic principles and perceive the transport voucher's value as equivalent to an increase in income. In a scenario where there is no influence of MAB, would anticipate a consistent increase in expenses across all weeks between vouchers. Figure 3 results demonstrate that this is not the case.

During week 1 following the distribution of vouchers, the increase in SITP expenditures of participants exhibited an increase of approximately +11.7% (+0.42 USD) for group treatment B and +14.9% (+0.53 USD) for group treatment A. By week 3, this surge had decreased to +8.2% (treatment B, +0.29 USD) and +7.1% (treatment A, 0.28 USD). By week 4, there was no statistically significant increase in SITP expenditures. It is imperative to emphasize that these statistics represent average responses. Furthermore, our results center around the intention-to-treat approach, wherein we consider both participants who used their vouchers and those who did not.

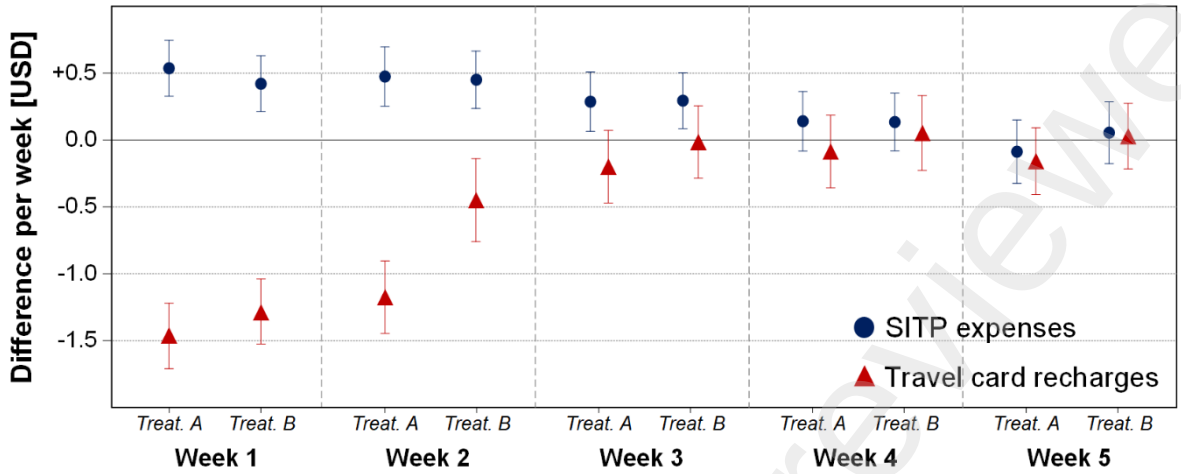


Figure 3. Changes in SITP expenses and travel card recharge between participants who received the transport voucher (treatment) and those who did not (control)

This trend, characterized by higher SITP expenditures compared to the control group during the initial three weeks post-voucher delivery, closely corresponds with the patterns of travel card recharging. This relationship becomes evident when we analyze these travel card recharge patterns (from participants) following voucher activation. This is represented in Figure 3 with triangles. In week 1, there was a notable decline in the weekly funds that participants loaded onto their travel cards. This decline persisted into week 2, although to a lesser extent, with a more pronounced reduction observed in the treatment A group. By week 3, weekly recharges aligned with those of the control group. Participants who received the voucher spent the same amount of money on SITP trips as those who did not receive vouchers, and their recharge amounts also equalized. In terms of SITP expenditures and recharge patterns for travel cards, the actions of participants undergoing treatment were indistinguishable from those in the control group in the second part of each month.

Additional trips primarily occurred during weeks when participants did not recharge their travel cards with their own funds and instead utilized the voucher. This behavior aligns with the concept of MAB. With the introduction of a voucher that increases the budget available for travel, participants heightened their usage of the SITP. However, when participants needed to tap into their own resources, they reverted to their previous travel patterns, even

if they had more funds than usual due to the voucher savings. The presence of MAB among participants increased SITP expenditures only when they perceived that the expenses were sourced from vouchers, as opposed to when they believed the expenses were funded from their personal funds.

