Summary and course relation:
Evaluating the Impact of Urban Transit Infrastructure: Evidence from Bogotá's TransMilenio
by Nick Tsivanidis (2023)

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1. Summary of the paper

The paper studies welfare effects of a system of Bus Rapid Transit (BRT) in the capital of Colombia, Bogota. It relies on a sufficient statistic approach of elasticity of wealth to Commuter Market Access (CMA) of employees and firms that can be estimated by running linear regressions. Using these estimates in a model of firms and workers including housing supply and externalities of productivities and amenities, the introduction of the system increased welfare by 2.28% while inequality rose by 0.55% in the baseline scenario where BRT does not influence migration into the city.

Bus Rapid Transit is a complex system of bus network that operates in a similar way to subway: there are 2 separate lanes for the buses, the stops can be entered using a smart card. Accessibility is extended through feeder buses which drive the citizens from peripheries of the city to the BRT stops without a charge. This system has 2 advantages in a context of a developing country: it is much cheaper to build than metro, and it is faster to construct - which is especially important in rapidly growing city like Bogota (from 6.3M in 2000 to 10.6M citizens in 2018[2]).

In Bogota, the system was constructed in phases. The first one of 42 km length along 2 main arteries of the city finished in 2000, second and third added additional 70km in 2006 and 2012. The system has been built to connect the city center with residential areas, without reducing the number of car lanes. It is the most utilized BRT system in the world servicing 2.2M passengers daily on 147 stations. Its average speed is 26.2km/h, close to New York subway and 10km/h faster than the incumbent bus network.

Before the creation of BRT, average work commute in Bogota took 55 minutes (double the average of a US city), with deregulated bus network serving 73% of trips clogging traffic flow as no restrictions on bus stops had been enforced.

The analysis of this system is attractive for 3 reasons: the preparation works had been conducted since 1980s with multiple construction plans, which provides natural placebo checks; after identifying the neighborhoods to connect the city center with, the route was chosen to minimize the cost, which can be used as an instrument in the analysis; the construction works were fast and unanticipated with staggered opening allowing time series variation to analyze.

The Data used in the paper is on census tract level. There are 2,799 tracts with mean population of 2,429 (2005). Population data with education level is available for 1993, 2005 and 2018. Employment data is available for 1990, 2000, 2005 and 2015. Housing market data is available for every year between 2000 and 2018 and is a good reflection of the purchase price. Microdata on commuting behavior is

[2]https://worldpopulationreview.com/world-cities/bogota-population

available for 2005, 2011 and 2015 and reports respondent's characteristics and travel itenary for the previous day.

With this data, the author builds a model of a city with workers, firms, housing and externalities.

Workers consume goods, residential floorspace and amenities (like kindergarten or stores). They can also own a car which provides an additional mode of transportation but it comes at a fixed cost. They decide to own one based on the location and their preference which is reflected in amenities (this is constructed in a way that richer own more cars).

A worker can also be of low or high productivity. The population of the city is assumed to be fixed. A worker first chooses a location to live, to work and whether or not to own a car, then the transport mode that gets them to the work location. The problem is solved by backward intuition assuming a nested logit demand across transportation modes. That simply means that we have 2 groups of public and private modes which are not directly comparable - as to use the car, a worker has to own one.

An individual has their own random preferences on which mode to use when going from particular locations, so that their commuting cost is a mix of travel time, average preference for the mode and preference for the particular mode when going from particular location. To decide which mode to use, they minimize their cost.

Individuals also have some random productivity that match the firm. Workers choose the working location so that it offers the highest income net of commuting costs. Depending on where they live, they have different access to well-paid jobs - this mix of salary and commuting costs is called Residential Commuter Market Access. If individuals have skills that are very high (low), they are less sensitive to the commuting choice. It reflects the reality where the rich will always own a car as they can afford it and the poor will never do so.

