FUNDAÇÃO GETULIO VARGAS
ESCOLA de PÓS-GRADUAÇÃO em ECONOMIA

**Yan Richard Alfeu de Oliveira**

# Subway station effects on housing prices: Evidence from São Paulo

**Rio de Janeiro**
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Dissertação para obtenção do grau de mestre apresentada à Escola de Pós-Grauação em Economia

Área de concentração: Microeconomia aplicada

Orientador: Sophie Mathes

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**MESTRADO EM ECONOMIA**
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**YAN RICHARD ALFEU DE OLIVEIRA**

**"SUBWAY STATION EFFECTS ON HOUSING PRICES: EVIDENCE FROM SÃO PAULO".**

**DISSERTAÇÃO APRESENTADO(A) AO CURSO DE MESTRADO EM ECONOMIA PARA OBTENÇÃO DO GRAU DE MESTRE(A) EM ECONOMIA.**

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*Aos que ficam*

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For hanigen with hunigen still haunt ahunt to finnd their hinnigen where Pappappapparrassannuaraghеallachnatullaghmonganmacmacmacwhackfalltherdebblenonthedubblandaddydoodled and anruly person creeked a jest

Finnegan's Wake - James Joyce

# Resumo

Estações de metrô novas têm impacto conhecido nos preços de moradia em suas redondezas, com parte dele já acontecendo quando do anúncio da construção. Estudando tipos diferentes de estações, esse trabalho considera possível heterogeneidade nos efeitos de preços devido a diferentes definições de tratamentos, tipos de transporte por trilhos, efeitos devido a um cancelamento e restrições temporais para os mercados de venda e aluguel na cidade de São Paulo. Encontra-se, através do método de diferença em diferenças, efeitos totais que vão de -2,30% para moradias à venda distantes até 200 metros de uma estação de metrô nas partes mais ricas da cidade até um aumento de 11,80% para moradias à venda distantes até 350 metros de uma estação de monotrilho em bairros pobres. São encontrados indícios de que o mercado de aluguéis responde com maior intensidade a esses fatos. Ademais, usando um estudo de evento, a evolução de preços entre o anúncio e a inauguração de uma nova estação é calculada, novamente mostrando fortes indícios de heterogeneidade entre as estações e uma resposta mais significativa do mercado de aluguéis.

**Palavras-chave:** Metrô, moradia, antecipação, estudo de evento, diferença em diferenças

# Abstract

New subway stations are known to have significant impacts in housing prices in its vicinity, with part of it taking place when the station's construction is announced. Exploring different types of stations this work examines possible heterogeneity in price effects due to different treatment definitions, types of rail, cancellation effects and time-related restrictions for both rental and sales market in the city of São Paulo, Brazil. It finds, with a difference-in-differences approach, total effects ranging from -2.30% for units for sale closer than 200 meters to a subway station in the richer parts of town to a 11.80% price bonus for units for sale closer than 350 meters to monorail stations in poor neighborhoods. Evidence is found that the rental market generally responds in a stronger fashion to these developments. Additionally, using an event study design, the price evolution from announcement to opening of a new station is calculated, again showing strong signs of station heterogeneity and a more relevant response from the rental market.

**Keywords:** subway, housing, anticipation, event design, difference-in-differences

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# Chapter 1

# Introduction

Subways are a very efficient means of transportation, helping a large amount of people to move around town quickly and cheaply. This higher mobility turns an apartment next to the station in a highly prized asset for many individuals, specially in cities that suffer from streets clogged with traffic. As a lot of people look for a home close to a station, prices go up correspondingly. Accordingly, people react to announcements of a new subway line and, looking forward to living next to a future station, they start to bid up housing prices around it before the station is even there, considering its net present value. These effects are well known and have been widely documented for many cities in the world.

However, renters have normally been left out from this analysis. From their point of view, this early price hike does not make sense, as they are not going to necessarily be there to profit from this future amenity. Furthermore, not all stations are created equal. A better service should be more highly valued than the most basic connections. Additionally, what counts as close to a station may be relative, a 5 minute walk is a very different distance for a 18 year old and a retiree. These kinds of conditionals are important and worth studying on their own.

But even then, even if all these aspects have been taken into account when estimating how much a station is worth to the prices of housing units close to it, not all announcements and inaugurations are the same. A station that will be here in 3 years is not the same as one that will be in 6 months. A station that will open in a neighborhood already serviced by other lines is not the same that one that will open in a previously disconnected area. If these kind of effects are better understood, as there surely is place for them to be, better public policy can be structured around it.

For mass transportation expansions are commonly planned and financed by the public, it makes sense that its interests should be taken into account. It may be interesting, for instance, to tax those who stand to gain the most from property appreciation, in order to pay for part of the expansion that generates this extra value, avoiding that the private captures a large chunk of the public expense. Moreover, arguments can be made over which part of a new line should be prioritized, if a new station in an impoverished area further away has the potential of fostering long-term effects improving its surroundings, it should be delivered faster than those in already wealthy areas.

If those policies and discussions are to take form, though, it is necessary first to understand how prices move due to a station, both in regards to the station's characteristics and the moment in time. A great opportunity to do so lies in São Paulo, home to over 23 million people in its metropolitan area. With a system that has seen gradual and incremental expansions for the last 50 years, the city has seen many different types of neighborhoods being reached recently, providing the variety in cases necessary for this type of research. Also, finding homes for all these people, who are the most affluent in Brazil, creates a very large housing market and one that still sees significant construction today.

Another point in favor of São Paulo is the proximity to a free market that its rental market

enjoys, with no units under rent control or affordable housing units mandated for new development. Although the city has incentives for building affordable new units, they are merely that, incentives, and can be ignored if market conditions are right. In addition to that, Brazil's rent law only stipulates that contracts are valid for 30 months, during which the only rate changes are annual inflation corrections, leaving the landlord free to initially set the rent as high as market conditions allow. Thus, no special considerations regarding idiosyncratic control mechanisms need to be made for the eventual results.

São Paulo's experience is important as the city still plans major subway expansions for the next two decades and can learn from what has happened so far in its history. This information can also be valuable for other cities in Brazil, that have recently started to implement or expand their mass transit infrastructure, and to other large cities in emerging markets worldwide, who are likely to come across similar challenges in the near future.

# Chapter 2

# Literature Review

The impact of subway stations on housing prices has been studied since the early 70's, with some of the earlier work analysing whether the station had an impact, such as Dewees (1976). Previous works shows that there is an effect on land values due to the presence of rail stations, but it is mostly focused on whether this effect is absolute or dependent on devaluation of land further from the station. This paper, however, considers a new subway line in Toronto, where the author uses housing sales data to study whether the lower cost of travel to a central business district is reflected on higher prices in this region, comparing the same region before and after the construction of the subway. First results were promising, showing an effect in a radius of one third of a mile from each station, in all directions and creating a pattern of pricing based on the stations themselves, not on the line.

Another important point comes with the results found by Damm, Lerman, Lerner-Lam and Young (1980) with data from the Washington, D.C., subway system. The authors show that the price effect is already extant before the stations are actually opened, as people start considering the future value of living in proximity to the subway and increase the relative desirability of the area around the station, and that it depends directly on the distance from the future station. Moreover, as the construction phase of subway systems normally takes a long time, the announcement of a new station may already be enough to start changing the characteristics of a neighborhood. The paper, though, doesn't have data on post-inauguration prices since it was published while construction was still underway, thus, the authors couldn't quantify how much of the price effect is brought forward.

A third relevant study was done by Grass (1992), where through the use of control areas, an estimate was made of the value of having a station at all, instead of the distance to the station. Building on earlier work that tried to identify how far from the station a unit could be and still receive a price premium from access to the rail system, the author defined one quarter of a mile circles around stations in Washington,D.C., and compared their prices in 1970, before the subway system was in operation, and 1980, using similar zones in the city that did not get stations as controls. Thus, the premium was estimated as a 19% increase in price for those units who were inside one of these regions, or around $17,350.

A more recent study has been made by Agostini and Palmucci (2008), who used Santiago, Chile, data to investigate how much of the appreciation is anticipated, by considering a time frame composed of a starting point, the announcement that a new subway line was going to be built, the publication of the basic engineering project including station location, the start of construction, the opening of the new line and the first few months of operation, when the population would have been already used to it. With this setup, the authors found that the announcement of a new line increased prices between 4.1% and 7.9% depending on the distance to the future station, while the begin of construction led to a further 3.9% to 5.4% increase. The paper, however, did not quantify the impact of the start of operations.