5.2 The Marginal Propensity to Consume public transport

It is noteworthy that the marginal propensity to consume SITP trips through the provided voucher is relatively high, amounting to 35%. Conversely, the average *APC* observed in our dataset stands at 20% of per capita income. If participants were to utilize the voucher similarly to their regular income, we would anticipate that on average, no more than 20% of their income would be spent on additional trips. This observation hints at a potential overspending phenomenon within the SITP among participants, suggesting the presence of MAB. A comprehensive investigation of this potential overspending was undertaken employing the methodology outlined in Section 4.2.

Figure 4 illustrates the diverse β_T coefficients derived from the model presented in Eq. (15) applied to polynomials of varying degrees. Figure A1 in the Supplementary Material presents a depiction of how well a polynomial function can approach the average relationship between income and *APC* for the participants in the experiment. As shown in Figure 4, as the degree of the polynomial used to model income effects increases, there is an upward shift in the estimated difference in *APC* between the treatment and control groups. This shift in the difference in *APC* becomes apparent starting from a polynomial of degree 4 and continues up to degree 7, where it stabilizes. Given the stabilization of the β_T value and the empirical evidence supporting the effectiveness of higher-degree polynomials in capturing the income-*APC* relationship, we can infer that the β_T value obtained from a polynomial of degree 4 or higher provides an accurate estimate of the difference in *APC* between the treatment and control groups. I.e., the relationship between public transport expenses and income fits well with a degree 3 or higher polynomial.

This allows us to compare APC_c with APC_v. It's noteworthy that this estimated difference is 2.4 percent points. Note that this corresponds to an increase of more than 10% from the average value of 20% of per capita income.

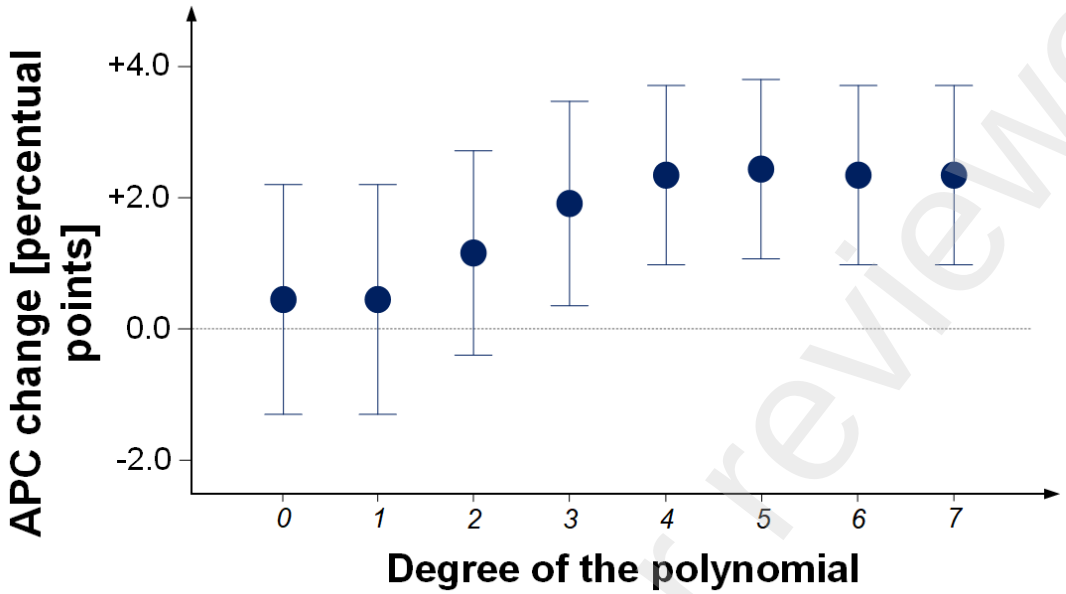


Figure 4. Coefficients corresponding to the differential in the APC on public transport between treatment and control for different levels of a polynomial fit to the income per week

