THE UNIVERSITY OF CHICAGO

Medellín's MetroCables: Real Progress or Mirage?

A causal analysis of Medellin's MetroCables and their impact on annual income growth.

By

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Abstract

Global cities are increasingly integrating cable cars into their public transit systems. These initiatives are often motivated by the need to spur development in peripheral mountainous communities. Despite continued investment, the literature surrounding the causal relationship between cable car stations and income growth is minimal. This thesis investigates the causal impact of Medellín's MetroCable public transit system on neighborhood-level income using a pooled difference-in-differences (DiD) model and household survey data from the *Encuesta de Calidad de Vida* (2004–2017). Focusing on barrios where MetroCable stops opened during the observation period (2004-2017), the analysis identifies a statistically significant causal effect: residents of treated barrios experienced an average annual income increase of over 2 million Colombian pesos relative to untreated barrios. This result reflects the estimated effect of MetroCable access while controlling for fixed differences across years and barrios, as well as socioeconomic status. Descriptive analyses of median and cumulative income growth trends further support the conclusion that treated neighborhoods outperformed their matched control groups in income growth over time.

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Introduction:

The Medellin's mountainside periphery is home to many historically marginalized and under-resourced neighborhoods. The difficult topography of these mountainside communities has led to the chronic underdevelopment of road infrastructure. These issues, coupled with the frequency of improvised housing and unplanned development in these neighborhoods have left them isolated from the city despite their relative proximity to the city proper in the valley below. In 2004, the city of Medellin introduced the MetroCable program, which aimed to connect these peripheral neighborhoods to the urban core at the center of the Valley of Aburrá by using cable cars as a form of public transportation, integrated into the public metro network. These cable cars increase the ease of access to isolated mountainside neighborhoods with limited road infrastructure and have halved transit times (*The Metrocable: Transport by Urban Car in Medellin.*[1]) Nonetheless, support for the MetroCable program is not universal. As recently as 2011, city council members described it as a "pretty toy" meant to demonstrate commitment to urban economic development rather than as a practical driver of development (*Medellin's Low-Carbon Metrocables.*[2]) Cable-car public transit systems have sprung up in Caracas, La Paz, and Vietnam, with projects underway in India and the Philippines.[3] In the face of such continued investment, it is important to understand if these programs can contribute to development in low-income peripheral communities. To address this question, this paper will investigate the causal link between a barrio having a MetroCable stop and increased income among barrio residents while controlling for year-fixed effects, barrio-fixed effects, and socioeconomic status through a proxy measurement – estrato.

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[1] Centre for Public Impact, "The Metrocable: Transport by urban cable car in Medellín"
[2] Davila, Julio D. "Medellín's Low-Carbon Metrocables: Lifting Informal Barrios Out of Poverty."
[3] Barber, Megan. "11 Urban Gondolas Changing the Way People Move."

Historical Context:

It is worthwhile to take a step back and understand the context that led to the emergence of the MetroCable program. A historical analysis of settlement patterns shows that the city was formed from the consolidation of two colonial Spanish towns in the Valley of Aburrá called San Lorenzo del Poblado and Nuestra Señora de la Candelaria de Aná. In retrospect, the advantages of settling on this site were apparent. The Valley of Aburrá is situated at a relatively comfortable average of 4,800 feet above sea level, affording it a year-long mild climate, while also providing fertile land to would-be settlers. The same cannot be said for the surrounding mountains. Enclosed by the Andes, elevations quickly rise past 8,000 and even 9,000 feet over sea level just outside the city limits. These mountainous lands were historically unsettled due to their dangerous combination of elevation, steep slopes, and frequent precipitation, which make mudslides a frequent occurrence. Further discouraging settlement, cultivation in these areas can contribute to soil erosion, only increasing the chances of a deadly mudslide. These threats remain pertinent, for as recently as 2024 thirty-three people died in the neighboring department of Chocó due to a mudslide on a mountainside road. These inherent risks to settlement left the mountain slopes surrounding the valley for only the bravest, or most desperate, of settlers.

As the city of Medellín expanded, the question of mountainside settlement came to the forefront. Seeking housing in extreme poverty, informal communities were built on the surrounding mountain slopes. These informal communities are referred to as “invasiones”, or literally “invasions” in English. Construction in these areas is haphazard and unplanned, resulting in safety hazards for residents. Informal settlement also hinders economic mobility due to residents often lacking formal property ownership of their homes, potentially complicating the

accumulation of generational equity[4]. The steep mountainside left barrios surrounding the urban core of Medellín close but isolated. With limited road infrastructure connecting these communities to the city below, non-state actors held significant influence in these communities and sometimes governed in place of the state. While such vacuums of state control have been common in Colombia's 50+ year armed conflict, a rather infamous incident at the turn of the 21st century exposed the necessity to integrate Medellín's informal communities into its urban fabric. The incident, or rather battle, in question was 2002's Operation Orion, where the Colombian military had to raid and occupy the Comuna San Javier neighborhood to root out FARC and ELN urban guerillas that had taken control of the area, causing significant civilian casualties in the process. Due to this isolation from the city below, cycles of extreme violence and poverty persisted in these communities, and after a spur of economic development in Medellín in the early 21st century, debate ensued about how these neighborhoods could share the city's newfound success.

In 2004, the Fajardo mayoral administration made urban renewal and development a key objective. To reverse what they saw as "generational social debts"[5] to the people at the margins of the city, the administration underwent the PUI/Proyecto Urbano Integral (Integrated Urban Project), with the MetroCable system as the centerpiece, meant to connect people at the margins to Medellin's metro system. The development of the first MetroCable line (Line K) was jointly funded by the municipality and the publicly-owned Metro de Medellin Company, costing approximately 24 million USD, while the second line cost approximately 47 million USD[6].

[4] Alcaldía de Medellín, "199 Familias Vulnerables de Nueve Comunas de Medellín Recibieron Los Títulos de Propiedad de Sus Viviendas."
[5] Centre for Public Impact, The Metrocable: Transport by urban cable car in Medellín
[6] Centre for Public Impact, The Metrocable: Transport by urban cable car in Medellín

MetroCables are a form of public transportation in which a gondola lift transports groups of about five people from station to station. While these gondolas travel rather slowly (about 11 miles per hour), the ability to travel aerially in a straight line often makes them faster than alternative modes of transportation, especially so due to the poor road infrastructure in marginal neighborhoods. The airborne nature of this solution makes it practical for the difficult terrain in the informal mountainside communities surrounding Medellín, and as a result, the municipal government has celebrated it as a key contributor to improving conditions in these aforementioned marginalized communities, especially so after the PUI/Proyecto Urbano Integral won the Veronica Rudge Green Prize, the foremost recognition within the field of urban design. Local successes have also captured the attention of observers. Chief among these is the revitalization of Comuna 13, also known as Comuna San Javier. Today, the area near the San Javier MetroCable station is a hub of tourism thanks to its urban graffiti tours. The reinvention of San Javier is an extreme rupture from its recent past as an urban battleground in 2002's Operation Orion, and has served as a vision of hope for the city. This manuscript seeks to explore the veracity of the narrative of success surrounding MetroCable by investigating how MetroCable has affected the economic prospects of residents of affected communities. It will do so by investigating the impact of the introduction of a MetroCable station into a given neighborhood's residents' average income.

In the context of the UN's 2030 Sustainable Development Goals[7], this manuscript situates itself within a larger current of literature that seeks to address SDG Goal 1: Eliminating Poverty. The body of work surrounding Medellín's MetroCable system has historically studied its impact on accessibility, crime rates, informal housing, and quality of life. While each of these factors is

[7] United Nations, "The 17 Goals | Sustainable Development."

surely valuable, they do not address the most critical of all Sustainable Development Goals: namely, the MetroCable's contribution to decreasing poverty. By investigating the veracity of the success story surrounding the MetroCable, this paper seeks to determine if this novel form of public transportation can truly serve as a practical means to alleviate poverty in mountainous communities across the world.

Literature Review:

As previously stated, the literature surrounding Medellín's MetroCable system primarily focuses on accessibility, housing, and social outcomes. First, I will examine the body of research related to how public transportation, specifically MetroCable, influences neighborhood accessibility and mobility, highlighting key studies that analyze changes in transportation costs and travel times. Next, I will review the literature on the impact of the MetroCable program on housing, especially regarding informal housing and gentrification, and consider whether transportation improvements have led to rising rents or shifts in neighborhood demographics. The review will then move to social outcomes, discussing studies that assess the program's impact on quality of life and social inclusion. Finally, I will address a gap in the literature by focusing on the economic effects of MetroCable, particularly how it affects income, and present a description of how this area has been underexplored in previous studies. The section will conclude with a summary of the gaps in the literature that this manuscript aims to address.