Since then, this effect has been studied and quantified for many cities around the world and

there have been attempts to better quantify it through larger data sets, find other potential determinants and different ways through which it can manifest. Works in this area include extensions to developing countries, such as in Seoul by Bae, Jun, and Park (2003), impacts on land use and population growth such as in Wuhan by Tan, He, Zhou and Xie (2019) and differences between ordinary and main transfer stations in Beijing by Dai, Bai and Xu (2016). The results are in line with earlier works, finding a positive premium based on proximity to a subway station, that is anticipated by the population and manifests through higher prices and/or increased housing supply in the area. Thus, it can be said that it is well established that this effect exists and it is possible that a similar scenario exists in São Paulo.

Overall, additional studies, such as McDonald and Osuji (1995), McMillen and McDonald (2004) and Hess and Almeida (2007), have estimated the subway premium to be in between 3.7% to 23% increase in housing prices in the proximity of new stations. These results are found through multiple means, such as direct regression of housing prices, analysis of saved commuting time for the average earner living around stations, hedonic price models and network effects for connecting new neighborhoods.

In the São Paulo context, while there appears to still be no estimation for expected increases in housing values for a generic subway station in the city as a whole so far, there have been studies about the impact of a single station on its district, such as Moraes(2016) or land use such as Alvim, Darido, Lippe and Mehndiratta (2013), whose results are as described in other cities in the literature.

In Gupta, van Nieuwerburgh and Kontokosta (2022), an analysis regarding rent values is made, comparing it to increases in sales values around New York's Second Line recent expansion into the Upper East Side. It is shown that rent values increase less than sales value, 2% versus 6% and there is evidence of anticipation effects of a smaller magnitude in this market, as there is an increase of only 0.69% in rents relative to the construction period.

This present work can improve the literature by studying further differences between rental and sales markets in different contexts, taking into account rail types and possible treatment definitions. Also, the evaluation of a cancellation and an analysis of price evolution through time are apparent gaps in the literature that can be filled. Finally, in the specific context of the data used, an aspect of the rent law can be measured.

# Chapter 3

# Estimation Strategy

The first instinct to calculate effect of subway station presence is to obtain it from a comparison between regions that have them and those that don't, holding everything else constant. However, the choice of where a station is going to be built isn't random, so there may be effects other than the stations themselves that cause difference in prices or construction activity between areas. For a given place to be chosen as a subway station, it likely has some characteristics that other places don't, such as the presence of a bus terminal, higher density, proximity to hospitals, etc. If a regression is done on all regions, the estimation is going to have difficulty separating how much of the difference is due to the subway itself and how much is due to these other factors.

To identify the effect on the desirability of a given neighborhood depending on the presence of subway stations, it is helpful to have some kind of counterfactual. As it isn't possible to get data from a parallel São Paulo where the stations are placed differently, the next best option is to compare regions with their surroundings, limiting how different they may be from the immediate area that was treated. This is done considering housing units that are inside a 700 meters radius from a station as its interest zone, with a smaller circle around it as the treatment zone. To decide which is the limit for the treatment zone, the first analysis is done, aiming to see whether there is any difference in the announcement and opening values for different distances from the station. Treated then is considered anything up to the tested distance, and control is tested both as starting at the same distance or 100 meters away, always considering its outer limit as 700m. This analysis is done through equation 3.1, which is a two-way fixed effects difference-in-differences model.

$$\log P_{i,t} = \alpha + \beta_1 d_{1i,t} + \beta_2 d_{2i,t} + \gamma X_{i,t} + \eta_{loc} + \mu_t + \varepsilon_i \tag{3.1}$$

This equation, where the dependent variable is the log of prices asked, either sale or rent, on control variables and an indicator for the treatments of having had a station announced in the region and this station having already entered service. Specifically, $P_{i,t}$ is the price of transaction of a house $i$ in moment $t$, $d_1$ is a dummy for the announcement of a new station in that area, $d_2$ is a dummy for the inauguration of a new station in that area, $X$ is a vector of unit characteristics, meaning those discussed in the Data section with the housing unit's age added, $\eta$ is a fixed effect for the location in the city and $\mu$ a fixed effect for a moment $t$, with individual error $\varepsilon_i$. Note that once a station opens, the housing units inside its treatment zone have both treatment dummies as 1.

Once the control/treatment border is chosen from the first analysis, the same framework is used to study the difference of treatment effects for monorail and subway stations, by choosing the respective datasets. There is, then, a case where the second treatment is now read as having had a station cancelled in the housing unit's area, which is used to analyse the effects of Line 18's announcement and later cancellation.

Now, equation 3.2 is used to study how does the asking price vary through time as the opening approaches, using an event study design. The equation drops the dummies for announcement

and operation of new stations, substituting them for $d_3$, which is a dummy for each category of time expected until the opening or elapsed since it. The categories range from 21+ quarters left until opening until 2 quarters left and 1 quarter after until 4 quarters after, dropping one quarter before opening to avoid a dummy trap.

$$\log P_{i,t} = \alpha + \beta_3 d_{3i,t} + \gamma X_{i,t} + \eta_{loc} + \mu_t + \varepsilon_i \tag{3.2}$$

# Chapter 4

# Data

## 4.1 Housing data

The source is ZapImóveis, the main online housing marketplace for renting and selling units in both São Paulo and Brazil as a whole. The database is composed of monthly entries of ads in the platform, starting in January 2014 and ending in October 2022, each containing the unit's geographical coordinates, state, city, neighborhood, address, postal code, type (house, apartment or rural), floor (for apartments), transaction type (for rent or for sale), median listing price, condominium fees, usable private area, number of parking spaces, rooms, regular bedrooms, bathrooms and en suite bedrooms, construction year and total area.

As the data is generated by the website's users, there may be many typos and inconsistencies in it, as well as legitimate outliers. To try and clean it, the following selections are imposed after observing histograms from the whole data set:

- Cities are restricted to São Paulo, São Caetano do Sul, Santo André and São Bernardo do Campo, as these are the only ones so far to have proposed subway stations;
- Both total area and usable private area are limited at 1000m$^2$;
- Rooms, parking spaces, bedroom, bathrooms and en suite bedrooms are limited to a maximum of 10 units;
- Highest possible floor admitted is 50;
- Earliest possible building year is 1901;
- Highest condominium fees are 15000 reais per month;
- Highest possible selling price is 15 million reais;
- No attempt is made to exclude potential typos in addresses and postal codes;
- Coordinates and neighborhood data are generated by ZapImóveis's system, not from user input, and are thus considered to be correct;
- No duplicates are allowed, as it is a common practice for competing real estate agencies hired by the same person to put up individual ads for the same housing unit.

This database is then further restricted to certain circles in some neighborhoods of Greater São Paulo. To define these circles, a list of locations of interest are defined in the city, composed by all of the subway and monorail stations currently in operation in São Paulo, all of the stations under construction in lines 2, 6, 15 and 17, as well as those that have been cancelled in line 17. Also, stations of the cancelled line 18 in the surrounding cities of Santo André, São Bernardo do

Campo and São Caetano do Sul are considered. No input is considered from train stations. The circles, then, are defined for 700 meters around each station. This limit is chosen to reflect the fact that if a housing unit is over 700 meters away from a station, it would already be closer to the next station in that direction, if there were any. The limit of what is treatment and what is control inside this circle is defined at each test and is explained in the Estimation Strategy section.

Each housing unit is tied only to the closest station, if it is closer than 700 meters for more than one station, and for those close to transfer stations they are always tied to the one that opened earlier. The only exception for this rule are stations Consolação (Line 2) and Paulista (Line 4), which have different coordinates and are treated as completely different places. Which stations are considered is defined at each test and is explained in the Results section.

## 4.2 Stations data

Each station's coordinates are retrieved from GeoHack and Google Maps. For those on line 18, they are retrieved per Google Maps from location previews from a presentation[1] given at a São Paulo State Assembly public hearing by VemABC, the consortium hired to build the line. For the stations that have already opened, the inauguration date is available at Metrô's Portal da Transparência, the website where the state-owned company that operates most of the system publishes some of its data. For the announcement dates, these are retrieved from newspapers and public archives, considering the day when the building contract was signed for those stations announced from 2004 and the day construction started for those announced before, due to changes in Brazilian public procurement processes.

For expectations, that is, how many months were expected until inauguration for each under construction station since 2014, official progress and expectations are published monthly by Metrô since January 2017 for all lines whose construction was hired by it, which includes every expansion in the period except for Line 6, and these are available as well at Portal da Transparência. For Line 6 as a whole and the others between January 2014 and December 2016, predictions are taken from public announcements by the Governor of São Paulo, the President of Metrô and the State Secretary of Metropolitan Transportation.