These findings suggest that participants who received the voucher experienced an increase in their *APC* compared to those in the control group. Importantly, this increase persists even after accounting for the increases attributed to the additional income introduced by the voucher. This increment cannot be solely explained by the rise in resources resulting from the voucher. If participants treated the voucher merely as cash, without considering the MAB, there should be no discernible difference between the treatment and control groups in the model from Eq. (15). The presence of such a difference implies an additional impact on *APC* stemming from the voucher itself, which aligns with the expectations for participants influenced by MAB.

5.3 The response to no public transport vouchers

The third and final approach provides insights into how SITP expenditures respond to an increase in income resulting from the provision of a grocery voucher. Despite the value of this grocery voucher, it is considered equivalent to any other form of income-boosting transfer. In other words, in the absence of the MAB influence, a participant's reaction to SITP expenditures should be consistent, whether the transfer is provided in cash, in the form of a transport voucher, or as a grocery voucher.

Figure 5 illustrates the outcomes of the model from Eq. (16) assessing participants' responses to receiving a grocery voucher. In Figure 5 left, the graph shows the variations in SITP expenditures induced by the grocery voucher (the point value and 95%CI of the β_s estimates in the regression model represented by dark dots) and the transport voucher (the point value and 95%CI of the β_p in dotted lines). These changes are presented as alterations in SITP expenditures over the weeks starting from and following the distribution of the vouchers. Notably, the previously presented response pattern to the transport voucher is depicted in Figure 5, which exhibits a substantial reaction during the initial two weeks followed by a diminishing effect in subsequent weeks (higher values for the black depicted β_p in weeks 1 and 2). In contrast, the β_s estimates indicate that there is no discernible alteration in SITP expenditures upon redeeming a grocery voucher in week 1 or the subsequent weeks (2 to 5).

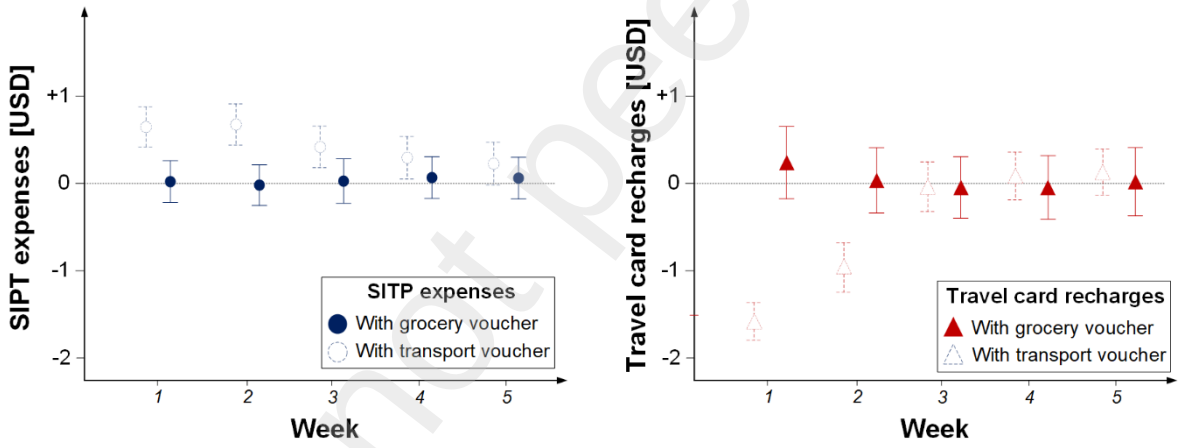


Figure 5. Change in SITP expenditures (left graph), and weekly recharge to travel cards (right graph) due to the reception and use of a grocery voucher