Based on the expected net income of a location, a worker decides to settle and to own (or not) a car.

Labor supply available to a firm is therefore driven by 2 forces: wage level offered and, conditional on wage, access to pool of workers through the commuting network. The latter is called Firm Commuter Market Access.

A firm operates in an industry and produces goods that vary by location under perfect competition. Inputs of production are technology (exogenous and dependent on location and industry), labor and commercial floorspace. Industries differ in terms of their demand for low- and high-skilled workers. A firm therefore pays for the workers and the floorspace.

Floorspace renters decide to rent only taking into account the demand, so that they maximize profit.

Productivity of a location depends on some external factors like access to roads or slope of land, and the density of employment. Amenities also depend on some external parameter that captures the

location's benefits, e.g. pretty architecture, and a fraction of highly educated people. It reflects the reality pretty well, where it's the wealth bringing amenities in a city like Bogota.

For the markets to clear, labor supply has to be equal to labor demand setting a wage, floorspace demand to supply setting a price, and population of the city has to add up.

To estimate welfare effects of the model, the author proposes sufficient statistic that can be estimated using a reduced form of the logarithm of outcome variable (population and price for floorspace in a census) on Commuting Market Access (CMA) change. The residuals are unobserved location characteristics that are external to the economic activity like amenities, floorspace supply for firms and workers, and productivities.

Residential CMA reflects access to well-paid jobs and is a sum of the supply firms that can be reached with a cost. Firms CMA reflects access to workers through the commuting network and is a sum of the supply of workers that reach the firm with a cost. These statistics are co-dependent. To calculate these statistics, the author uses the 2015 Mobility Survey identifying the sensitivity of mode of transport choice to travel time, sensitivity among the modes themselves, preferences for modes holding the travel time constant.

In order to avoid bias that arises from the tracts having differential trends in unobserved characteristics (which is likely the case), the author includes a rich sets of controls, utilizes CMA variation further from the location where it is less likely to be correlated with unobservables, conditions on distance to the bus station to examine whether it is accessibility rather than other station features (e.g. complementary infrastructure) that drive the results, uses historical unrealized plans as placebo checks, exploits variation in time across BRT phases to see whether there is growth in outcomes prior to line openings, and constructs IV regression with 2 instruments - distance historical tram lane and cost minimization estimates. All these checks strongly confirm the robustness of the estimates. Changes in CMA due to the BRT have strong, positive impacts on all outcomes - population and price of the floorspace.

The usual approach quantifies the gains of public transportation in "value of travel time savings" (VTTS). Here, we add the effects for workers and firms to access jobs and employees. While VTTS accounts for 1.26% welfare gain comparing to a situation without the BRT system, our approach expands these gains to 2.34%. This is the paper's central result - equilibrium effects matter majorly when assessing gains from infrastructure. Size of the shock accounts for 1/3 of the difference between VTTS and equilibrium gains while the externalities for the other 2/3.

The author incorporates additional parameters of share of floorspace cost in firms and workers expenses, and labor elasticity of substitution from other literature. This brings estimated influence of

GDP and welfare growth of 2.98% and 2.21% with a fall in floorspace prices when no migration is assumed. With external migration, welfare gains fall to 0.6% since the population increases by 9.51% and floorspace prices by 5.67%. Overall, BRT can account for 2.96%-13.36% of Bogota's GDP growth between 2000 and 2016, and up to 34.9% of population growth. This welfare gain is even larger by 0.55% when we account for the congestion reduction caused by switching to BRT.

Contradictory to the intuition, BRT brought larger benefits to high-skilled workers. Welfare inequality rose by 0.55% as a result. The author provides the intuition of labor substitution - better commuting system makes easily replaceable, low-skilled workers even more replaceable, while high-skilled workers are imperfect substitutes. Second reason is that the system connects a better fraction of the rich who live in strongly concentrated neighborhoods than the dispersed population of poor.