Medellín's MetroCable program has been a subject of considerable academic interest ever since it began in 2004. This is not entirely surprising, as its innovative approach of integrating cable cars into public transit has since inspired similar programs in La Paz, Caracas, and Hong Kong[8].

[8] Centre for Public Impact, "The Metrocable: Transport by urban cable car in Medellín"

Therefore, as the first mover for a new type of public transportation, the twenty-year longevity of the MetroCable program has allowed researchers a unique opportunity to see how it has influenced accessibility, housing, quality of life, crime, and social exclusion throughout its lifespan. Still, there has been very limited research on whether the MetroCable program has been associated with greater income growth in neighborhoods with stops, which is the research goal of this manuscript. Therefore, this literature review will highlight how methods and conclusions from existing sources will inform the scope and objectives of this manuscript's inquiry.

Before going into the existing research on the MetroCable program's impact on accessibility, it would be best to define the term. In short, accessibility is a metric that weighs people's demand to go to a certain place with how much the trip costs in money and time. Logically, as commute times shorten and commute prices decrease, accessibility scores will improve. This was the scope of the analysis in Bocarejo (2014)[9], which explored the relationship between the MetroCable system and its effect on accessibility for low-income users by using origin-destination surveys to analyze travel patterns and transportation costs in marginalized neighborhoods. Unsurprisingly, the authors found that the MetroCable system significantly improved accessibility scores in affected neighborhoods. The reason for this was less apparent, as accessibility improved primarily due to reduced transportation costs instead of faster travel times.

Posada and Garcia-Suaza (2022)[10] provide some insight into the MetroCable system's impact on housing. At the onset of the program in 2004, many of the neighborhoods treated with MetroCable stops had a considerable quantity of informal housing. This study aimed to isolate

[9] Bocarejo, Juan Pablo, Ingrid Joanna Portilla, Juan Miguel Velásquez, Mónica Natalia Cruz, Andrés Peña, and Daniel Ricardo Oviedo. "An Innovative Transit System and Its Impact on Low Income Users: The Case of the Metrocable in Medellín."

[10] Posada, Héctor M., and Andres García-Suaza. "Transit infrastructure and informal housing: Assessing an expansion of Medellín's Metrocable system."

the effect of the MetroCable on these neighborhoods' gradual decrease in informal housing units. The results conclude that the MetroCable's expansion into these barrios correlated with a 15% reduction in informal housing, thus increasing housing quality in these sectors. The study also recognized that these effects resulted in an increase in rent prices.

The MetroCable's effect on social development has received attention. Vásquez and Anzoategui (2013)[11] contribute to this discussion by assessing the MetroCable's impact on quality of life in Medellín. This paper uses a rather prolific source called the "Encuesta de Calidad de Vida" which appears in a great deal of research surrounding Medellín, as it is a quality-of-life survey performed annually by the mayor's office. Their research indicates an initial spike in quality-of-life ratings after the MetroCable system was implemented in a new neighborhood, followed by a slowed increase and finally, a decline in quality of life in subsequent years. Their overarching argument is that while the program made immediate improvements, the morale gains generated by these improvements are not sustained, indicating potential stagnation in longer-term benefits. This is an interesting vein of inquiry for this paper, as this stagnation in long-term quality of life could be associated with stagnation in income growth.

There have been other relevant papers studying the MetroCable's effect on Medellín's social fabric, such as Decker (2020)[12], which found that MetroCables are associated with a slight increase in crime due to their potential role in facilitating the movement of criminals out of isolated neighborhoods. Relatedly, Cordoba (2014)[13] has indicated that the MetroCable improved

[11] Vásquez, Sr, and Sr Anzoategui. "The metrocable line k and its impact on the quality of life of the population of the commune one in the city of Medellın system: analysis of perception between the years 2004-2008."
[12] Decker, Nicholas, Defense Council, Francisca Antman, and Brian Cadena. "Aerial Cable Cars as Public Transportation: Examining the Effects of Medellin's Metrocables on Crime."
[13] Cordoba, Diego Zapata, John Stanley, and Janet Robin Stanley. "Reducing social exclusion in highly disadvantaged districts in Medellín, Colombia, through the provision of a cable-car."

social connectivity throughout the city by increasing cross-city travel. Therefore, as can be expected, the increased interactions between social classes allowed by the MetroCable system has brought a mixed bag of positive and negative effects. Cordoba (2014) did not find that increased social connectivity promoted an improvement in income and social capital variables for residents of affected communities, a point which this manuscript will investigate further.

Cordoba (2014) remains the most direct investigation of the economic outcomes associated with the MetroCable, specifically for income trends among residents. Still, its results were somewhat inconclusive, and ten years have passed since its publication. This study aims to address this gap in the literature by focusing explicitly on the relationship between the presence of the MetroCable and household income in marginalized mountainside communities in Medellín and providing a much-needed second look at MetroCables' legacy as a tool for economic development.

Methods:

This study evaluates the causal impact of the MetroCable public transit system on neighborhood-level income growth in Medellín using a Difference-in-Differences (DiD) methodology. For context, Differences-in-Differences is a statistical technique that aims to measure casual effect by analyzing pre and post treatment results for the treated and control groups respectively. At the most basic level, DiD uses the following formula to determine average treatment effect on the treated (ATT):

$$ATT = \left(Treated\ Group_{post\ treatment} - Control\ Group_{post\ treatment}\right) - \left(Treated\ Group_{pre\ treatment} - Control\ Group_{pre\ treatment}\right)$$

The analysis is based on household survey data from the Medellín Alcaldía's Encuesta de Calidad de Vida (ECV), using data from 2004 through 2017 to create a merged dataset. This section details the data sources, limitations, analytical decisions, merging process, treatment-control design, and statistical modeling framework.

Data Import and Scope

The core dataset used in this study is the ECV, administered annually by the Medellín municipal government. This household survey provides rich microdata on income, geographic location (barrio and comuna), and socioeconomic status (estrato), making it highly suitable for neighborhood-level causal inference. Each respondent's values for monthly income, barrio, comuna, year, and estrato were collected and merged into the initial dataset.

While the dataset nominally spans from 2004 to 2023, substantial data limitations reduce the effective analytic window. Specifically, the year 2006 is entirely missing from the archive, while the 2018 wave lacks geographic identifiers, rendering it unusable for spatial analysis. More critically, barrio-level geographic detail is only available from 2004 through 2017. After 2017, the ECV ceased publishing barrio-level identifiers, instead aggregating responses at the comuna level or omitting geographic information altogether. These constraints preclude the analysis of several later MetroCable expansions (e.g., 2019 and 2021 cohorts) and necessitate restriction of the analytic sample to the years 2004–2017.

Analytical Design Choice

Given the hierarchical and spatial complexity of Medellín's administrative geography, a key methodological decision involved the selection of the geographic unit of analysis. The ECV provides geographic identifiers at two levels: comuna (the larger administrative unit) and barrio (the smaller, neighborhood-level unit). While comuna-level analysis offers broader coverage in

later years, it suffers from a significant risk of aggregation bias. Comuna-level data amalgamates diverse neighborhoods that often vary dramatically in socioeconomic conditions, urban development, crime rates, and proximity to infrastructure. As a result, identifying causal effects at the comuna level can conflate the true impact of an intervention like MetroCable with unrelated trends occurring elsewhere within the comuna.

To mitigate this risk, the present study adopts the barrio as the primary unit of analysis. The barrio-level perspective enables the isolation of treatment effects with finer geographic precision, facilitating cleaner comparisons between treated and control units. While this decision necessarily sacrifices the ability to study post-2017 treatment cohorts, it enhances internal validity as barrios often represent socially and economically cohesive units in Medellín, making them more meaningful units for studying localized interventions. This decision also aligns with best practices in urban policy evaluation, where smaller, community-level units are often preferred when high-resolution data are available. The limitation on post-2017 barrio data is acknowledged as a constraint on external validity and the capacity to generalize to newer MetroCable expansions, but it is a justified trade-off in favor of cleaner causal inference. The following table visually displays this reasoning for choosing years to include in the dataset.