The right graph of Figure 5 illustrates shifts in weekly recharges to the travel card. In this graph, the point value and 95%CI of the β_s grocery value estimates are presented in dark triangles. The point value and 95%CI of the β_p transport voucher estimates are presented in dotted lines. It is crucial to note that if participants were utilizing a portion of the additional monetary value from the grocery voucher to augment their SITP expenses, we would expect to observe an increase in travel card recharges. However, this is not the case because β_s grocery value estimates are always statistically equal to zero for all weeks after the

redemption of the voucher. Both graphs in Figure 5 consistently demonstrate that participants' SITP expenditures remain unaffected upon receiving a grocery voucher.

Referring to Table A1 in the Supplementary Material, in the absence of the MAB influence, we would anticipate that the coefficients estimated for reactions to the grocery voucher and the transport voucher would be equivalent to SITP expenditures. However, this is not the observed results. It is evident that the coefficients for the transport voucher are larger than those for the grocery voucher ($\beta_p > \beta_s = 0$, 0.59 vs 0.016). This suggests that we find ourselves in one of the three scenarios outlined in Table A1, where the influence of MAB exists, either in both categories (SITP and grocery expenditures) or in one of them.

6. DISCUSSION AND POLICY IMPLICATIONS

In this study, three distinct approaches have been presented, each of which consistently demonstrates the presence of Mental Accounting Bias (MAB) among users of public transport induced by the use of vouchers. It is noteworthy that each methodological approach draws upon distinct data sources to conduct their respective examinations. The initial approach examines the differential SITP usage weekly, starting from the moment when the voucher is distributed. The second approach departs from this week-by-week analysis and relies on the average usage of the travel cards over the treatment period, incorporating income information. The third approach, also adopting a week-by-week perspective, centers on the grocery vouchers provided to the control group participants.

The first approach reveals that participants undertake additional public transport trips when utilizing the voucher, as opposed to using their regular income. The second approach demonstrates that this additional travel card usage averaged over the treatment period, exceeds the expected usage if the voucher were perceived as merely an increase in the commuter's budget. The third approach indicates that providing a similar amount of money in the form of a grocery voucher, which represents an additional income, does not result in any changes in public transport expenditures. All three pieces of evidence align with the MAB framework, providing robust support for the presence of MAB when transport vouchers are distributed to regular public transport users in Bogotá.

In classical economic theory, cash transfers to *tullave plus* travel cards are deemed equivalent to cash transfers, implying that the transport voucher equates to an increase in income. However, this study suggests that participants do not behave as standard economic agents. In economic language, they exhibit a behavioral bias, specifically a mental account bias. This bias is induced by changes in the perceived size of a budget category and is not observed when changes occur in fare prices. The effects of delivering subsidies in the form of a price reduction (fare discount) or a voucher differ significantly in their impact on travel behavior and ridership. When subsidies are received on travel cards (as transport vouchers), individuals tend to use public transport more than they would if the money were not earmarked for this specific purpose. The crucial point lies in how much of the voucher is spent on additional trips and how much on regular trips.

Our findings underscore the significance of the method by which public transport subsidies are delivered. Directly transferring funds to *tullave plus* travel cards reinforces the "public transport" mental spending account and encourages increased spending on SITP. Therefore, providing purpose-specific funds, such as transport vouchers, prompts individuals to spend more on SITP than they would if the funds lacked this condition. These findings have practical implications for transport authorities. Firstly, it is imperative to adjust the current subsidy policy to enhance its efficacy by incentivizing beneficiaries to increase their usage of the SITP. Vouchers have proven to be effective in achieving this aim. Secondly, vouchers not only result in higher SITP utilization but also free up resources for vulnerable users to engage in other activities, thereby improving the affordability of the system. Thirdly, the money spent on vouchers would return to the system and even increase revenues due to additional trips.