## 4.3 Inflation

For real price corrections, the IPCA index number, Brazil's main inflation gauge, is published monthly by the Brazilian Institute of Geography and Statistics - IBGE, and is rebased to 1 at January 2014.

[1] Available in Portuguese at https://www.al.sp.gov.br/repositorio/bibliotecaDigital/21032_arquivo.pdf

# Chapter 5

# Results

## 5.1 Treatment areas

The definition of treatment is not clear cut, as there is no specific distance at which people will stop considering a housing unit close to a station. It is, in fact, likely that the treatment effects vary along the distance to the station and the different factors in play suggest that this effect may not vary in a linear way. To try and take into account these possible variations, different borders between control and treatment are considered inside the interest zone circles described in the Estimation Strategy section.

Possible treatment zones are evaluated considering distances from 100 meters until 550 meters, every 50 meters. The control zones are, then, calculated with two different instruments, the first one, named "donut", taking an immediate transition to control at the border, and another, named "buffer", with a 100 meters buffer zone between them, always considering the outer limit as the interest zone's outer limit at 700 meters, e.g. for the 300 meters border, the "donut" instrument will consider everything up to 300 meters as treated and everything between 300 meters and 700 meters as control, while the "buffer" instrument will consider everything up to 300 meters as treated and everything between 400 meters and 700 meters as control.

Using Equation 3.1, announcement and operation treatment values are retrieved for different treatment borders inside the interest zone. The summary statistics and main regression results for the border at 200 meters, using donut instrument in the sales market are shown in Tables 5.1 and 5.2, respectively, to exemplify the measures taken. As the tables show, there is not a significant difference between housing units in the treatment and controls zones at this border choice, with only a small tendency of units further away to be larger, but in the same price range of around 8.100 reais per square meter of useful area. Also, it is important to note that the regression shows results that are expected for the confounders, such as higher prices for larger units, units with more bedrooms, en suites, bathrooms and parking spaces, as well as more recently built units. The regression also shows a preference for the increase in size to not be spent in an increased number of livings rooms. Finally, there is a large premium when pricing an apartment, likely due to the increased amenities that a condominium can offer.

These values are retrieved using all housing units between January 2014 and October 2022 close to any of the 15 subway stations that have opened in this period. For this analysis, the location fixed effect is done at the *bairro* level in ZapImóveis' database, which aligns with São Paulo City Hall's official division in 96 neighborhoods. Note that the treatment zone is always enlarging in this framework, so, for instance, what is considered treated at 100 meters will be considered treated for all specifications, but the influence of this group progressively diminishes as not only more entries are considered treated but also this happens at a quickening pace, due to the usage of circles.

Doing this regression for all border limits and for both instruments, we find the results in Table 5.3. The significance levels for announcement and operation values are based on standard

Table 5.1: Summary statistics for border at 200 meters, using donut instrument in the sales market

| Statistic | Mean(Sd) Treatment | Mean(Sd) Control |
|---|---|---|
| useful_area | 130.855 | 149.764 |
| | (85.505) | (107.858) |
| bedrooms | 2.579 | 2.727 |
| | (1.021) | (0.984) |
| en_suites | 1.297 | 1.453 |
| | (1.192) | (1.218) |
| bathrooms | 2.604 | 2.840 |
| | (1.499) | (1.540) |
| parking_spaces | 1.782 | 1.987 |
| | (1.237) | (1.271) |
| total_area | 147.869 | 171.051 |
| | (115.058) | (141.133) |
| living_rooms | 2.281 | 2.445 |
| | (1.183) | (1.195) |
| median_unit_price | 1,060,157 | 1,214,475 |
| | (908,412) | (1,061,732) |
| condominium_fees | 1,030 | 1,204 |
| | (771) | (968) |
| distances | 0.136 | 0.495 |
| | (0.046) | (0.111) |
| age | 24.162 | 25.19 |
| | (18.134) | (16.948) |
| apartament | 0.971 | 0.967 |
| N | 397,517 | 3,776,036 |

Table 5.2: Regression results for border at 200 meters, using donut instrument in the sales market

| | *Dependent variable:* |
|---|---|
| | log(median_unit_price) |
| useful_area | 0.003*** |
| | (0.00000) |
| bedrooms | 0.129*** |
| | (0.0003) |
| en_suites | 0.092*** |
| | (0.0002) |
| bathrooms | 0.037*** |
| | (0.0001) |
| parking_spaces | 0.099*** |
| | (0.0002) |
| total_area | −0.00003*** |
| | (0.00000) |
| living_rooms | −0.003*** |
| | (0.0003) |
| apartament | 0.129*** |
| | (0.001) |
| floor | −0.015*** |
| | (0.002) |
| condominium_fees | 0.00001*** |
| | (0.00000) |
| age | −0.004*** |
| | (0.00001) |
| announced | −0.021*** |
| | (0.001) |
| operational | 0.014*** |
| | (0.002) |
| apartament*floor | 0.015*** |
| | (0.002) |
| Observations | 4,833,824 |
| $R^2$ | 0.832 |
| Adjusted $R^2$ | 0.832 |
| Residual Std. Error | 0.293 (df = 4833691) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

errors retrieved from the regressions. These, and all other confidence intervals in this work are defined at a 95% level.

Table 5.3: Results for varying treatment distances

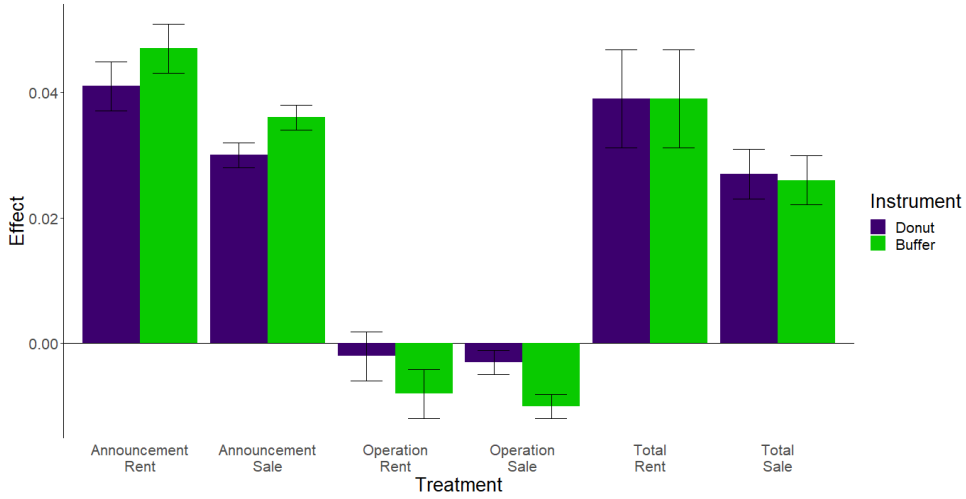
| Distance(m) | Mode | Announcement | | Operation | | Total | |
|---|---|---|---|---|---|---|---|
| | | Rent | Sale | Rent | Sale | Rent | Sale |
| 100 | Donut | -1.10%* | -3.90%*** | 5.40%*** | 2.70%*** | 4.30%*** | -1.20%* |
| | Buffer | -1.80%*** | -4.10%*** | 6.00%*** | 2.70%*** | 4.20%*** | -1.40%* |
| 150 | Donut | -1.90%*** | -3.10%*** | 1.00%** | 0.80%*** | -0.90% | -2.30%*** |
| | Buffer | -1.70%*** | -2.60%*** | 1.30%*** | 0.60%*** | -0.40% | -2.00%*** |
| 200 | Donut | -0.40% | -2.10%*** | 1.80%*** | 1.40%*** | 1.40%** | -0.70%** |
| | Buffer | 0.50%* | -1.40%*** | 2.00%*** | 1.50%*** | 2.50%*** | 0.10% |
| 250 | Donut | 1.00%*** | 0.05% | 1.00%*** | 1.30%*** | 2.00%*** | 1.35%*** |
| | Buffer | 2.50%*** | 0.90%*** | 0.60%*** | 1.10%** | 3.10%*** | 2.00%*** |
| 300 | Donut | 4.10%*** | 3.00%*** | -0.20% | -0.30%*** | 3.90%*** | 2.70%*** |
| | Buffer | 4.70%*** | 3.60%*** | -0.80%*** | -1.00%*** | 3.90%*** | 2.60%*** |
| 350 | Donut | 5.40%*** | 3.60%*** | -1.40%*** | -1.40%*** | 4.00%*** | 2.20%*** |
| | Buffer | 6.20%*** | 3.70%*** | -1.80%*** | -1.90%*** | 4.40%*** | 1.80%*** |
| 400 | Donut | 3.90%*** | 3.80%*** | -2.80%*** | -2.80%*** | 1.10%*** | 1.00%*** |
| | Buffer | 5.10%*** | 4.00%*** | -3.00%*** | -2.90%*** | 2.10%*** | 1.10%*** |
| 450 | Donut | 4.60%*** | 2.80%*** | -2.20%*** | -2.30%*** | 2.40%*** | 0.50%*** |
| | Buffer | 5.70%*** | 3.50%*** | -2.40%*** | -2.20%*** | 3.30%*** | 1.30%*** |
| 500 | Donut | 4.20%*** | 2.70%*** | -2.20%*** | -2.00%*** | 2.00%*** | 0.70%*** |
| | Buffer | 6.70%*** | 3.70%*** | -2.60%*** | -2.30%*** | 4.10%*** | 1.40%*** |
| 550 | Donut | 4.50%*** | 3.00%*** | -1.90%*** | -1.90%*** | 2.60%*** | 1.10%*** |
| | Buffer | 4.20%*** | 3.80%*** | -2.50%*** | -2.00%*** | 1.70%*** | 1.80%*** |