Table 1: Encuesta de Calidad de Vida Usable Years

Year	**Has Monthly Income?**	**Has Estrato?**	**Has Barrio?**	**Has Comuna?**	**Usable**
2004	Yes	Yes	Yes	Yes	Yes
2005	Yes	Yes	Yes	Yes	Yes
2006	No	No	No	No	No
2007	Yes	Yes	Yes	Yes	Yes

2008	Yes	Yes	Yes	Yes	Yes
2009	Yes	Yes	Yes	Yes	Yes
2010	Yes	Yes	Yes	Yes	Yes
2011	Yes, *total monthly income, not monthly income from job*	Yes	Yes	Yes	Yes
2012	Yes	Yes	Yes	Yes	Yes
2013	Yes	Yes	Yes	Yes	Yes
2014	Yes	Yes	Yes	Yes	Yes
2015	Yes	Yes	Yes	Yes	Yes
2016	Yes	Yes	Yes	Yes	Yes
2017	Yes	Yes	No	Yes	No
2018	Yes	Yes	No	No	No
2019	Yes	Yes	No	Yes	No
2020	Yes	Yes	No	Yes	No
2021	Yes	Yes	No	Yes	No
2022	Yes	Yes	No	Yes	No
2023	Yes	Yes	No	Yes	No

Merging and Standardizing Data

A significant effort was devoted to constructing a unified panel dataset from individual ECV cross-sections. Each annual wave between 2004 and 2017 was imported, inspected, and harmonized to ensure consistency across variable names, data types, and value labels. Given that the ECV periodically revised its variable naming conventions and formatting standards, especially with respect to geographic and income variables, a standardized schema was developed to facilitate merging. This schema included consistent naming for geographic

identifiers (e.g., comuna_std, barrio_std), income (converted to an annualized measure), and estrato scores (ranging from 1 to 6).

The process was complicated by the fact that different years included relevant variables such as income in different parts of the questionnaire or under different variable names. Harmonizing these variables required manual review of each year's survey documentation to extract and rename variables to fit the standardized schema. The income variable in particular often appeared under multiple different labels and was reported in either monthly or annual formats depending on the year, necessitating standardization to a common annual income measure across all observations. Further, income was often presented in numeric ranges, likely due to respondents' discomfort in giving an exact income figure. For years where this was the case, an income cleaning function estimated that the respondent's income was in the exact middle of their respective income range.

Geographic standardization was especially intricate. Raw barrio and comuna names frequently included typographical errors, inconsistent abbreviations, alternate spellings, and formatting discrepancies across years. For example, "santo domingo sabio numero 1" might appear as "santo domingo 1" or "santo domingo s. 1". To address this, a custom standardize_string() function was developed and applied uniformly to all geographic name fields. This function corrected known misspellings, applied canonical capitalization, and removed or replaced punctuation marks.

The standardized barrio and comuna names were matched against a canonical set of geographic names used in the analysis. The respective geographic names are visible under C1, C2, and C3 in the appendix. After standardizing and cleaning the data, all usable annual datasets were appended into a single panel data frame. Observations missing valid geographic identifiers or income data

were excluded. This harmonized dataset formed the analytical backbone for treatment assignment and regression modeling.

Treatment and Control Assignment

Following the merging process, each barrio in the dataset was evaluated for potential treatment status. A barrio was classified as treated if it received a MetroCable station during the observation window (2004–2017). The year of treatment was defined as the year in which the MetroCable stop in that barrio officially opened. Accordingly, all residents of a treated barrio were flagged as treated if their barrio had ever received a MetroCable stop during the observation period. To construct an appropriate comparison group, control barrios were defined as those that never received a MetroCable stop at any point during the observation window. This was the control assignment process for the DiD. For the charts, each individual barrio was assigned a control under slightly different conditions. Treatment barrios' controls were barrios that never received treatment controls and were also not neighbors of the treated barrio in question. This was meant to prevent spillover effects. This tactic could not be repeated in the DiD since it was pooled, meaning excluding all neighboring barrios would have significantly decreased the sample size, and thus the power of the analysis.

Building on this, the DiD analysis was performed after controlling for barrio fixed effects, year fixed effects, and estrato. Estrato is a measure of a neighborhood's socioeconomic status, based on factors like income, access to services, and living conditions, and is primarily used to determine residents' eligibility for utility subsidies. By controlling for treated respondents' estrato, we control for initial socioeconomic differences, allowing us to isolate the effect of the MetroCable stop as an exogenous shock to neighborhood-level income growth.

Justification for Pooled DiD Approach

While the original intention was to estimate separate DiD models for each MetroCable stop, the limited observation window made this impractical due to a lack of data points. Several treatment cohorts were excluded from analysis either because their treatment year fell outside the usable data window (post-2017), or because they occurred in 2004, the first year of the dataset, leaving no pre-treatment data for comparison. These exclusions significantly reduced the number of valid DiD pairs and risked underpowering the estimation strategy.

To address this issue, a pooled DiD approach was adopted. In this framework, all valid treated barrios and their corresponding control pools were aggregated into a single analytical sample. This strategy increased statistical power by leveraging variation across multiple treated units and survey years. The pooled approach also facilitated the estimation of an average treatment effect across diverse implementation contexts, improving the generalizability of findings within the 2004–2017 window.

This approach, however, depends on the parallel trends assumption; the requirement that treatment and control groups would have followed the same income trends in the absence of treatment. In practical terms, this means that treated barrios should not exhibit systematic income growth differences compared to their matched controls before the MetroCable stop was introduced.

To evaluate whether this assumption holds, the study will include an event study. This model estimates the effect of treatment at each year relative to the year of intervention. In doing so, it allows for the detection of any significant pre-treatment differences in income growth. If the event study shows upward or downward income trends in treated barrios before treatment, it would suggest that the parallel trends assumption is violated.

Pooled DiD Model Specification

The pooled differences-in-differences model was created with the following formula:

annual_income ~ pooled_treated + estrato.

annual_income	The outcome variable, standardized to represent annual income.
pooled_treated	A binary indicator equal to 1 if the observation is from a treated barrio in or after the treatment year.
estrato	A control variable representing the respondent's socioeconomic score.
year + barrio_std	Two-way fixed effects controlling for time-specific shocks and time-invariant barrio characteristics.
cluster = ~barrio_std:	Standard errors clustered at the barrio level to account for intra-cluster correlation.

This specification isolates the average effect of MetroCable exposure on annual income while adjusting for baseline socioeconomic status and unobserved heterogeneity at both the barrio and year levels. The pooled_treated coefficient represents the primary quantity of interest and is interpreted as the causal effect of residing in a MetroCable-treated barrio on income growth, conditional on covariates and fixed effects.

Table 2: Formalized Model:

$$\boldsymbol{Annual\ Income_{it} = \beta_1 \cdot Treated_{it} + \beta_2 \cdot Estrato_{it} + \gamma_t + \alpha_i + \varepsilon_{it}}$$

$\boldsymbol{Annual\ Income_{it}}$	The annual income of respondent i in year t
$\boldsymbol{Treated_{it}}$	A binary variable equal to 1 if the respondent lives in a treated barrio in or after the treatment year
$\boldsymbol{Estrato_{it}}$	Socioeconomic classification *(1–6 scale)*
$\boldsymbol{\beta_1}$	MetroCable effect on income
$\boldsymbol{\beta_2}$	Estrato effect on income
$\boldsymbol{\gamma_t}$	Year fixed effects
$\boldsymbol{\alpha_i}$	Barrio fixed effects
$\boldsymbol{\varepsilon_{it}}$	Error term

Results:

Parallel Trends Assumption Confirmation

Before estimating the causal effect of MetroCable implementation on income growth, it is critical to verify that the fundamental identifying assumption of the Difference-in-Differences (DiD) design holds—namely, the parallel trends assumption. This assumption stipulates that, in the absence of treatment, the treated and control groups would have followed similar income trajectories over time. In practice, this means that treated barrios should not exhibit systematically different income trends in the years leading up to the introduction of MetroCable relative to control barrios.

Our primary DiD model is pooled, so all barrios that ever received a MetroCable stop during the observation window are flagged as treated. Barrios that never received a stop are used as the control group. This model estimates the average difference in income between ever-treated and never-treated barrios over the full period, controlling for fixed differences across years and neighborhoods. Because this approach does not account for variation in treatment timing, it does not allow for a built-in check of pre-treatment divergence through standard event study methods.

To assess the plausibility of the parallel trends assumption under this specification, we conducted a robustness check presented in Table 1. Specifically, we constructed an event study-style analysis focused only on future-treated barrios prior to their treatment year. We compare their average income levels in the years before treatment to assess whether they exhibited upward or downward trends relative to the baseline year. Although this test does not evaluate the full treatment-control relationship used in the main regression model, it serves as a diagnostic for pre-treatment divergence among the eventually treated group.