The bottom line, MAB can be harnessed to increase public transport ridership by changing the way that subsidies (or fares) are presented to potential users. To take advantage of this, public transport costs could be presented as a bundled cost, similar to a monthly/weekly subscription service, which would encourage users to think about the total cost of public transport rather than individual fares. This would also make it easier for users to budget for transport expenses and reduce cognitive bias. It is time to reconsider and reform the method of delivering public transport subsidies in Bogotá. This experience can also serve as a

valuable reference for other cities with similar pricing and technology policies, offering substantial potential for the implementation of similar measures.

7. CONCLUSIONS

The Mental Accounting Bias offers individuals a simplified method for determining their expenditures but hinders their capacity to make optimal choices. From a policy standpoint, the consequence of its influence on reactions to interventions necessitates addressing this bias. In situations where the policy objective is to boost consumption, it may be intentionally induced. Typically, in contexts where MAB has been identified (such as social programs, fuel consumption, or tax rebates), there appears to be limited room for policy intervention. In these contexts, it becomes evident that MAB distorts individuals' decision-making, reducing their overall utility. If policy intervention is feasible, it will likely involve finding strategies to mitigate or eliminate this bias, often through the manipulation of information or the reframing of expenditure choices.

In contrast, in the case of public transport, where increased usage is desirable, users often fail to consider the positive externalities associated with its use, such as congestion and pollution reduction. This results in travel demand falling below the socially optimal level. Given the unique nature of the public transport sector, there exists an opportunity to design policies that leverage MAB to induce greater public transport utilization. For instance, in the presence of MAB, a policy can be crafted to be budget-neutral from the government's perspective while incentivizing public transport use. For example, implementing an income tax that is fully refunded in the form of a transport voucher can influence users' decisions, promoting the use of public transport. Importantly, this does not alter consumers' budgets or restrict their choices. Within this framework, equality concerns can be addressed by providing subsidies to low-income users while maintaining the voucher component.

Emerging technologies such as smart cards and mobile apps provide an opportunity to reconsider pricing policies for public transport. Specifically, when contemplating demand-side subsidies, there exists substantial potential for innovation in the available instruments. While many ideas center around more precise targeting mechanisms, this study's findings underscore the importance of carefully analyzing the methods of subsidy delivery, such as vouchers versus fare discounts. This paper has demonstrated that understanding the

cognitive biases of public transport users plays a crucial role in designing more effective instruments to stimulate ridership. By identifying the presence of MAB in a developing context, we have not only furnished the initial empirical evidence of its impact on public transportation but have also established a proof-of-concept for a specific mechanism that policymakers can harness.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the Bogotá Urban Planning Department (www.sdp.gov.co), for the funding and general support given for the development of this study through Agreement 369 of 2018.

APPENDIX 1. SUPPLEMENTARY MATERIAL

Table A1. Expected relationships between coefficients of reaction to transport voucher and coefficients of reaction to grocery vouchers

		β_s: Public transport expenditures reaction to grocery voucher	
		MAB	No MAB
β_p: Public transport expenditure reaction to transport voucher	MAB	$\beta_p > \beta_s \geq 0$	$\beta_p > \beta_s > 0$
	No MAB	$\beta_p > \beta_s \geq 0$	$\beta_p = \beta_s \geq 0$