Lastly, the author conducts a series of counterfactuals:

- Alternative networks: the southern line has a bigger effect on welfare as per higher population density of poor and middle income workers; welfare would be 0.94% lower without the feeder bus network; increasing buses' speed to 35km/h would greatly improve welfare gains.
- Had the city adjusted the zoning laws to allow housing supply response to the new lines, the welfare would have been 44.04% higher than it is today.

2. Relation to the course

2.1. Distance to job

In poorer areas (here, the south of Bogota), lower quality of local public goods can result from the presence of deprived people (Crane 1991). Building a BRT system to connect the south with the city center and the north can compensate for the hindering local externality. It could also diminish the spatial mismatch (Kain 1968), so that low-income Bogotanos can have access to same job opportunities as the high-status ones. According to Kain, when the distance (here, we can paraphrase the distance to time) to jobs increases, job search efficiency decreases as local advertising is not available to job seekers, the job search intensity decreases as the net wage is lower, the cost of job search increases and commuting costs increase. This program has an aim to do the opposite - decrease the time that is needed to commute, so that the job market is more efficient. This should increase productivity, as the time to reach the job place is shorter, and even trasmit the effect to future generations (Gobillon, Selod, and Zenou 2007). However, this program causes an indirect cost from the introduction of new distortions - house prices hikes in the newly connected areas. If the city adjusted for this distortion, the welfare gains of the program would be 44% higher than today. Note, that when migration is included,

the welfare gains are only at 0.6%. A large part of this policy has been capitalized in housing prices, off-setting the gains for the local population in real terms (Glaeser and Gottlieb 2009).

2.2. Difference-in-Differences

Although the author provides a placebo check, comparing the areas that were planned-but-unbuilt using old construction plans and showing that they do not grow differentially in the absence of new transit in terms of Consumer Market Access. Instead of using a difference-in-difference approach, the author continues with the reduced form linear estimate but predicts change in CMA if the lanes had been built. If the observed impacts are due to BRT and not the not-random selection itself, the impact of these networks shouldn't be significant. This approach seems more effective: it confirms the validity of the model (including proper number of control variables), and shows that the CMA measure is well-constructed if the (potentially similar) areas do not grow in the absence of new transportation. This advances the usual reduced-form analysis as in (Busso, Gregory, and Kline 2013) but it does not try to match the neighborhoods on their characteristics.

2.3. House and land prices

Bogota is a monocentric city: a central business district now expanding northward contains over 42 percent of the city's employment[3]. Connecting new districts to the Central Business District (CBD) influences house and land prices: it's cheaper now to commute (in terms of time), so the workers can move further from their workplace, therefore the house prices around the CBD should decrease. However, the rents should increase around the line itself, as these places are now cheaper in terms of the commuting cost. Additionally, with open migration (which was the case of Bogota), the new line providing lower cost of living can attract new people into the city, creating more demand for housing and further increase the prices. This is a complex question because land prices differ across neighborhoods but are endogenous: they result from the workers location choice, they are interdependent across locations and the consumer's utility depends on the choice of other consumers, as they compete for the same housing units. This is confirmed by a simple model with a Cobb-Douglas utility function that depends on housing and consumption, where consumption can be expressed as a function of commuting cost (that is based on distance). The problem is:

$$\max_{h,z} U(z,h) = \frac{z^{1-\alpha} h^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} \tag{1}$$

subject to

[3]https://www.lincolninst.edu/publications/articles/land-use-expansion-bogota#:~:text=Bogota%20is%20densely%20developed%20with,percent%20of%20the%20city's%20employment.