The table summarizes income differences for years 2 through 17 prior to treatment. Each estimate is statistically insignificant (p-values = 1.000), and the standard errors are extremely large, reflecting substantial noise in the data. This lack of significance across all pre-treatment years suggests that there is no evidence of systematic pre-treatment income trends in the treated barrios, strengthening the case that our identification strategy is not compromised by prior divergence.

While this diagnostic is not embedded in the final model, it provides important reassurance that income trajectories were not already trending upward or downward in treated areas before MetroCable implementation. As such, the test supports the validity of the parallel trends

assumption and increases our confidence in the causal interpretation of the regression estimates presented in the next section.

Table 3: Event Study — Dynamic Effects of MetroCable

Years before Treatment	Estimate	Std. Error	t-value	p-value
2	678,965	33,239,798,861	0	1.000
3	519,255	66,479,454,982	0	1.000
4	1,260,167	99,719,158,742	0	1.000
5	242,071	132,959,222,320	0	1.000
6	714,386	166,198,466,746	0	1.000
7	983,842	199,438,290,650	0	1.000
8	523,641	232,677,959,976	0	1.000
9	383,674	265,917,647,180	0	1.000
10	1,561,136	299,157,052,170	0	1.000
11	1,004,466	332,397,112,902	0	1.000
12	1,066,211	365,636,492,165	0	1.000
13	2,618,288	398,875,883,314	0	1.000
14	1,312,779	432,115,960,070	0	1.000
15	1,913,561	465,355,788,677	0	1.000

Years before Treatment	Estimate	Std. Error	t-value	p-value
16	631,561	498,595,658,385	0	1.000
17	2,106,917	531,835,282,161	0	1.000

Causal Analysis Results

To estimate the causal impact of the MetroCable public transit intervention on household income, this study employed a Difference-in-Differences (DiD) design using a pooled model with fixed effects. DiD models are commonly used in policy analysis when random assignment of treatment is not possible. They estimate the treatment effect by comparing the change in outcomes for treated units before and after treatment with the change in outcomes for untreated control units over the same period. The key identifying assumption is that, in the absence of treatment, both groups would have followed similar trends—an assumption verified in the previous section through an event study analysis.

The pooled version of this model allows us to leverage all available data across cohorts, combining variation from multiple treatment years and control pairings into a single regression. This approach enables us to estimate a general treatment effect for MetroCable across all eligible treated barrios.

The model includes year fixed effects to control for shocks that affect the entire city in a given year (e.g., macroeconomic changes, inflation, national policies), and barrio fixed effects to absorb time-invariant unobserved characteristics of each neighborhood (such as long-standing infrastructure, culture, or geographic features). Standard errors are clustered at the barrio level to account for within-barrio correlation over time.

This pooled DiD design gives the analysis greater statistical power than a single-cohort approach and allows us to evaluate the average treatment effect for the 2008 and 2016 MetroCable cohorts, the only two sets of stations for which both pre- and post-treatment income data exist within the barrio-level survey years (2004–2017). However, the limited post-treatment data—particularly the absence of income information beyond 2017—may have weakened the model's ability to detect significant treatment effects. It is plausible that the income effects of MetroCable grow over time, especially in neighborhoods facing structural barriers to mobility. In that sense, the model could represent a lower-bound estimate of the true long-term effect. Alternatively, Vásquez and Anzoategui (2013)[14] point out that quality of life gains among treated neighborhoods stagnate, which could mean that income gains mostly happen in the early years after treatment. Subsequent analysis can settle this debate by integrating post-2017 data.

Table 4: Pooled Diffs in Diffs Regression Results

The updated fixed effects regression model is based on 208,655 observations, including 318 barrios and 13 years of data. The output is summarized below:

Variable	Estimate	Std. Error	t-value	p-value
Treatment (MetroCable)	2,027,968 COP	393,169 COP	5.16	4.41e-07
Socioeconomic Level (Estrato)	3,385,668 COP	494,410 COP	6.85	3.90e-11

- **Adjusted R^2**: 0.0055

[14] Vásquez, Sr, and Sr Anzoategui. "The metrocable line k and its impact on the quality of life of the population of the commune one in the city of Medellın system: analysis of perception between the years 2004-2008."

- **Within R^2**: 0.00043

Interpretation of Coefficients

The treatment coefficient—the main variable of interest—has an estimated effect size of 2,027,968 Colombian pesos (approximately USD 471), and is highly statistically significant with a p-value well below 0.001. This finding indicates that, on average, residents of barrios with MetroCable access earned over 2 million COP more annually than those in similar, untreated neighborhoods. This income difference is not only economically meaningful but statistically robust. Considering that the national minimum monthly wage is 1,423,500 COP, this treatment effect amounts to nearly a month and a half of minimum wage income, making it a substantial gain for low-income communities.

The positive direction and significance of this coefficient align with the theoretical expectation that improved transportation infrastructure facilitates better access to jobs, education, and markets—especially in historically underserved urban peripheries. The MetroCable system, by connecting steep and isolated neighborhoods to the city center, may reduce travel times, expand job search radii, and improve participation in the formal labor market. These mechanisms are likely contributing to the observed income effect.

The coefficient for estrato—the socioeconomic classification of each household—is both large and, as expected, highly significant. With a value of 3,385,668 COP and a p-value far below 0.001, this variable confirms that income strongly increases with each step up the socioeconomic ladder, holding other factors constant. Each one-step increase in estrato is associated with a 3.3 million COP rise in annual income, reinforcing the strong stratification of income in Medellín's urban hierarchy.

This control variable plays a critical role in the model by adjusting for pre-existing differences in class and neighborhood development. In a city where patterns of inequality are deeply entrenched, failing to control for estrato would risk conflating the effects of socioeconomic background with the impact of infrastructure. Including estrato ensures that the treatment effect attributed to MetroCable is not merely a reflection of long-standing disparities between higher- and lower-income areas.

Model Fit and Limitations

While the treatment effect is statistically significant, the adjusted R^2 (0.0055) and within R^2 (0.00043) remain relatively low. However, this should not be interpreted as a failure of the model. Rather, it reflects the fact that annual income is determined by a wide array of factors not explicitly modeled here. These include education levels, household composition, occupational sector, informal labor participation, health, migration patterns, access to digital infrastructure, and exposure to violent crime—all of which are likely stronger predictors of income than MetroCable access alone.

The purpose of the DiD model is not to explain all variation in income, but to isolate the causal effect of a specific intervention—in this case, the presence of a MetroCable stop. The fact that the model detects a statistically significant effect in this limited scope is a strong result. In causal inference, effect identification and statistical confidence are more important than predictive power per se.

Another key limitation is the lack of post-2017 barrio-level data. Because MetroCable's economic effects may take time to materialize—particularly in low-income neighborhoods facing multiple structural barriers—a short post-treatment window likely understates the full

long-term impact. Earlier case studies (such as Comuna 13) have shown that economic revitalization tied to improved mobility can take five to ten years to bear fruit, especially when fueled by secondary outcomes like increased tourism, entrepreneurial activity, or improved public safety.

In sum, while the model does not explain all income variation, it successfully captures a clear and statistically significant economic benefit associated with MetroCable access. The results support the hypothesis that public transportation infrastructure, when appropriately implemented, can help reduce spatial inequality and improve economic outcomes for historically marginalized communities. These findings validate Medellín's investment in aerial transit and reinforce the potential of similar systems in other cities seeking to integrate excluded neighborhoods into the urban economy.

Median Income Growth for Control vs Treatment Groups

While the previous subsection confirmed a statistically significant relationship between MetroCable treatment and increased annual income, this section aims to provide a more intuitive and visual understanding of that relationship by directly examining income growth trends for each treated barrio over time. These graphs allow us to assess the trajectory of median incomes in the treated barrios compared to the matched control barrios and help us identify patterns that may not be fully captured by the pooled difference-in-differences (DiD) models. The choice of median income over mean income is intentional, as the median trends are much more stable and linear than the mean trends, which are highly volatile thanks to occasional outliers in annual income. Further, given the significant amount of income inequality in Medellin, this provides us a better insight into how fortunes have changed over time for the median residents of these barrios.