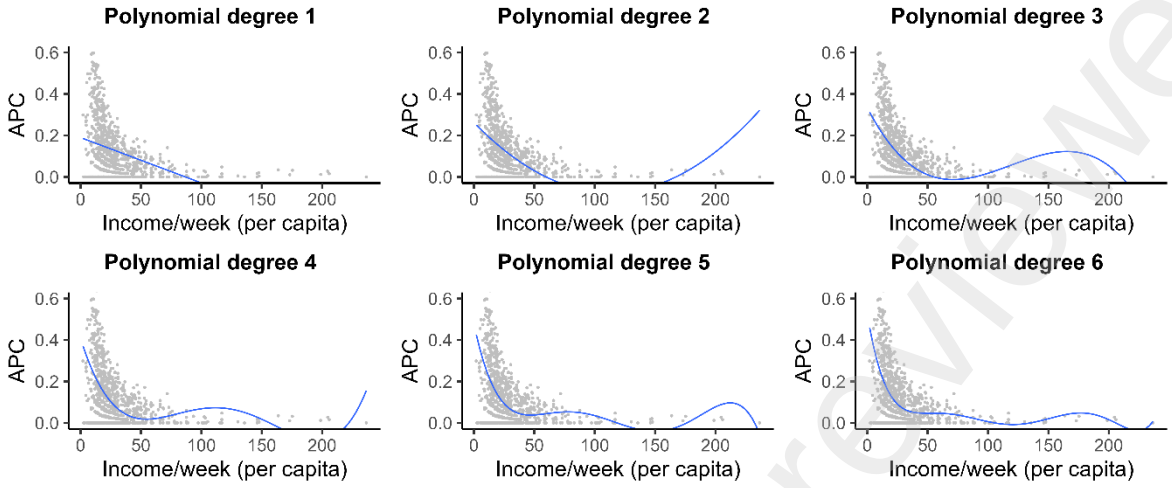


Figure A1. The proportion of money spent on public transport as a function of the income per week

Each point corresponds to a different participant in the sample. Each graph presents the same data fitted with a polynomial function of the income per week. Polynomial functions range from the 1st degree to the 6th degree. These polynomial fits are represented by the blue lines. A satisfactory level of fit appears to be achieved, starting from the fourth-degree polynomial and extending beyond. This shows a polynomial of a sufficiently high degree can adequately control for the average changes in APC as income increases.

Model extension. A Mental Account Theoretical Framework

The model Farhi and Gabaix (2020). Starts with an agent that maximizes his welfare by looking at the basket of two goods, t, and a, that brings a higher utility level.

$$\max_{\{t,c\}} u(t,a)$$

The consumer is nonetheless restricted to a maximum budget *w*, and faces the prices of the two goods, that are respectively p_t and p_c:

$$p_t \cdot t + p_a \cdot a \leq \overline{w}$$

The consumer utility is represented by a Cobb-Douglas function. In this form, the substitution decision between the two goods hinges on the parameters *α* and *γ*. It is of the following form:

$$u(t,a) = t^{\alpha}a^{\gamma}, \text{ with } \alpha + \gamma = 1$$

Under this condition, the solution to the consumer problem is to choose a fixed proportion of the budget to be used for each good, defined by the parameters *α* and *γ*.

$$a^* = \alpha\frac{\overline{w}}{p_a}; \quad t^* = \gamma\frac{\overline{w}}{p_t}$$

The level of consumption of each good depends on this proportion and the price of the good. As α+γ=1, the consumer completely uses her budget.

To introduce Mental Account Bias, a cash transfer *c* and a voucher *v* are given to the consumer. The cash transfer *c* can be used for any of the two goods. The voucher *v* can only be spent on good *t*. It is assumed that the value of the voucher *v* is below the cost of the goods before the transfer and the voucher is given to the consumers ($v < \gamma \cdot w$). This guarantees the voucher is equivalent to a cash transfer and should, in the absence of bias, have the same effect. This means the consumer budget is updated to:

$$w = \overline{w} + c + v$$

In the absence of any Mental Account Bias, the consumer will choose a basket that maximizes their utility given the new budget:

$$a^* = \alpha\frac{\overline{w} + c + v}{p_a} = \alpha\frac{w}{p_c}; \quad t^* = \gamma\frac{\overline{w} + c + v}{p_t} = \gamma\frac{w}{p_t}$$