$$w - \tau(x) = R(x)h + z \tag{2}$$

Where w is wage, z is consumption, h is housing space consumption x is distance from the CBD $\tau(x)$ is commuting cost and $R(x)$ is the land price. Then, after solving the model, the housing price is decreasing in x (for a particular utility level $\overline{u}$), while housing consumption is increasing in x and $\overline{u}$:

$$\begin{aligned} R(x) &= \left(\frac{w - \tau(x)}{\overline{u}}\right)^{\frac{1}{\alpha}} \\ h^*(x, \overline{u}) &= \frac{\alpha \overline{u}^{\frac{1}{\alpha}}}{(w - \tau(x))^{\frac{1-\alpha}{\alpha}}} \end{aligned} \tag{3}$$

That confirms our previous intuition: when commuting cost is increasing with distance, land price decreases while housing consumption increases from the center to the periphery. When the BRT system comes into place, $\tau(x)$ is still increasing but in a slower manner, so that the land prices should go up in the peripheries and down near the CBD. However, this is a model of a closed city with all workers earning same wage.

Extending this to two types of workers (poor and rich) with identical commuting costs shows that the poor workers are more sensitive to commuting costs, so they would locate closer to the city center while the rich would locate in the outskirts of the city. This is partially true in Bogota, where the rich locate in the north, although does not apply to the city in general, as the average commuting time is still high, even with the BRT system. Also, the housing choice depends on amenities (such as kindergartens, stores) or crime rates.

In our context, the problem is different. A lot of land around the newly built line is owned by the government, and it also manages the development rights on building density. A lack of adjustment of the housing density caused an indirect cost, to both consumers and the government: the authors build a counterfactual showing that if a land value capture scheme, under which development rights to increase building density are sold to developers, is implemented, the welfare gains could have been increased by 44% with government revenues covering 6-23% of the BRT's capital costs (depending on migration response).

Another important remark is that the BRT system also provided a system of 'feeder buses' which connected peripheries with the stations for free. This is a pleasant result for poor workers, who are more sensitive to the commuting cost changes, and at the same time who are ready to commute longer in terms of time. This would explain city's wealth dispersion and a large part of the south being populated by poorer communities. However, again, it might increase land prices even further away from the stations, with a smaller effect though.

2.4. City size, transportation and productivity gains

One of the author's result states that the BRT system can account for between 2.96% and 13.36% of Bogota's GDP growth from 2000 to 2016, and up to 34.9% of observed population growth. Meanwhile, there's a clear correlation between wages (which can serve as a measure of productivity) and employment density (Combes et al. 2010). The literature estimates the gains to be around 1.4%-4.2% in productivity for twice higher density. In Colombia, a developing country with high density differences cite(), these gains can be even larger. In China, the productivity gain for a worker can go up to 52.7% (moving from the first to the last decile of density) (Combes, Démurger, and Li 2015).

However, these effects are not necessarily causal: some effects are correlated to both density and productivity but not related to agglomeration economies themselves or it's the higher productivity actually attracting more people and making the city larger. This is partially the author's assumption, that the new bus system makes the job allocation more effective, so that the wages increase and it allows more people to locate in the city. At the same time, he emphasizes the that the welfare gains are higher in a closed city model and diminish from 2.2% to 0.6% when migration is allowed since the population growth bid up floorspace values by 5.28%.

The author does not use the suggested approach in the course, that is a Bartik instrument (Bartik 1991), instead, he conducts a placebo tests searching for effects of Commuter Market Access in other areas that were in previous construction plans but the line hasn't been built there. This slightly reminds of the Bartik approach but, first, it seems easier to do, second, it is simpler to explain. Even though it might be biased with contamination from other groups, this CMA measure is proved not to be affected, which entirely fulfills the role of this analysis.

Another issue is to include the knowledge spillovers that can arise in this context. I further exploit it in the second essay, however, this is not accounted for in the author's analysis, but is widely confirmed by the literature (Feldman and Florida 1994; Audretsch and Feldman 1996; Jaffe 1989). Therefore, the author's result can be treated more as a lower bound of the welfare gains from the new transportation system.