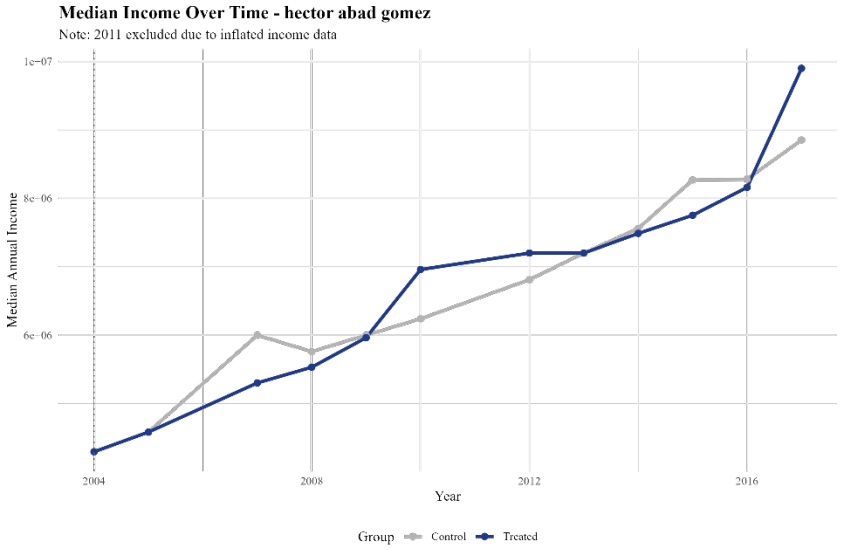
These visualizations are especially valuable for cases where formal DiD analysis could not be conducted — notably, the 2004 treatment cohort, for which no reliable pre-treatment data exists due to the survey's limited geographic detail in the earliest years. Likewise, barrios treated after 2017 are excluded entirely from this analysis, as Medellín's Annual Quality of Life Survey (Encuesta de Calidad de Vida) no longer includes barrio-level data in the post-2017 years, making it impossible to observe their trends over time.

One final note: 2011 data is excluded from the median income graphs across all cohorts. As mentioned in the Methods section, the 2011 version of the survey lacked the variable for monthly job income, which served as the consistent source of annual income estimates across the rest of the dataset. Instead, the 2011 version of the survey used "total monthly income", which resulted in visibly higher averages for this year. To avoid distortions, income in 2011 was calculated from total monthly income instead — a broader and likely inflated measure — which would create an artificial spike in that year's chart values. Dropping that year from the visualization preserves the internal consistency of our trendlines.

2004 Treatment Cohort:

The first MetroCable line opened in 2004, bringing cable car transit access to some of the city's most underserved neighborhoods. This cohort includes the barrios Héctor Abad Gómez, Andalucía, El Popular, and Santo Domingo Sabio Número 1. While this early cohort couldn't be incorporated into the DiD model due to the lack of pre-treatment geographic detail, it remains useful as a reference point for longer-term trend analysis.

Table 5: Median Income Over Time – Hector Abad Gomez



Among all treated barrios analyzed in this cohort, Héctor Abad Gómez stands out as the most economically successful. While the barrio briefly fell behind the untreated controls (represented by the dotted line), it rallied towards the end of the observation period and overtook the controls in median annual income. This suggests that the MetroCable intervention in this area may have compounded its effects over time, possibly reinforcing a virtuous cycle of increased access to jobs, services, and opportunities. This long-term growth trend lends weight to the broader argument that the benefits of MetroCable are cumulative and most visible several years after implementation.

In contrast, Andalucía experienced a more modest upward trend in income. Its post-treatment income path generally tracks closely with the control group. There are no dramatic divergences either positively or negatively. While this suggests a stable recovery, it does not show clear

outperformance. This could be due to various local contextual factors — for instance, differences in violence levels, community infrastructure, or complementary interventions.

Table 6: Median Income Over Time - Andalucia

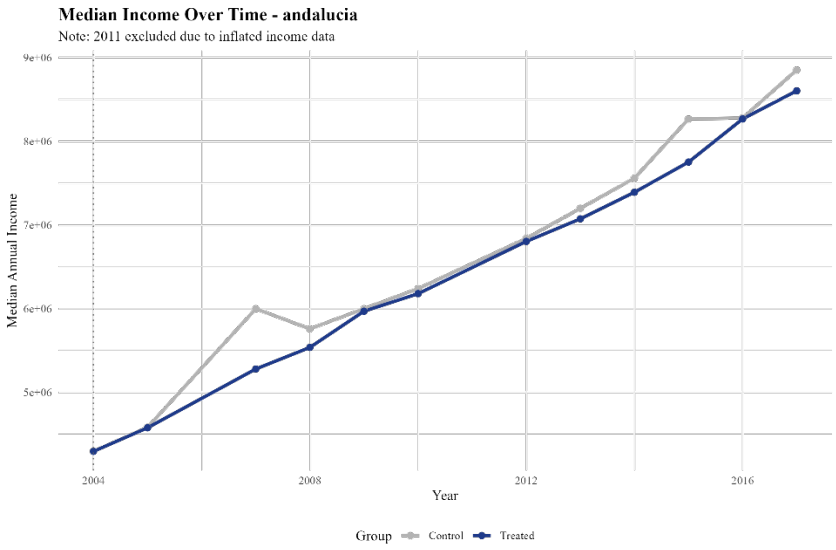
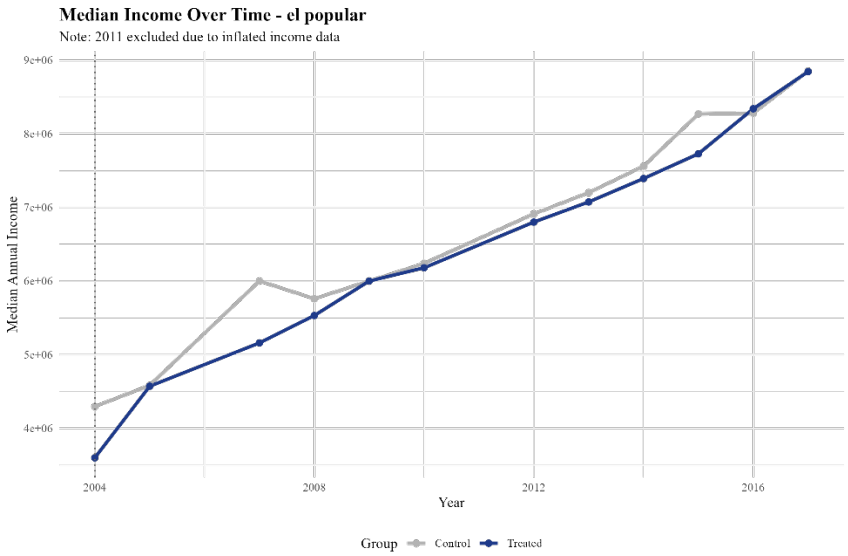


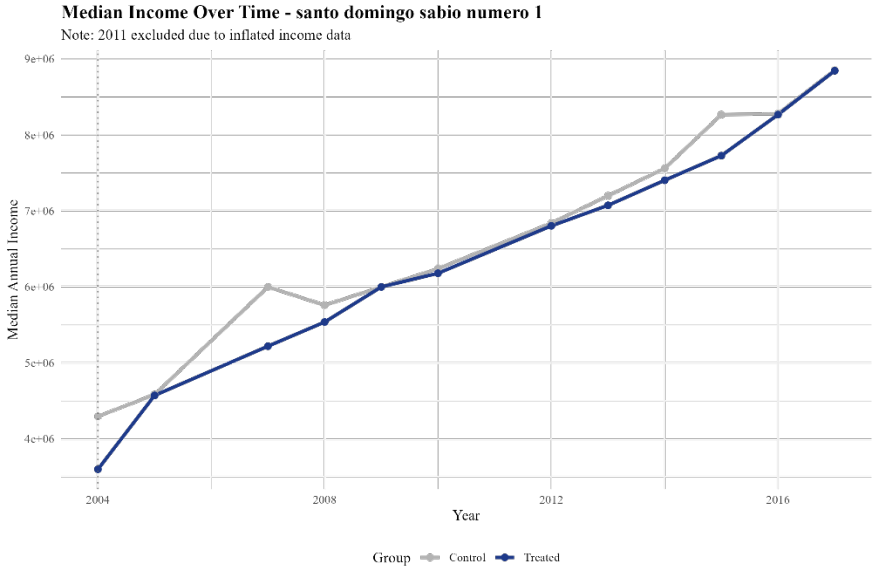
Table 7: Median Income Over Time – El Popular



The barrio of El Popular mirrors Andalucía's trajectory in many respects. Median income rises gradually over time and ends up roughly equivalent to the matched control group by 2017. While

the treatment does not appear to have significantly accelerated income growth here, the fact that El Popular closed a noticeable gap in median income between itself and the untreated controls over the span of the observation period is a positive sign of the success of the intervention.