*Note:* *p<0.1; **p<0.05; ***p<0.01 *(announcement and operation)*

From these values we can see that there is a higher announcement effect in the rental market for every distance tested and for both border specifications, while the operation effect is larger until 200 meters, then becomes comparable for the next distances, again, for both specifications, as can be seen for 300 meters in Figure 5.1, . The total effect is larger for the rental market at all distances and for both specifications. This can be explained both by the sales market having a much higher baseline, as it is more difficult to pass a 5% increase in a sale of a 1 million reais house than it is to pass the same increase for the same house in a rent contract of 5,000 reais per month, and by a perceived higher bargaining power for the buyers in the sales market. The rationale is that renters generally are moving to a given area due to employment or studying requirements and are, thus, more inclined to accept a contract faster and easier, as they are often subject to a deadline and are generally able to change a housing arrangement deemed unsatisfactory in the future. Buyers, however, are normally conducting the largest transaction of their lives and plan to live in their target housing unit for many years, so should be much less pressed into closing a deal quickly and can negotiate better terms. Finally, it should be noted that all these effects are relative to the control group, so it is possible that nearly all of

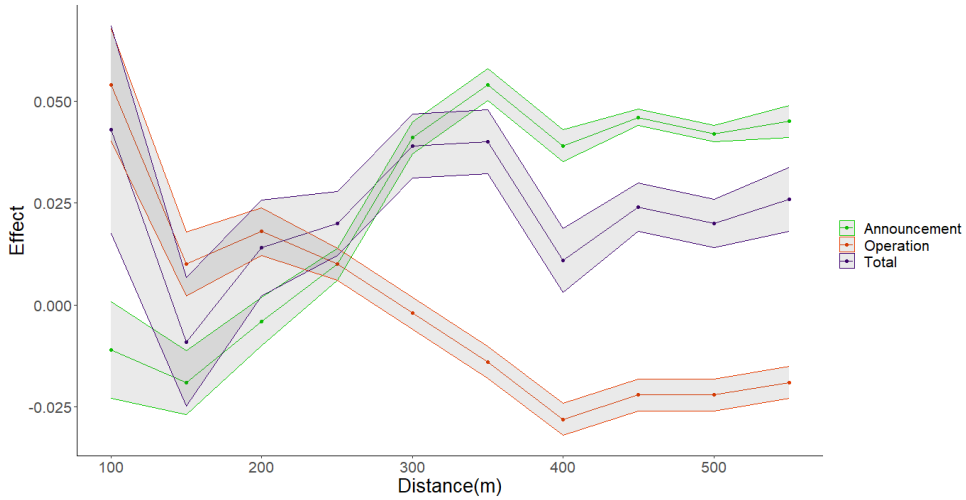
the housing units in this sample increased in value in this time period, the difference being only in how fast this happened.

Figure 5.1: Treatment effects for different instruments with the border at 300 meters




Interesting results also include the large drop in value in relation to the control zone at the closest units for both specifications and for both markets, as can be seen for the rental market in Figure 5.2. This may happen due to a concern that the house may be targeted for expropriation and from the perspective of living around five years exposed to negative externalities of station construction, such as noise and air pollution and higher traffic due to closed lanes, which are worse at blocks closest to the future station. It is also noticeable that this effect is strongly reversed in the rental market when the station comes into service, as it is now very desirable to live close to it. This opening bonus also happens in the sales market, but apparently is not strong enough to make the total effect positive. This may happen due to the age composition of renters and buyers, with typically older buyers perhaps valuing more living in less busy regions of the neighborhood and choosing to stay away from the station.

Figure 5.2: Treatment effects for different borders in the rental market with a donut instrument




A similar but opposite effect apparently happens at the other end of the scale, with treated housing units further away from the station driving a large announcement effect in both rental and sales market and for both specifications, but then suffering a relative drop when the operation starts. This can be explained by the same rationale as the preceding effect, with people wanting

to move away from the construction work but then preferring to live close to the now functioning station. It is noticeable, then, that this exodus from the station's vicinity is not to the more remote regions in the neighborhood, but only to slightly further away, since the effect is already positive and significant at 300 meters, meaning that even including the housing units until 100 meters, that suffer with the announcement, these housing units as a group are already relatively more valuable than those further away.

A fourth noticeable point is that the literature in this subject generally considers the treatment effect to last a quarter of a mile, which is roughly 400 meters, as was used in Grass (1992) when he introduced the circle method to this type of analysis. Here, we see that this is a good estimate, as the inclusion of housing units further away diminish the result for both specifications, probably due to the fact that these units are not perceived as close to the station by the real estate market. This effect, however, seems to start at 350 meters in São Paulo, so this will be taken as the main specification for the next treatment definitions.

Finally, there seems to be an increase in total effects in some cases regarding the buffer specification, but this is not true for all distances and both markets, as could be observed in Figure 5.1. This is also an advantage in choosing 350 meters as the default border going forward, it does not have this effect in a significant and consistent manner,as well as having the strongest effects in general. Furthermore, the plain donut instrument is also chosen as the default specification in order to generate results that can be compared to those from other works in the literature.

## 5.2 Different types of rail

For the second analysis, four different datasets are considered, to check whether there is any difference in announcement and operation effects on housing prices for different types of transportation. The opening of a monorail line provides an opportunity to compare it to the traditional subway stations that opened in other parts of town. From an intuitive point of view, the monorail should have worse results, as it has a much more disruptive construction, requiring the closure of street lanes all along the line and generating both air and noise pollution above ground, whereas subway construction negative traffic impact is mainly restricted to the block where the station is going to be and most of its noise and air pollution is generated underground, where it is not a nuisance. Additionally, when finished, the monorail carries less people than the subway, while also generating noise and visual pollution for those living around it.

As was done in the last section, summary statistics in the rental market around subway stations and the regression results for the sales market around the 10 monorail lines that opened in the period are presented, respectively, in Tables 5.4 and 5.5. It is noticeable that houses in the rental market are smaller than those in the sales market, observed in the first analysis, but this is true for both treated and control units, which are still similar to each other. Also, the results from the regression show again numbers that are in accord with economic intuition, varying only a little from those from the first analysis, even when now considering a very different region in the city.