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Criticism and extensions:
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1. Minor comments

First, in the paper the workers first choose where to live and whether or not to own a car, then where to work, and finally which transportation mode to use. In the course, however, we mentioned that it might be inverse - it's first the job that is chosen, then the workers choose where to live. Also, the decision about purchasing a car is strongly dependent on financial situation of a worker. Although the author reports results with joint decisions taken together in the appendix, he does not disentangle location-car choice, neither he does not take into account the inverse decision making process for a part of society, especially immigrants, who rather pursue the job first, then they choose the location.

Secondly, the author tells us little about the choice of the housing supply that is unobservable. An assumption of Oakland, CA is quite specific and tests on other cities in terms of Land Value Capture (LVC) are not provided. The author should have tested this approach with some observable data - conduct the analysis on a city that is similar in size and other characteristics to Bogota but has the housing supply data available. This assumption highly affects the LVC analysis and author's conclusions that may drive policy decisions.

2. Social impact - crime and gentrification

Although the paper studies welfare gains in terms of utility, it does not account for the spillover effects that change the social welfare. Building new transportation lines is known to be an effective measure of alleviating crimes in fragile neighborhoods[2]. This might also lead to further gentrification and social integration. Additionally, it may create new job opportunities for the locals, as it's happening in Comuna Trece, Medellin.

An extension I propose would look at the crime rates change across the zones affected by the BRT system. There are 2 main channels that may affect crimes in that areas. First, the wealth increase among the workers might reduce the incentives to commit economically motivated crimes. Also, infrastructure built around the stations, that is the lighting or the network of feeder buses (that makes people travel less on foot and alone). However, Bogotanos fear to use mass transport because of the crimes as well. According to the Bogota's city council, in 2016 15% of all thefts were committed in public transportation system. Also, over 2.5kg of narcotics were smuggled in the infrastructure provided by the BRT[3].

[2]see an example of Medellin https://tuljournals.temple.edu/index.php/mundi/article/view/368
[3]https://transport.opendatasoft.com/pages/crimen-seguridad/

To initially assess the influence of BRT on neighborhood crime, we would need the data on crime location, date and type of it (to analyze heterogeneity). We could construct it using data from the police departments of Bogota. Then, we could use a synthetic control (SC) where the treatment is an opening of the line. Assuming we do not observe tract characteristics over small periods of time, the SC algorithm would match based only on the outcome variable, that is crime rate. The control group would be created for every tract. It would not serve as a perfect counterfactual, as it is affected by the spillovers as well - the control areas are prone to negative migration from well-connected areas after house prices hikes from the poor, and we may expect the rich leaving the area to save time using BRT. Therefore, our results would be more of a gross effect - including the the migration and not being able to separate the im- and emigrants. We could utilize the staggered treatment, as the author did, to compare control and treated areas. To further develop the topic, we could search for crime dispersion along the new line, as it's easier to commute (so it's also easier to commit crimes).

3. City size and productivity

The productivity in the author's model depends closely on the employment density. Along with the population relocation, the productivity of a location may change. However, the paper lacks the productivity analysis when the access to city is unrestricted (open migration). As in popular growth models, productivity depends on total population, not only population density (Larger number of people means also more inventors. If we assume that a probability of becoming an inventor is constant, larger population is strictly correlated with number of inventors, therefore productivity). In my opinion, productivity gains from attraction new workers to the city are not examined sufficiently in the paper. Although the open city model shows lower welfare gain, the productivity gain might be larger in the long term.

To examine short-term gains on productivity, we would examine firm-level data on production, revenues, labor composition and costs. As the matching is more effective in the presence of BRT, firms should hire more effective workers. On the same note, there should be more talented people available, who can come up with inventions in the city. Given these two effects, we can focus on cost and cost-profit firm analysis to search for larger productivity effects.