Table 8: Median Income Over Time – Santo Domingo Sabio Numero 1



Lastly, Santo Domingo Sabio Número 1 similarly converges with its control group. Though its income level begins lower than the control median, it follows a similar growth slope over time and ends up in a comparable position by the end of the sample window. This could suggest that the MetroCable had a leveling or catch-up effect, helping this historically underserved area narrow the income gap with other parts of the city.

2008 Treatment Cohort:

The second major expansion of the MetroCable system occurred in 2008, bringing access to four new barrios: San Javier Número 2, Juan XXIII, Santa Margarita, and San Cristóbal. Unlike the 2004 cohort, these barrios are included in the DiD analysis, but they also serve as critical case studies in visualizing the median income trajectories after treatment. While the original analysis

included graphs embedded in the text, these visualizations have been moved to the appendix for improved document clarity. The reader may refer to Figures A1 through A4 for the corresponding charts. Note that 2011 remains excluded across all graphs for consistency.

San Javier Número 2 experienced a rapid and impressive post-treatment rise in median income. In the immediate years following MetroCable implementation, income in this barrio outpaced its control group, indicating a strong early effect of improved connectivity and access. However, this growth began to plateau in the mid-2010s, and by the end of the observation window in 2017, the control group had effectively caught up, eroding the early gains in relative terms.

Despite this convergence, San Javier Número 2 remains a compelling case for further study. Itself a part of Comuna 13, this area has become a center of tourism, attracting visitors from around the world through its famous urban graffiti tours and community-led revitalization projects. Many of these tourists arrive via the MetroCable, underlining the line's role as both a literal and symbolic bridge to the broader economy. These post-2017 developments may not yet be visible in the available data, reinforcing the importance of incorporating newer survey waves in future research. See Appendix Figure A1.

Both Juan XXIII and Santa Margarita display median income trajectories that are closely aligned with their control groups. In both cases, post-treatment income grows steadily but does not significantly diverge from the control median at any point. These results suggest that while the MetroCable intervention may have supported stability and moderate growth, it did not produce an outsized income effect in these barrios—at least not in the medium term. Factors such as local infrastructure, employment availability, or complementary policies may be important moderating variables worth investigating further. See Appendix Figures A2 and A3.

Among the 2008 cohort, San Cristóbal presents the most dynamic growth pattern. In the years immediately following treatment, it experienced a sharp rise in median income, outperforming its control group. This was followed by a plateau phase, where income levels stabilized and the gap narrowed. Notably, in the mid-2010s, San Cristóbal saw a resurgence in income growth, pulling ahead of the control group once again. This U-shaped trajectory may reflect an initial shock of opportunity followed by a delayed structural adaptation, potentially involving increased business formation, improved job access, or better education outcomes. See Appendix Figure A4.

2016 Treatment Cohort:

The third and final cohort analyzed in this study corresponds to MetroCable stops implemented in 2016, the last year for which post-treatment barrio-level data is available in the *Encuesta de Calidad de Vida* (ECV). This cohort includes the barrios Alejandro Echavarría, San Antonio, and La Sierra. Although the available post-treatment window is shorter than for earlier cohorts, the median income trends of these barrios still yield meaningful insights about early-stage outcomes following MetroCable integration. As with the 2008 cohort, the visualizations for these barrios have been relocated to the appendix. Refer to Figures A5 through A7 for the graphs discussed below.

Alejandro Echavarría presents a unique starting point in this cohort. At the time of treatment in 2016, this barrio already had higher median income levels than its matched control group. Despite this head start, the income trajectory post-treatment shows an even steeper upward slope, suggesting that the MetroCable intervention may have accelerated or reinforced pre-existing growth patterns.

This pattern is particularly important in demonstrating that MetroCable interventions are not only effective in low-income, underserved areas, but may also provide additional value in barrios

already on an upward economic path. Whether this acceleration is due to improved job access, increased property value, or enhanced mobility remains an open question, but the growth differential is visually evident. See Appendix Figure A5.

In contrast, San Antonio offers a case study in neutral economic response. The barrio began the post-treatment period with a median income nearly identical to that of the control group, and this parallel trend persisted through 2017. There is no significant divergence between the two lines, which implies that the MetroCable intervention may not have had an immediate or measurable effect on income levels in this area—at least not in the short post-treatment window available for analysis.

Several factors might account for this muted impact. It is possible that the neighborhood lacked the complementary infrastructure or job connectivity required to translate mobility improvements into economic gains. Alternatively, it may be that the effects are simply too recent to be captured within the one-year post-treatment data window. Regardless, San Antonio's case underscores the need for a longer observational horizon when evaluating transit-oriented development initiatives. See Appendix Figure A6.

La Sierra presents a particularly compelling trend. This barrio began with lower median income than its control group, reflecting a position of socioeconomic disadvantage. Following MetroCable implementation, however, La Sierra experienced steady and meaningful growth, ultimately equalizing with the control group by 2017.

This convergence suggests that the MetroCable may serve as an important equalizing force, enabling previously marginalized communities to catch up with their more advantaged peers. The trendline supports the argument that public transportation infrastructure can function not

only as an economic catalyst but also as a tool for reducing spatial inequality in urban environments. See Appendix Figure A7.

Cumulative Income Growth

While the prior subsections focused on median annual income trends in absolute terms, this section introduces a new analytical lens: cumulative income growth. The charts presented here track the percentage growth in median income for treated and control barrios from the year of treatment onward. This approach controls for differing starting points, allowing a more standardized comparison of relative economic improvement following the MetroCable intervention.

Unlike the median income charts where treatment barrios may have begun with higher or lower income levels than their controls, these new cumulative growth charts all begin at a common baseline of 0% in the year of treatment. The y-axis reflects the cumulative percentage growth in median income since treatment, not the absolute income level. If the treatment barrio's line trends above that of the control group, it indicates that the barrio has grown faster in relative terms, regardless of whether it started from a higher or lower base. These graphs allow us to assess how effectively treated barrios have outpaced or lagged behind their respective control group growth trajectories over time. All referenced figures for this section are located in the Appendix as Figures B1 through B11.

2004 Cohort:

We begin with the 2004 treatment cohort, the earliest group of MetroCable beneficiaries in the analysis. This group includes Héctor Abad Gómez, Andalucía, El Popular, and Santo Domingo Sabio Número 1. Since the survey data does not extend before 2004 for barrio-level

observations, these barrios were excluded from the difference-in-differences analysis. Nonetheless, tracking their post-treatment growth allows for valuable descriptive insight.

The cumulative growth chart for Héctor Abad Gómez displays a dynamic trajectory. In the initial years following treatment, growth in the treatment barrio occasionally lagged behind that of the control group. However, beginning in the early 2010s, the barrio's growth rate began to accelerate. After a period of catching up, Héctor Abad Gómez began to outgrow the control group decisively in the latter half of the observation period. By the end of the timeframe, the barrio exhibits a clear advantage in cumulative median income growth compared to its control group. (See Appendix Figure B1.)

In contrast, the performance of Andalucía relative to its control group was more restrained. From the onset of the treatment period, Andalucía's cumulative growth has consistently trailed the control group by a narrow but persistent margin. Although the trajectory shows a healthy overall increase in income, the gap between the two lines suggests that the treatment effect in Andalucía was either weaker or more gradual compared to its cohort peers. (See Appendix Figure B2.)

El Popular's growth trajectory tells a markedly different story. After treatment, this barrio rapidly accelerated, achieving higher cumulative income growth than its control group from the outset. While both lines trend upward throughout the period, El Popular maintains a consistent and widening lead. By the end of the observation period, the treatment barrio registers over 50% more cumulative income growth than the control group. (See Appendix Figure B3.)

Much like El Popular, Santo Domingo Sabio Número 1 demonstrates consistent and strong performance relative to its control group. Post-treatment, the barrio's median income grew at a faster pace and sustained that trend throughout the observation period. The gap between the

treatment and control lines steadily widens over time, resulting in a gap of over 50 percentage points in cumulative growth by the final year of data. (See Appendix Figure B4.)