The second variation in this analysis comes from the stations allowed into the dataset. The "total" specification considers all stations opened between January 2014 and October 2022, while the "restricted" specification only allows for those opened between January 2017 and December 2019, when there was a burst of inaugurations, including 8 out of the 11 monorail stations. This is done to reduce possible differences in long run effects in the operation value from earlier openings in the comparison between subway and monorail stations, as there is only one station opened in

Table 5.4: Summary statistics for the total subway dataset in the rental market

| Statistic | Mean (Sd) Treatment | Mean (Sd) Control |
|---|---|---|
| usefl_area | 122.219 | 142.802 |
| | (95.200) | (114.845) |
| bedrooms | 2.336 | 2.509 |
| | (1.066) | (1.1) |
| en_suites | 1.148 | 1.290 |
| | (1.136) | (1.243) |
| bathrooms | 2.344 | 2.562 |
| | (1.442) | (1.581) |
| parking_spaces | 1.715 | 1.898 |
| | (1.221) | (1.3) |
| total_area | 135.444 | 160.166 |
| | (126.149) | (149.571) |
| living_rooms | 1.976 | 2.113 |
| | (1.220) | (1.296) |
| median_unit_price | 4,488 | 5,079 |
| | (10,543) | (15020) |
| condominium_fees | 1,019 | 1,224 |
| | (784) | (1024) |
| distances | 0.245 | 0.514 |
| | (0.081) | (0.095) |
| age | 24.351 | 26.784 |
| | (16.199) | (14.939) |
| apartament | 0.965 | 0.964 |
| N | 359,059 | 754,909 |

Table 5.5: Regression results for the total monorail dataset in the sales market

| | *Dependent variable:* |
|---|---|
| | log(median_unit_price) |
| useful_area | 0.002*** |
| | (0.00003) |
| bedrooms | 0.096*** |
| | (0.002) |
| suites | 0.154*** |
| | (0.001) |
| bathrooms | 0.074*** |
| | (0.001) |
| parking_spaces | 0.117*** |
| | (0.001) |
| total_area | 0.0003*** |
| | (0.00002) |
| living_rooms | −0.006*** |
| | (0.002) |
| apartament | 0.121*** |
| | (0.002) |
| floor | −0.177*** |
| | (0.011) |
| condominium_price | 0.0002*** |
| | (0.00000) |
| age | −0.003*** |
| | (0.00005) |
| announced | 0.061*** |
| | (0.005) |
| operational | 0.009* |
| | (0.005) |
| apartament*floor | 0.176*** |
| | (0.011) |
| Observations | 156,179 |
| $R^2$ | 0.674 |
| Adjusted $R^2$ | 0.674 |
| Residual Std. Error | 0.215 (df = 156056) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

the monorail before 2017[1], while the subway has 12 out of 15 openings in this restricted period[2]. For both specifications, all housing entries in the database related to the selected stations are used. Finally, this is the point used to test differences between location fixed effects using the *bairro* and *distrito* entries in the ZapImóveis database. As previously stated, *bairro* follows the official division of the city in 96 sections, whereas *distrito* has 126 sections, some of which are identical to a *bairro*, while some may overlap more than one *bairro*. The results can be seen in Table 5.6.

Table 5.6: Results for monorail and subway systems

| Treatment | | | Subway | | Monorail | |
|---|---|---|---|---|---|---|
| | | | Total | Restricted | Total | Restricted |
| Announcement | Sales | Bairro | 3.60%*** | 2.60%*** | 3.90%*** | 6.10%*** |
| | | Distrito | 3.00%*** | 2.90%*** | 0.50% | 2.00%*** |
| | Rent | Bairro | 5.50%*** | 4.30%*** | -0.70% | 1.40% |
| | | Distrito | 5.20%*** | 4.80%*** | -4.00%*** | -1.50% |
| Operation | Sales | Bairro | -1.40%*** | -1.30%*** | 7.90%*** | 0.90%* |
| | | Distrito | -0.60%*** | -1.20%*** | 5.70%*** | 2.50%*** |
| | Rent | Bairro | -1.50%*** | -1.20%*** | 8.00%*** | 2.40% |
| | | Distrito | -0.20% | -0.60%*** | 6.70%*** | 1.60%*** |
| Total | Sales | Bairro | 2.20%*** | 1.30%*** | 11.80%*** | 7.00%*** |
| | | Distrito | 2.40%*** | 1.70%*** | 6.20%*** | 4.50%*** |
| | Rent | Bairro | 4.00%*** | 3.10%*** | 7.30%*** | 3.80% |
| | | Distrito | 5.00%*** | 4.20%*** | 2.70% | 0.10% |
| *Note:* | | | *p<0.1; **p<0.05; ***p<0.01 *(announcement and operation)* | | | |

The first and most important point is that the results for the monorail seem to be much larger, as can be seen with the total dataset when using *bairro* fixed effects, in Figure 5.3, contrary to what was expected, in both markets. This, however, can be explained by two main factors. The monorail was built in a poor neighborhood, aiming to someday reach Cidade Tiradentes, the poorest neighborhood of São Paulo, the subway, on the other hand, had stations opening mainly in the rich neighborhoods of Pinheiros and Moema. Therefore, the same baseline effect that differentiates rental and sales markets are in play here between these neighborhoods, even when accounting for location fixed effects.

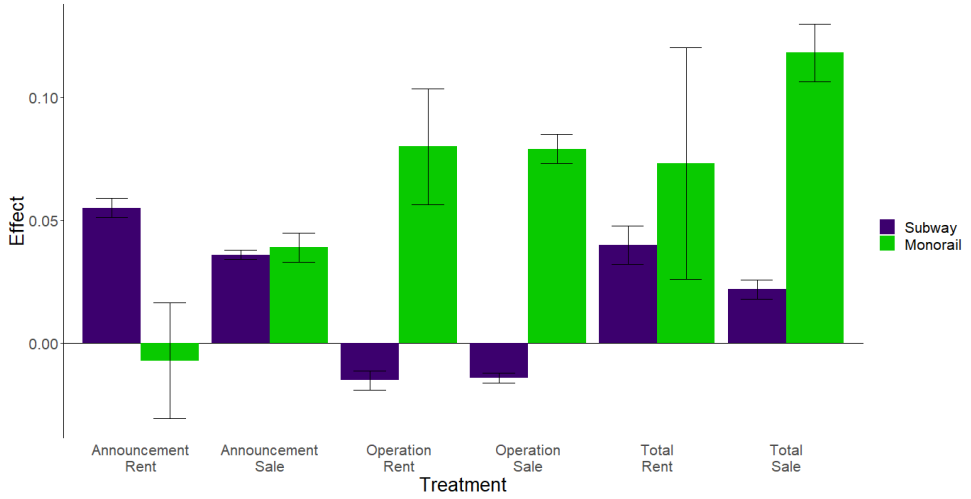
Furthermore, the subway lines built in this period, Lines 4 and 5, follow the Campo Limpo-Rebouças-Centro and Vereador José Diniz-Ibirapuera-Centro bus corridors, respectively, along rich neighborhoods where many of the inhabitants have cars and work fairly close in the main white collar hubs of of Paulista and Faria Lima avenues. This could mean that the subway lines here are seen as merely an upgrade of connectivity, shaving only some minutes from a typical commute, which is not the case for the neighborhoods serviced by the monorail. These regions are now serviced by a convenient line, which can get them to main job hubs in some 25 to 40 minutes, opposed to the previous usage of buses in a regularly clogged avenue that could take nearly two hours to reach the same place. Then, these neighborhoods are now an option for middle class workers who want to live reasonably close to work, instead of a last resort for people who couldn't afford other places in São Paulo, hence, the much greater price bonus around monorail stations from increased demand.

This line of reasoning is further supported by the literature, where we could argue that the

[1]This is the Oratório station, which opened alongside Vila Prudente in August 2015. However, Vila Prudente, being a transfer station, has no housing units attached to it. The final station so far, Jardim Colonial, opened in December 2021.

[2]Fradique Coutinho and Adolfo Pinheiro opened in 2014, while Vila Sônia opened in December 2021

Figure 5.3: Treatment effects for different rail types




subway effect here should be seen as similar to an upgrade, so it has results a bit higher than those seen for an expansion of the system for existing stations in Fesselmeyer and Liu (2018) in Singapore, where an effect of 1.8% in the sales market was found. Also, the monorail should be seen as a worse option than the subway, but still transformative as it is opening in a region previously served only by low quality buses and this is also reflected in having a positive and significant effect, but lower than those found in studies such as Grass(1992) and Agostini and Palmucci(2008).