To include a Mental Account Bias, the notion of an expenditure goal is introduced. Specifically, the consumer has the following expenditure goal for the good *t*:

$$w^* = \gamma \cdot w + \beta v$$

In which $\beta \in (0,1\text{-}\gamma)$ measures the degree of Mental Account bias with the lower value (0) indicating the absence of it. Note in this formulation, in the absence of a voucher, the expenditure goal is equal to the optimal expenditure in good *t*, given the budget. And consequently, *β* is the extra expenditure above the optimal one in the good for which there

is a voucher. This expenditure goal affects the consumer, as they perceive it as a (psychological) cost to deviate from this goal. This psychological cost is represented by the parameter *κ*. The consumer has a perceived psychological budget restriction equal to:

$$a \cdot p_a + t \cdot p_t + \kappa |\, t \cdot p_t - w^* | \leq w$$

With *κ* high enough, the psychological cost is enough to make the consumer comply with the expenditures goal instead of choosing the optimal one. In this case, the result of it is that the consumer chooses a basket of goods that can be defined as:

$$a^* = \alpha \frac{\overline{w} + c + v}{p_a} - \frac{\beta v}{p_a} = \alpha \frac{\overline{w} + c}{p_a} + \frac{(\alpha - \beta)v}{p_a} \; ;$$

$$t^* = \gamma \frac{\overline{w} + c + v}{p_t} + \frac{\beta v}{p_a} = \gamma \frac{\overline{w} + c}{p_t} + \frac{(\gamma + \beta)v}{p_t}$$

A useful way to understand these expressions is to look at what happens at the maximum value of *β=1-γ*.

$$a^* = \alpha \frac{\overline{w} + c}{p_a}$$

$$t^* = \gamma \frac{\overline{w} + c}{p_t} + \frac{v}{p_t}$$

Also, when at its minimum *β*=0.

$$a = \alpha \frac{\overline{w} + c}{p_a} + \alpha \frac{v}{p_a}$$

$$t^* = \gamma \frac{\overline{w} + c}{p_t} + \gamma \frac{v}{p_t}$$

REFERENCES

Börjesson, M., Eliasson, J., Rubensson, I., 2020. Distributional effects of public transport subsidies. J. Transp. Geogr. 84, 102674. https://doi.org/10.1016/j.jtrangeo.2020.102674

Bradford, D.F., Shaviro, D., 1999. The Economics of Vouchers, NBER Working Paper No. w7092.

Cherry, T.L., 2001. Mental accounting and other-regarding behavior: Evidence from the lab. J. Econ. Psychol. 22, 605–615. https://doi.org/10.1016/S0167-4870(01)00058-7

Falavigna, C., Hernandez, D., 2016. Assessing inequalities on public transport affordability in two latin American cities: Montevideo (Uruguay) and Córdoba (Argentina). Transp. Policy 45, 145–155. https://doi.org/10.1016/j.tranpol.2015.09.011

Farhi, E., Gabaix, X., 2020. Optimal Taxation with Behavioral Agents. Am. Econ. Rev. 110, 298–336. https://doi.org/10.1257/aer.20151079

Feldman, N.E., 2010. Mental Accounting Effects of Income Tax Shifting. Rev. Econ. Stat. 92, 70–86. https://doi.org/10.1162/rest.2009.11892

Garcia-Sierra, M., van den Bergh, J.C.J.M., Miralles-Guasch, C., 2015. Behavioural economics, travel behaviour and environmental-transport policy. Transp. Res. Part D Transp. Environ. 41, 288–305. https://doi.org/10.1016/j.trd.2015.09.023

Graham, D.J., Crotte, A., Anderson, R.J., 2009. A dynamic panel analysis of urban metro demand. Transp. Res. Part E Logist. Transp. Rev. 45, 787–794. https://doi.org/10.1016/j.tre.2009.01.001