2008 Cohort:

The 2008 treatment cohort, which includes the barrios San Javier Número 2, Juan XXIII, Santa Margarita, and San Cristóbal, offers a rich variety of post-treatment trajectories that help illustrate the diversity of local responses to MetroCable implementation. Unlike the median income charts, which reflect absolute income levels, these cumulative income growth charts trace the rate of change—allowing us to examine the extent to which income levels accelerated or stagnated in treated barrios relative to their control groups.

San Javier Número 2 presents one of the clearest cases of early post-treatment acceleration followed by a plateau. Shortly after the MetroCable implementation, San Javier Número 2 leapt ahead of its control group in cumulative income growth, appearing to fulfill the promise of infrastructure investment. However, this rapid growth was not sustained. By the mid-2010s, growth in San Javier slowed considerably, allowing the control group to gradually catch up. By the end of the observation period in 2017, both groups had reached roughly the same cumulative growth level. This trajectory is noteworthy, especially considering that the area has since become a popular tourist destination due to graffiti art tours. While the 2017 convergence might suggest a fading economic effect, the area's more recent transformation points to the possibility of delayed or indirect economic benefits not captured in this dataset. A follow-up study with more recent data would be necessary to fully evaluate the long-term trajectory of San Javier Número 2. (See Appendix Figure B5.)

In contrast, Juan XXIII and Santa Margarita followed a different pattern: slow but steady outperformance. Both barrios showed consistent, moderate growth that slightly outpaced their

respective control groups throughout the post-treatment period. While the gap between treated and control groups was never dramatic, both ended the observation period with a respectable advantage—more than 5 percentage points greater in cumulative income growth compared to their control groups. These cases reflect scenarios in which the MetroCable intervention may have fostered incremental improvements in economic well-being rather than immediate or transformative change. Their trajectories are valuable because they demonstrate that not all successful outcomes must involve dramatic surges in growth; in some communities, even modest acceleration can represent meaningful progress. (See Appendix Figures B6 and B7.)

San Cristóbal, finally, offers a hybrid case. After the 2008 treatment, the barrio experienced a significant initial surge in income growth, quickly pulling ahead of its control group. However, this was followed by a slowdown, during which the control group gradually closed the gap. What's striking, though, is that in the mid-2010s, San Cristóbal experienced a second wave of growth—a sort of "economic second wind"—that propelled it back ahead of the control group by the end of the observation window. This resurgence suggests that the benefits of MetroCable investments may be nonlinear or lagged, with initial effects potentially reinforcing themselves or enabling other growth dynamics years later. (See Appendix Figure B8.)

2016 Cohort:

This final set of cumulative growth charts explores the barrios treated in 2016: Alejandro Echavarría, San Antonio, and La Sierra. As with previous cohorts, these charts track the cumulative percentage change in median income from the year of treatment onward. However, there is a crucial limitation when interpreting the results for this cohort: the barrio-level data from the Medellín *Encuesta de Calidad de Vida* is only available through 2017. This means that we are observing only one year of post-treatment income data. As such, any patterns that appear

in the charts must be interpreted with caution, as they may not reflect long-term trends. These results provide an initial snapshot rather than a conclusive story of the economic trajectories triggered by the MetroCable interventions in these areas.

That said, the early performance of Alejandro Echavarría is particularly striking. The barrio experienced a dramatic rise in cumulative income growth relative to its control group, outperforming by more than 15% over the course of a single year. While the dataset does not allow us to determine whether this surge continued beyond 2017, it suggests a rapid and strong response to the MetroCable implementation. A jump of this magnitude in the short run could indicate a positive community reception to the new transit infrastructure, or perhaps a temporary influx of employment opportunities and commercial activity. However, if the patterns of other treatment cohorts are any indication, early surges like this may not always lead to sustained outperformance over time. Future research should aim to collect more years of data to determine whether Alejandro Echavarría's early gains persist, plateau, or decline in the long run. (See Appendix Figure B9.)

By contrast, San Antonio and La Sierra exhibited more modest cumulative gains in the short period following treatment. Both barrios grew slightly faster than their matched control groups, but by narrower margins. San Antonio achieved an approximate 6% advantage over its control by the end of 2017, while La Sierra's cumulative growth exceeded its control by about 4%. Though these results are not as dramatic as those of Alejandro Echavarría, they are still promising in their own right. Modest but consistent outperformance, when sustained over time, can lead to significant long-term differences in economic well-being. In this light, San Antonio and La Sierra may be exhibiting more stable forms of growth that could prove more resilient or equitable in the years ahead. (See Appendix Figures B10 and B11.)

Policy Recommendations & Conclusions:

The following recommendations build on these findings and offer a roadmap for researchers and policymakers committed to enhancing and replicating the success of the MetroCable system. They address both the technical opportunities to deepen the analysis and the broader policy design questions that arise from observed variation in treatment outcomes.

1. Extend Data Collection Beyond 2017

The most immediate recommendation is a simple but foundational one: Medellín's government, in partnership with local researchers and international institutions, should restore and expand access to barrio-level survey data. The *Encuesta de Calidad de Vida* was an invaluable resource for this thesis, but its utility is currently capped by a lack of post-2017 geographic detail. This data constraint severely limits the ability to assess the long-term effects of the MetroCable system, particularly for the most recent treatment cohorts, including those implemented in 2019 and 2021.

MetroCable's economic effects may take years to fully materialize. Neighborhood revitalization, employment shifts, and community-level changes often occur gradually. Without continuous barrio-level data, it becomes impossible to evaluate whether initial income gains are sustained or whether they fade with time. Ideally, the city should resume publishing annual ECV data with barrio identifiers or implement a follow-up longitudinal survey to capture post-treatment dynamics over the long term.

2. Analyze All Treatment Cohorts

Related to the first recommendation is the need to conduct a full evaluation of all MetroCable treatment cohorts, including those excluded from this thesis. The analysis here focused primarily on the 2008 and 2016 cohorts, the only two with sufficient pre- and post-treatment data. Barrios treated in 2004 were excluded because they lacked any pre-treatment years in the dataset, while the 2019 and 2021 cohorts were omitted due to a lack of post-treatment data.

Each cohort likely presents unique characteristics and contextual challenges. For instance, some recent lines extend into rural corregimientos, where dynamics of development, access, and labor differ significantly from those of the urban periphery. A future study that integrates all known MetroCable lines into a unified panel would allow for richer modeling of treatment heterogeneity and enable comparisons across time, location, and local governance structures.

3. Investigate Heterogeneity in Treatment Effects

One of the most important findings in this study — and one of the most understudied in the existing literature — is the variation in income growth among treated barrios. While barrios like Héctor Abad Gómez, El Popular, and Santo Domingo Sabio Número 1 exhibited substantial post-treatment growth, others like Andalucía and San Antonio displayed relatively stagnant trends, closely mirroring their control groups.

This raises a key question: why do some neighborhoods thrive while others do not under the same intervention? Are these differences purely exogenous — the result of pre-existing inequalities or other municipal investments? Or is the MetroCable's effectiveness a product of how it interacts with local conditions like employment density, economic informality, safety, and civic capacity?

Future research should prioritize comparative analysis of these high- and low-performing barrios. Mixed-methods approaches combining spatial econometrics with field interviews, case studies, and community-based research could reveal deeper causal mechanisms and point to opportunities for targeted enhancement of transit-driven development.

4. Study Complementary Infrastructure and Policy Synergies

In several neighborhoods, MetroCable treatment coincided with broader development strategies — new parks, police posts, job training centers, and urban renewal programs. These additional investments may be essential to understanding the full economic impact of the intervention. In fact, it is plausible that MetroCable serves more as an enabler or amplifier than as a primary driver of change. Without complementary infrastructure, even improved mobility may not be enough to spark economic growth.

To better understand this relationship, future studies should compile a comprehensive map of co-interventions, including dates of implementation, funding sources, and neighborhood-level deployment. Overlaying this data with income trends could help isolate the role of policy synergy in driving economic gains and clarify whether MetroCable is most effective as part of a broader development bundle.

5. Replicate the Model in Other Cities

The methodology developed in this thesis — a pooled DiD model with barrio and year-fixed effects and stratified control selection — offers a replicable framework for studying transit impacts in other global cities. Similar aerial cable systems have been implemented in La Paz (Mi Teleférico), Bogotá (TransMiCable), Caracas (Metrocable), and are being considered in cities in Africa, South Asia, and elsewhere in Latin America.

By adapting this model to new contexts, researchers can test the external validity of the findings here. Do cable cars produce similar income effects elsewhere? Do their successes or failures vary depending on urban form, institutional capacity, or local labor markets? Replication across cities can yield important lessons for the global diffusion of transit innovation and help avoid the pitfalls of overgeneralization from a single case study.