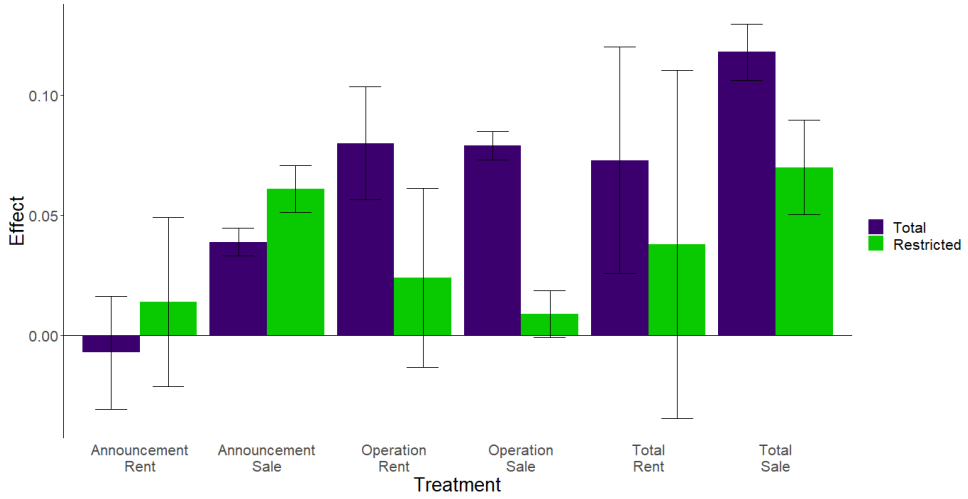
Also relevant is the difference between rents and sales in the monorail case. As expected, the rent announcement effect is much worse than in the subway case, due to a construction process that is much more of a hassle to people who live close by. However, this does not happen in the sales market and may be explained by the perspective that buyers in this region have of moving to a neighborhood that has great medium term expectations of improvements, as it attracts wealthier residents and should with time get better amenities, both private and public. As the construction of public rail transportation usually takes many years, it makes sense that the rental market does not incorporate this benefit at the same rate, since it is likely that whoever moves in just after the announcement is not doing it for some benefit years away. Note, though, that the rental market experiences large improvements when the station does open and has positive total effects.

An observation that can also be made based on the total and restricted datasets, as can be seen with *bairro* fixed effects in Figure 5.4, for the monorail is that a quality issue may be at play. The only difference between them is the inclusion of Oratório and Jardim Colonial stations, reflecting higher effects in the opening values, while worse results for the announcement. This could be caused by the fact that the stations that opened in the restricted period stayed for a much longer period than usual[3] in a "trial operation", where the system runs at a much lower capacity and only during off-peak hours during workdays, rendering the effect lower. Again, note that the announcement effects are actually larger for the restricted database, probably due to even stronger baseline and transformation effects as they are deeper inside São Paulo's poor east side, which can be read as meaning there was no reason to believe that there would be problems ahead for the line, making the diminished opening bonus the result of a reavulation of how much the service is worth.

The process of station selection does not seem important in the subway case, since the stations that are excluded in the restricted case do not differ substantially in where they are located from

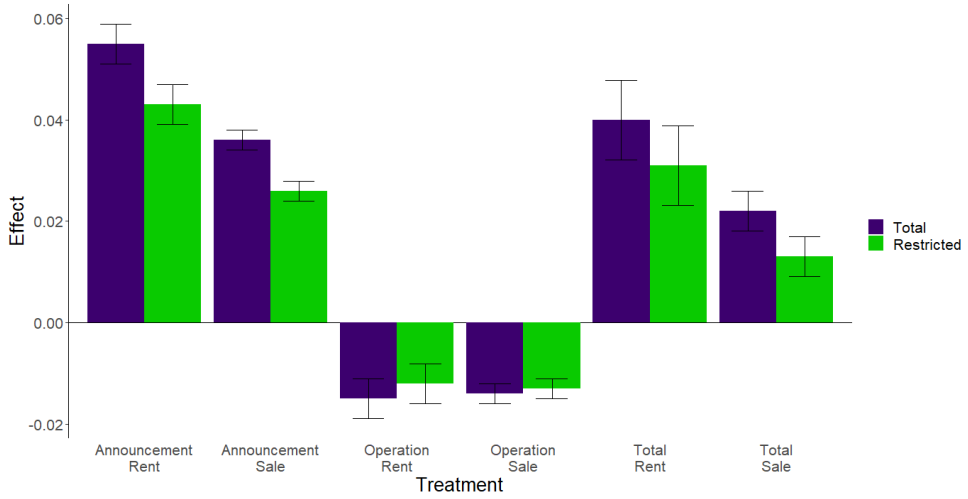
[3]This lasted for 8 months, where the usual period is 1 month. There are still relatively frequent issues with Line 15, resulting in occasional closures for tests.

Figure 5.4: Treatment effects for different monorail datasets




the others, as was the case in the monorail. Considering the larger effects found for the total dataset, as can be seen with *bairro* fixed effects in Figure 5.5, this may hint that the these bonuses may prove increasing in time, perhaps due to positive feedback loops being created around stations, where higher mobility and wealthier residents attract more desirable amenities, which by themselves attract wealthier residents, all this process reflecting in higher prices.

Figure 5.5: Treatment effects for different subway datasets

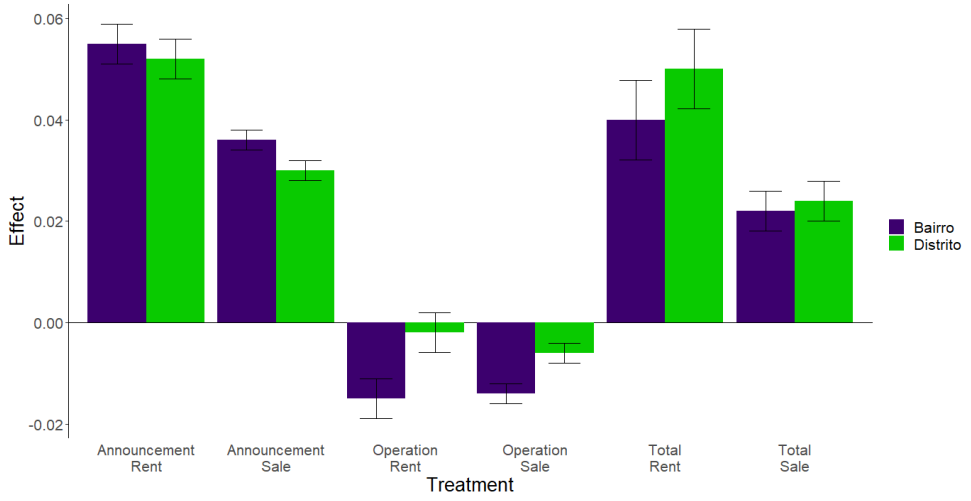



Finally, there does not seem to be any particular direction in the effect of using *bairro* or *distrito* as the fixed effect locations, as can be seen for the subway total dataset in Figure 5.6, resulting in somewhat larger effects for the subway and smaller for the monorail when using *bairro* fixed effects. This may be due to idiosyncrasies of the division limits in certain regions close to these stations. To ensure reproducibility for future works, *bairro* is preferred as the location fixed effect going forward given that this is the official division of the city, whose limits can be verified more easily.

## 5.3 The cancellation effect

For the third analysis, we consider a line that was announced and later cancelled by the state government to see whether the housing units in the regions concerned give up their announcement

Figure 5.6: Treatment effects for different location fixed effects




bonus once they learn that the transportation infrastructure is no longer going to be built. The intuition would be that they have to go back to their previous pricing patterns. The datasets here is composed of, in order, all housing units attached to a would be Line 18 station; only those ads that went up between January 2014 and December 2018, six months before the cancellation announcement; only those ads that went up between August 2014, the month of the first announcement, until October 2022.

As before, first summary statistics and regression results are presented in Tables 5.7 and 5.8. The housing units closer to the stations remain smaller and cheaper in absolute terms, but with the same range of price per square meter, as was before, with the only notable exception being the higher percentage of apartment buildings in the treatment zone. However, it is still considered that the groups are similar enough to move forward. As to the regression results, the numbers are read as before.

After estimating the effects for all the cases, the results are displayed in Table 5.9.

Contrary to intuition, we observe in Figure 5.7 that there was no drop in prices after the cancellation. As a matter of fact, in the sales market, there is even a small increase in the sales market, providing a total effect larger than that observed for subway stations that actually opened. This result is better interpreted when compared to the monorail line that got built.

First, the announcement values are similar, showing that the state's declaration of intent to build a line was believed, as it should be, since the considered announcement date is when a construction contract was signed. Second, the cancellation effect is much smaller than the opening effect is for the other monorail line, again, as expected, since they are effectively getting something worse than nothing at this moment. However, people may take the fact that the state wanted to build a monorail line in this region as an indicator that something will someday get built, as if the state signalled its perception of this region as relevant, so there may be incentives to consider housing in this region as a long term investment. This is specially true when taking into account the fact that the line was not built during this period mainly due to budgetary issues that afflicted the state, provoked by the 2015-6 recession, causing the then governor to not completely toss the project, instead replacing it with a segregated bus corridor that also faced funding difficulties. Supporting this hypothesis is also the fact that, when given the chance in the first gubernatorial election since the cancellation was announced, the front-runners, including the eventual winner, promised to build the monorail line, showing that the project is still considered desirable and future election calculations may eventually get it built.

This vision, though, does not apply to the rental market, as its benefits are very likely many years in the future, so it would make no sense for renters to pay for this possible benefit today.