Our identification strategy might be problematic. Large spatial spillovers and free firm relocation makes it difficult to compare stayers outside of the BRT systems with companies affected by the line. Verification of the hypothesis would have to rely on other comparison. First, we could simply create a productivity measure (e.g. output/cost) and examine its dynamics in the areas affected by the BRT

and those left unaffected. Possibly, using the staggered line construction might help to identify these effect by comparing the local productivities.

Another method that could potentially identify the productivity change would be using a Regression Discontinuity Design, as discussed in the course with non-parametric design as our primary design. Distance from the closest BRT station could serve as a measure of being affected by the system. Our design would be fuzzy, that is we do not expect a specific threshold to be a cut-off. We expect the productivity to decrease further from the system though. To account for the dynamic effects of relocation, we would have to keep the same samples with the same firm locations and conduct the analysis at 2 points in time. Of course, we risk that the stayers (firms that did not relocate) are different from the firms that were already there.

We could account for that by conducting a dynamic analysis of these firms. We could use a Two Way Fixed Effects analysis with firm and location fixed effects. Treatment would be defined as a point in time when the line was opened. We would expect a potentially positive outcome for the firms, where market access of workers was improved by the BRT. At the same time we would expect neutral or even negative effects for the firms that are left without the access to the BRT. These two analysis should provide us with initial motivating facts to extend the study.

4. Pollution

TransMilenio (the Colombia's BRT) had a 86% disapproval rate from its users in 2016. A 2015 analysis by the National University of Colombia determined 70% of the air pollution nearby the Transmilenio exits originated from buses in the initial phase of the system's operation. Government records further indicated that over half of the buses from the first and second phases exceeded permissible levels of atmospheric emissions of the city. Notably, concerns were raised regarding the use of diesel fuel in TransMilenio buses.

Having access to the TransMilenio network data, such as number of buses, their itenaries, time they drive, emissions of the buses would allow us to search for pollution effect of the new line. This could be included as a disutility in a worker's utility function, as well as could serve to build counterfactuals: first, where the buses are replaced with low-emissions ones; second, where instead of the bus lanes, a new car lane is created. This would require more data on car traffic and potential increase in it when a new lane is open.

The other effect of opening a new bus lane is decreasing commuting time. That might attract the workers to pay lower rents further from the city center, while keeping their commuting times constant.

This makes them emit more of the pollution, as the distance to job increases. It's an adverse effect of the new bus line that is left to be analyzed in the paper.

We could also examine the system's inefficiencies in terms of routes planned and pollution. However, it would require additional data on bus utilization which could be hard to obtain. Having this data, we could keep the workers' utility constant while simulating new bus routes to minimize the overall distance driven (which could serve as a proxy for pollution).

5. College decisions

New bus network gives new opportunities to individuals from the peripheries in terms of education access. Same as with the firms, we would expect the efficiency of a match of a student to a university to increase when the lane is created.

To examine the topic, we could conduct a survey at one of Bogota's universities that is located around the line. In the survey, we would ask about the student's characteristics (age, sex, final high school exam score that allowed them to get to the university) and address to calculate the commuting time. It would be done twice, before and after the line opening.

To identify an improved match, we would first provide descriptive statistics on students' residence before and after the line is open. Then, we could search for effects in the admission threshold. If number of spots for a particular course is constant, when the access to the university increases, the threshold to get in should increase.

To account for the general equilibrium effects, such as potential relocation or external migration, we could use the author's model, where workers would be switched to college candidates who would derive utility from quality of education. We could measure this quality using previous year's admission thresholds. Instead of university location decision, we could think of increasing university's capacity (e.g. to keep the admission scores constant). Then, we could measure the effects of increased number of college graduates (or increased quality of college graduates) by using the differences in wage of low and highly educated workers in Bogota. Quantifying this effect would surely help understand policy-makers how public transportation affects long-term efficiency of a city. Further analysis could be focused on inequalities, and how new transportation affects the access to new college opportunities for periphery-based students, low- and high-income ones. Adding the previously mentioned crime component with gender-based violence can show how college choices are affected by the traveling routes[4].