Guzman, L.A., Cantillo-Garcia, V.A., Arellana, J., Sarmiento, O.L., 2023. User expectations and perceptions towards new public transport infrastructure: evaluating a cable car in Bogotá. Transportation (Amst). 50, 751–771. https://doi.org/10.1007/s11116-021-10260-x

Guzman, L.A., Hessel, P., 2022. The effects of public transport subsidies for lower-income users on public transport use: A quasi-experimental study. Transp. Policy 126, 215–224. https://doi.org/10.1016/j.tranpol.2022.07.016

Guzman, L.A., Moncada, C.A., Gómez, S., 2018. Fare discrimination and daily demand distribution in the BRT system in Bogotá. Public Transp. 10, 191–216. https://doi.org/10.1007/s12469-018-0181-7

831 Guzman, L.A., Oviedo, D., 2018. Accessibility, affordability and equity: Assessing 'pro-poor'
832 public transport subsidies in Bogotá. Transp. Policy 68, 37–51.
833 https://doi.org/10.1016/j.tranpol.2018.04.012
834 Hastings, J., Shapiro, J., 2018. How Are SNAP Benefits Spent? Evidence from a Retail
835 Panel. Am. Econ. Rev. 108, 3493–3540. https://doi.org/10.1257/aer.20170866
836 Hastings, J., Shapiro, J., 2013. Fungibility and Consumer Choice: Evidence from Commodity
837 Price Shocks*. Q. J. Econ. 128, 1449–1498. https://doi.org/10.1093/qje/qjt018
838 Hybel, J., Mulalic, I., 2022. Transportation and quality of life. Evidence from Denmark.
839 Transp. Res. Part A Policy Pract. 157, 107–125.
840 https://doi.org/10.1016/j.tra.2021.12.003
841 Iseki, H., Taylor, B.D., 2010. The Demographics of Public Transit Subsidies: A Case Study
842 of Los Angeles.
843 Metcalfe, R., Dolan, P., 2012. Behavioural economics and its implications for transport. J.
844 Transp. Geogr. 24, 503–511. https://doi.org/10.1016/j.jtrangeo.2012.01.019
845 Milkman, K.L., Beshears, J., 2009. Mental accounting and small windfalls: Evidence from an
846 online grocer. J. Econ. Behav. Organ. 71, 384–394.
847 https://doi.org/10.1016/j.jebo.2009.04.007
848 Rivas, M.E., Serebrisky, T., Suárez-Alemán, A., 2018. How Affordable is Transportation in
849 Latin America and the Caribbean? Washington, D.C. https://doi.org/10.18235/0001530
850 Thaler, R., 2018. From Cashews to Nudges: The Evolution of Behavioral Economics. Am.
851 Econ. Rev. 108, 1265–1287. https://doi.org/10.1257/aer.108.6.1265
852 Thaler, R., 2008. Mental Accounting and Consumer Choice. Mark. Sci. 27, 15–25.
853 https://doi.org/10.1287/mksc.1070.0330
854 Thaler, R., 1999. Mental accounting matters. J. Behav. Decis. Mak. 12, 183–206.
855 https://doi.org/10.1002/(SICI)1099-0771(199909)12:3<183::AID-BDM318>3.0.CO;2-F
856 Thaler, R., 1985. Mental Accounting and Consumer Choice. Mark. Sci. 4, 199–214.
857 https://doi.org/10.1287/mksc.4.3.199
858 Tiznado-Aitken, I., Vecchio, G., Guzman, L.A., Arellana, J., Humberto, M., Vasconcellos, E.,
859 Muñoz, J.C., 2023. Unequal periurban mobility: Travel patterns, modal choices and
860 urban core dependence in Latin America. Habitat Int. 133, 102752.
861 https://doi.org/10.1016/j.habitatint.2023.102752
862 Zhang, C.Y., Sussman, A.B., 2018. Perspectives on mental accounting: An exploration of

budgeting and investing. Financ. Plan. Rev. 1. https://doi.org/10.1002/cfp2.1011