Table 5.7: Summary statistics for every entry around the cancelled line in the sales market

| Statistic | Mean (Sd) Treatment | Mean (Sd) Control |
|---|---|---|
| useful_area | 94.130 | 107.746 |
| | (54.768) | (81.221) |
| bedrooms | 2.579 | 2.561 |
| | (0.669) | (0.694) |
| en_suites | 0.905 | 0.955 |
| | (0.933) | (0.969) |
| bathrooms | 1.907 | 1.963 |
| | (1.108) | (1.206) |
| parking_spaces | 1.692 | 1.813 |
| | (0.908) | (1.118) |
| total_area | 97.555 | 110.076 |
| | (69.923) | (88.811) |
| living_rooms | 2.382 | 2.407 |
| | (0.836) | (0.836) |
| median_unit_price | 388,552 | 418,880 |
| | (294,461) | (410,590) |
| condominium_fees | 389 | 428 |
| | (251) | (375) |
| distances | 0.261 | 0.543 |
| | (0.064) | (0.101) |
| age | 11.480 | 13.028 |
| | (11.245) | (11.653) |
| apartament | 0.956 | 0.872 |
| N | 307,491 | 701,491 |

Table 5.8: Regression results for every entry around the cancelled line in the sales market

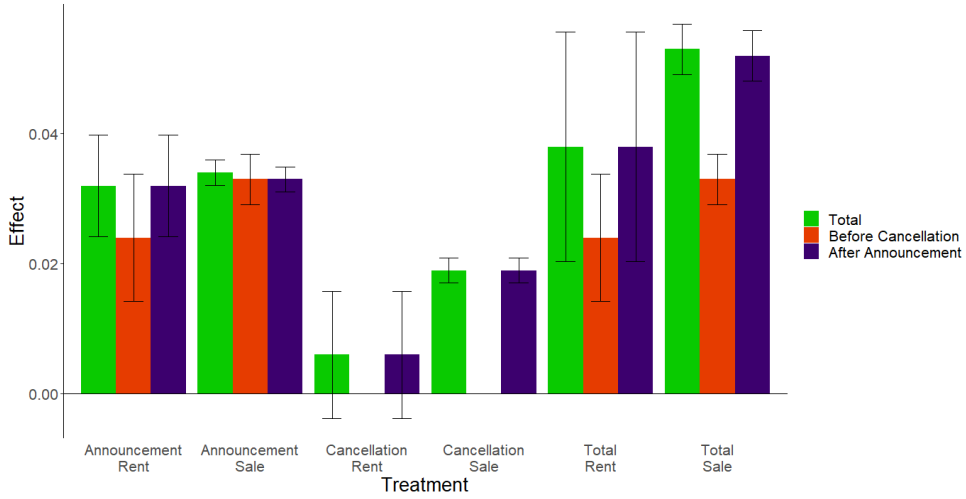
| | *Dependent variable:* |
|---|---|
| | log(median_unit_price) |
| useful_area | 0.002*** |
| | (0.00001) |
| bedrooms | 0.113*** |
| | (0.001) |
| suites | 0.140*** |
| | (0.0004) |
| bathrooms | 0.048*** |
| | (0.0003) |
| parking_spaces | 0.084*** |
| | (0.0003) |
| total_area | 0.0005*** |
| | (0.00001) |
| living_rooms | −0.017*** |
| | (0.001) |
| apartament | 0.031*** |
| | (0.001) |
| floor | −0.080*** |
| | (0.004) |
| condominium_fees | 0.00002*** |
| | (0.00000) |
| age | −0.003*** |
| | (0.00002) |
| announced | 0.033*** |
| | (0.001) |
| operational | 0.019*** |
| | (0.001) |
| apartament*floor | 0.083*** |
| | (0.004) |
| Observations | 1,002,975 |
| $R^2$ | 0.844 |
| Adjusted $R^2$ | 0.844 |
| Residual Std. Error | 0.222 (df = 1002842) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

Table 5.9: Results for cancellation effects

| Base | Announcement | | Cancellation | | Total | |
|---|---|---|---|---|---|---|
| | Sales | Rent | Sales | Rent | Sales | Rent |
| Total | 3.40%*** | 3.20%*** | 1.90%*** | 0.60% | 5.30%*** | 3.80%*** |
| Before Cancel. | 3.30%*** | 2.40%*** | - | - | 3.30%*** | 2.40%*** |
| Aft. Announc. | 3.30%*** | 3.20%*** | 1.90%*** | 0.60% | 5.20%*** | 3.80%*** |

*Note:* *p<0.1; **p<0.05; ***p<0.01 *(announcement and cancellation)*

Figure 5.7: Cancellation effects




And this holds true in the data, where we observe that rents stopped rising further when the cancellation was announced. The fact that they did not come down to their previous levels may reflect that during the 5 years where the line was expected, other developments in the local real estate market in anticipation to the stations made the would be locations more desirable by themselves. This also can be seen as a hint that this type of effective is cumulative through time, creating a positive feedback loop attracting more amenities to a region due to the presence of a subway or monorail station.

Finally, the different datasets used seem to make no difference, with the effects having the same magnitude throughout.

## 5.4 Price evolution

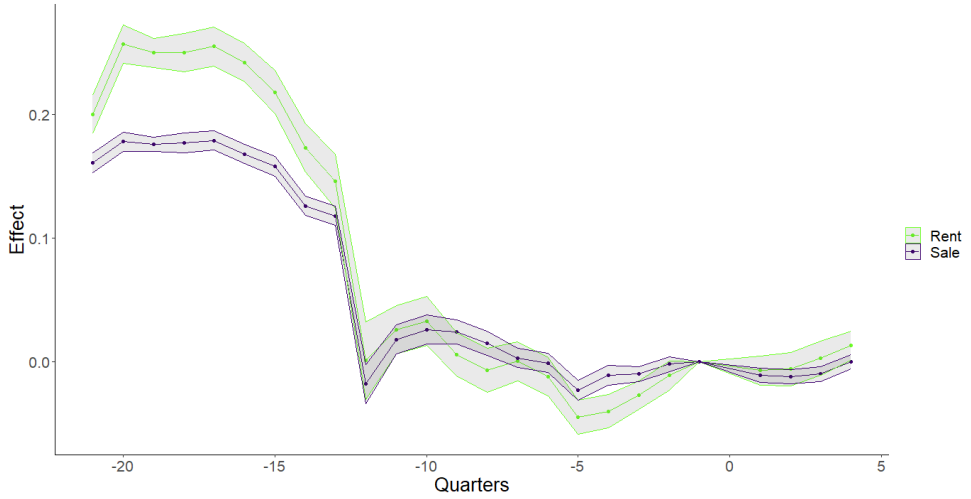
Now using Equation 3.2, the price dynamics for the rental and sales market are observed through time in an event study design, to observe how they responded to the construction progress. The monorail subset of stations is the same as in the second analysis, but the subway subset is increased by stations that were under construction in the period between January 2014 and October 2022, but have no yet opened, namely all the stations in Line 6 and the expansion underway in Line 2. In this regression, only treated housing units close to a station listed from the beginning of construction until one year after opening are considered, thus, there are no entries from before a station in that region was announced, nor entries from control zones. The time before an opening is taken as the expected construction time left at the time, not the actual time it took for a station to enter service.

Due to computational issues, it was not possible to use every possible entry in the sales

market around subway stations, so a sample was took randomly. All of the other three markets considered in this section used every available entry. Confidence intervals are defined from standard deviations. The quarter just before opening is dropped from the regression and taken as the reference against which all the other ones are compared.

First, in Figure 5.8, the price dynamics for the rental and sales market around subway stations is observed, with every entry from a station still more than 5 years away from the expected opening grouped in the -21 quarters point. As before, the rental market is more reactive than the sales market, even when considering relative terms, that is, it has a higher average level as revealed in the second section, and it deviates further away from it.

Figure 5.8: Subway price dynamics




Furthermore, a composition issue seems to be at play here. Most of the subway stations that made part of the analysis in previous sections were never more than three years away from their expected opening dates, while the new expansions, which serve poorer neighborhoods in the city's east and north sections, still have at least three years to go until inauguration. Thus, it seems that those housing units around stations in poorer places are having a much higher price bonus in both rental and sales than those in the richer neighborhoods. Again, it should be noted that these effects are in relation to prices one quarter before opening, and as the announcement value was positive in previous sections, it is likely that the true effect, in relation to housing units further away from the stations, is even larger. This is, also, yet another hint that the effect of stations on prices depends on whether the location being newly connected had other high quality transportation alternatives before. A further analysis in this section, separating datasets based on which line a station belongs to, which is a good proxy for transportation alternatives[4], is forthcoming.