[4]similar to the analysis conducted at Dehli University: Borker, Girija.
Safety First : Perceived Risk of Street Harassment and Educational Choices of Women (English). Policy Research working paper,no. WPS 9731 Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/723631626710146405/Safety-First-Perceived-Risk-of-Street-Harassment-and-Educational-Choices-of-Women

6. Incentivizing eco-friendly forms of transport

With 8 passengers per square meter[5], TransMilenio is a highly overcrowded system that disincentives the workers to use it. If the city is unable to provide more buses to overcome this problem, granting rights to use the bus lanes to other vehicles might be a temporary solution. Precisely, we could hypothesize of incentivizing to use electric scooters that are environmentally friendly to be allowed to use these lanes.

As we already have the data on transportation and preference for the transportation modes, the only data we're missing is on cost of having a motorcycle.

We would have to extend the author's analysis, allowing first, the worker to have a motorcycle, second, to distinguish between a combustion and an electric engine. The greatest challenge arising is to predict the time of commuting using a motorcycle on a new bus lane. As other cities widely practice sharing the bus lanes with motorcycles, we could search for data in time improvement there and come up with a similar analysis.

We would expect a large increase in welfare gains out of allowing electric scooters to share the lane with buses. However, deepened inequalities among rich and poor might also arise, as the cost of an electric scooter is high. Furthermore, we would have to examine the congestion effects of this policy.

This is particularly important for the policymakers, as it might be a compromise between the current overutilization of the system and efficiency. At the same time, appropriate concerns for pollution are addressed.

7. Rents distributions and inequalities

The author provides a comprehensive analysis of the impact of Bogota's TransMilenio BRT system on the city's structure and welfare. However, the paper's focus on welfare and inequality changes leaves a gap that is unanswered: how are the welfare gains and losses distributed across different income groups due to changes in rent prices resulting from the BRT's opening? In the author's analysis the profit from rent is distributed equally, while in fact, landlords are expected to be the main beneficiaries of the price hikes. The analysis primarily examines the aggregate effects of the BRT on welfare and inequality, using a quantitative model of a city with multiple worker skill groups and commute modes. While the author uses poor-rich worker distinction, the change in rents for the workers who own housing coming out of the BRT is not included. There is a space for an analysis to identify which

[5]https://www.semana.com/nacion/articulo/transmilenio-colapso/379695-3/

groups experience rent increases or decreases due to the BRT, and how these changes affect their welfare.

We would need detailed data on rent prices and household incomes at a tract level. This data should span the pre- and post-BRT periods to allow for a comparison of rent changes and their association with the BRT's construction.

To analyze this distributional aspect, we would need further distinction of workers in the analysis. If we assume a part of rich workers to be home-owners with rents distributed only to them, this would have significant effects on utility of rich and poor workers. With open migration, the floorspace prices experience a hike that could further extend the current inequality rise caused by the program.

The findings of this analysis would have significant policy implications. If the BRT is found to exacerbate rent inequalities, policymakers could consider implementing targeted interventions to mitigate these effects. These interventions could include rent control policies in areas with significant rent increases, affordable housing initiatives near the BRT, or targeted subsidies for lower-income households to offset increased housing costs.

Furthermore, the analysis could inform urban planning decisions regarding the location of future BRT lines. By understanding the distributional impact of rent changes, routes that minimize displacement of lower-income residents and promote equitable access to transportation and housing could be prioritized.

8. Conclusion

The author provides a deep analysis of the BRT's construction and its effects on welfare and inequalities. He includes plenty of extensions himself - congestion, change in floorspace use, Land Value Capture implementation, domestic services employment and home ownership.

Most of the extensions I propose are directed towards social issues, including crimes, rent distribution, education or pollution. However, the author's paper serves as a solid baseline to conduct further analysis and extend the strategies already provided in the paper.