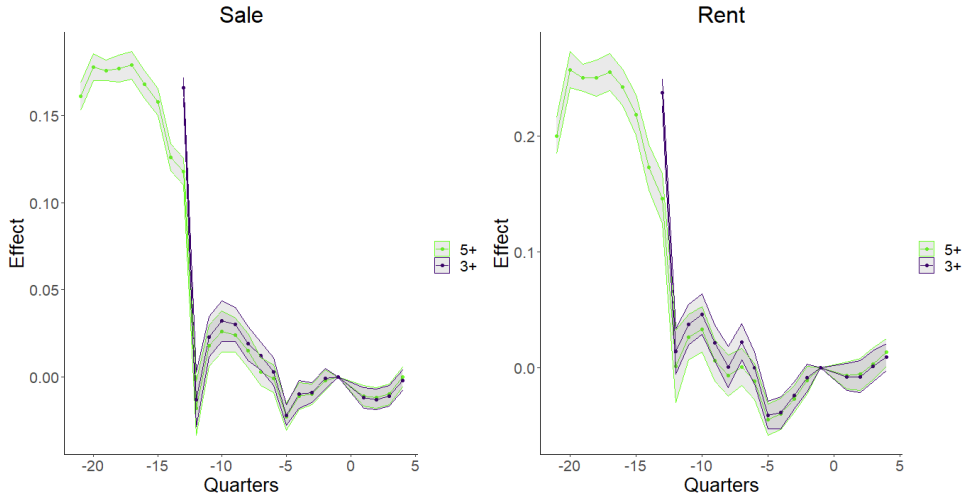
A third point is the behavior of rents in the quarters before opening. The Brazilian rent law has only one type of rent control, forbidding rate adjustment for the first 30 months after signing, when there is a fine for landlords or renters who choose to break this contract, allowing only for annual inflation corrections. Nevertheless, it is a common practice for a clause giving up the rights to the fine after 12 months to be included in rent contracts, effectively shortening the period where no rent adjustments can take place. In Figure 5.8, while the rent remains a tad directionless around two years before the opening, there is a drop at 7 to 6 quarters before the expected opening and then it starts picking up, perhaps showing that landlords start to price in the desirability of the service itself, progressively trying to lock in this bonus going forward. The fact that it does not happen all at once may be explained by the fact that different expectations

[4]As mentioned before, lines 4 and 5 follow main avenues with pre-existing bus corridors. Line 2's expansion and line 6, however, do not mainly follow any avenues or other existing means of transportation.

could drive some landlords to refrain from hiking prices so early, as they think delays are likely, to help compete in the quarters before an opening, hoping that enough time passes so that they could then increase prices when the inauguration actually takes place, as well as different practices regarding the fine removal clause. This upwards trend even reflects in the sales market, possibly through higher attractiveness for buy-to-rent investments, though further research is necessary to prove a causal relation. Notice, also, that the upwards trend continue after the opening in the rental market, and after a first slump apparently also in the sales market.

In Figure 5.9, a different horizon for the event study is tested, this time grouping everything over 3 years away from an expected opening in the quarter -13. There are no notable differences, except for the -13 quarter itself, since it is now responsible for the entries around lines 6 and 2.

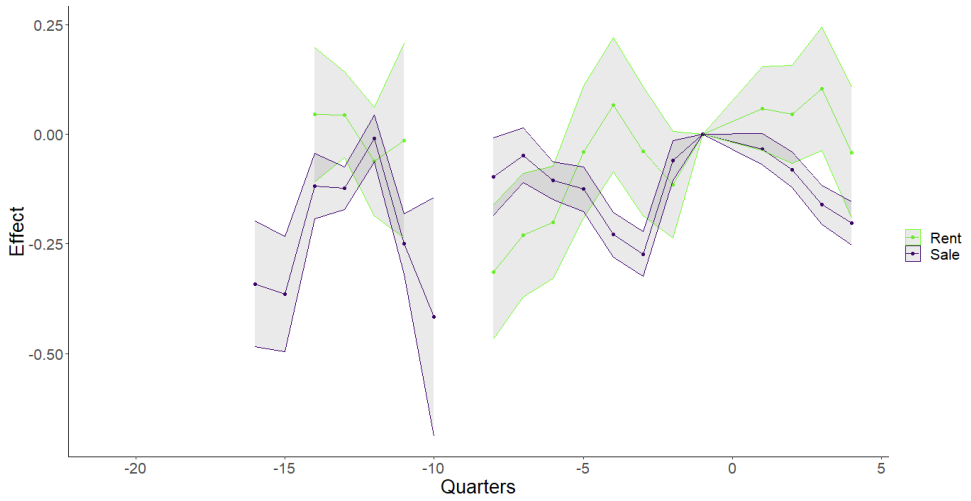
Figure 5.9: Subway price dynamics - Different models




Now, regarding the monorail stations, Figure 5.10 allows some comments. First, this is still a subject that could profit from more data points, as the large confidence intervals and the absence of a station with many entries passing through the 11 to 8 quarters to go period reveal. Nonetheless, it is still possible to observe a similar pattern on the rental market to the one present in the subway dataset. As there are only a few subway station, the spike of rent prices 4 quarters before the expected opening can be explained by an announcement in 2018 that sets back expectations for one year in 4 stations that were supposedly one month away from the opening. Also worthy of mention is the sheer magnitude of the effects before the opening, showing how unpleasant living close to a monorail construction site can be.

Moreover, a decrease in relative bonuses in the sales market, which still has a positive opening value in section 2, alongside a rental market that does not show the same continued impetus as the subway dataset showed, may betray a reevaluation of the monorail service worthiness, as was mentioned before. The constant operational problems observed in the first year of operation could have taken some of the shine off the housing units close to it.

Figure 5.10: Monorail price dynamics



# Chapter 6

# Conclusions

As the results achieved in this work show, the rental market appears to be much more sensitive to mass transportation developments in the vicinity, both in the announcement and inauguration phases and for both types of rail studied. This is an interesting result, as it contradicts what has been found in the literature and its possible causes, such as the impact of rent control laws in other cities or the increase in building potential around stations in São Paulo is a direction of further research on its own.

Also noticeable is how monorail and subway results diverge and are, at first, counterintuitive. However, specially aligned with the results in the price evolution analysis, these figures point to an importance of previous infrastructure in the region, showing that price increases depend not only whether a neighborhood is initially poor but whether it is already well connected to the rest of the city. Line 6 price increases so far have been well above those observed in Lines 4 and 5, even in the rich neighborhoods of Perdizes and Pompéia, which did not have a preexisting bus corridor or main avenue in the direction the subway takes.

Though an announcement seems to be enough to start a positive feedback loop of improvement in a region, even when the actual stations are never delivered, as seen in the Line 18 case, in the long run, it is likely that the actual quality of the service is essential for the price bonuses to retain their level. This expected phenomenon is most evident with the price evolution analysis regarding Line 15, where poor implementation and a rushed inauguration timetable resulted in trial runs that lasted for over a year and constant operational issues, which appear to have decreased the initial value attributed to the monorail by the real estate market.

Finally, it is also important to note the pickup in rent prices around the time constraint imposed by Brazil's rent law, the only control to which the market is subject in São Paulo. This may prove an interesting case to study the impact of different rent laws around the world, by analysing when does the expected price bonus kick in, providing an additional way to evaluate rent control mechanisms and their impacts on the real estate market.

Further research is necessary in this subject and there are many interesting points that can be studied. For instance, an analysis in the manner of Callaway and Sant'anna (2020) can be implemented to evaluate the price bonus of each individual station at a given moment in time, as to further test whether there is a difference between them and what could drive it, as well as check for increasing impacts over time, as the region around a station becomes ever more desirable through a positive feedback loop. These heterogeneous effects, if confirmed, could be used to argue for different construction priorities in future lines, using subway lines not only as a means of improving transportation infrastructure but also as a vector of development for certain neighborhoods.

An interesting direction for further research is comparing the results of the price evolution analysis, which are based on expected time until inauguration, with a similar regression done with actual time before inauguration. With this framework, a study about the credibility of government announcements could be done, São Paulo's data could be useful specially if Line

17, whose construction has undergone multiple problems throughout the last decade, can be included.

Further models could also be developed taking into account elements such as additional construction in a zone once the subway reaches it or a reduction of transportation to time saved and people carried as to make possible the evaluation of modes such as BRT and VLT.

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