6. Build Surveys That Capture Mechanisms of Impact

This thesis focused on income as an outcome, but it leaves open the question of how MetroCable affects income. Is the change driven by reduced commute times? Greater access to formal jobs? Higher household savings from reduced transport costs? The ECV surveys cover variables that measure these intermediate mechanisms, such as commute duration and cost, type and location of employment, access to education or child care, and subjective perceptions of mobility or opportunity. By capturing these dynamics, researchers can move from identifying whether MetroCable has an effect to understanding why and how that effect occurs. This insight is critical for optimizing policy design.

7. Disaggregate Impacts by Gender and Demographics

Another limitation of the present study is its lack of disaggregation by gender, age, or household structure. While the DiD model estimates average treatment effects, it does not reveal whether those effects are concentrated among — or excluded from — particular subpopulations. A future analysis that incorporates interaction terms or subgroup-specific regressions could reveal whether MetroCable is promoting inclusive growth or reinforcing existing inequalities.

Final Thoughts

This thesis set out to evaluate the causal impact of Medellín's MetroCable system on neighborhood-level income, applying a pooled Difference-in-Differences (DiD) model to household survey data from the city's *Encuesta de Calidad de Vida* between 2004 and 2017. The results of the analysis provide clear statistical evidence that MetroCable treatment had a meaningful positive effect. The regression model estimates a statistically significant treatment effect of just over 2 million Colombian pesos in additional annual income for residents of treated barrios, controlling for fixed year and barrio characteristics as well as socioeconomic strata.

This finding represents a meaningful contribution to both urban policy and transportation literature. It validates the MetroCable not only as a symbol of social integration but also as a tool for economic development through increased income. In addition to the regression results, descriptive and graphical analysis of median and cumulative income trends show that many treated barrios outpaced their matched control groups over time. Although treatment effects varied across barrios, the overall pattern affirms the causal potential of cable car transit systems to improve income growth outcomes.

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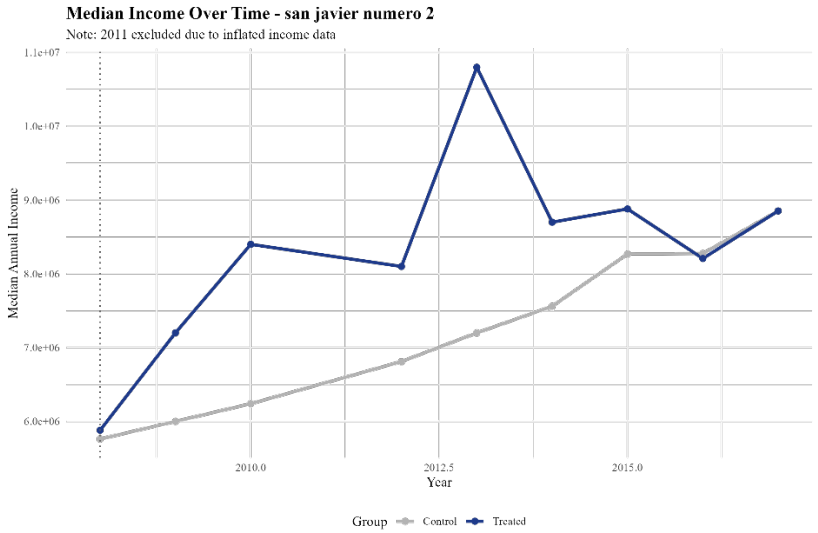
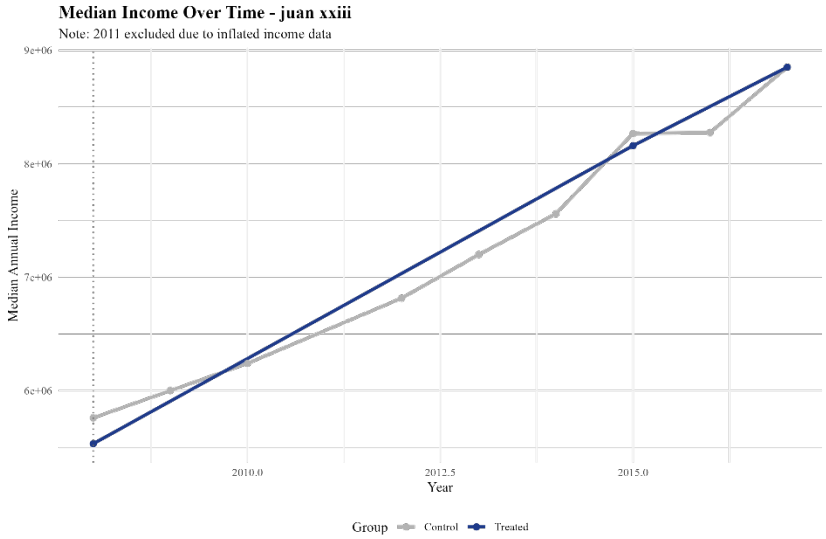
Appendix:

Appendix A: Median Income Graphs

2008 Cohort:

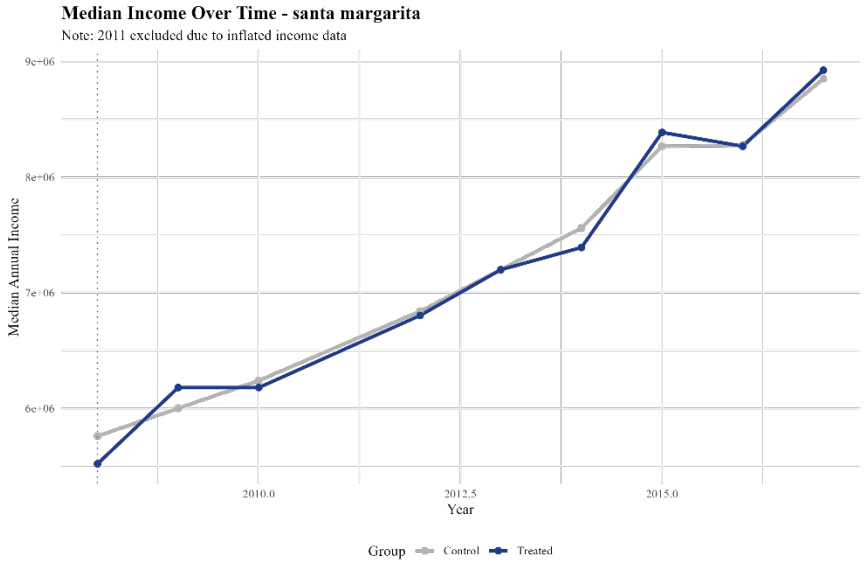


A1:

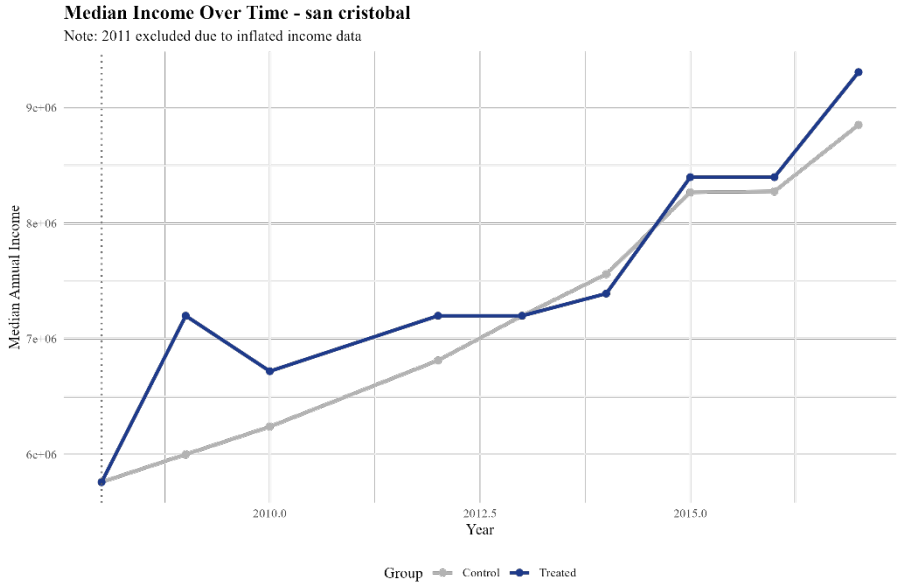


A2:

Note: Juan XXIII was missing data in several years, as shown in the graph



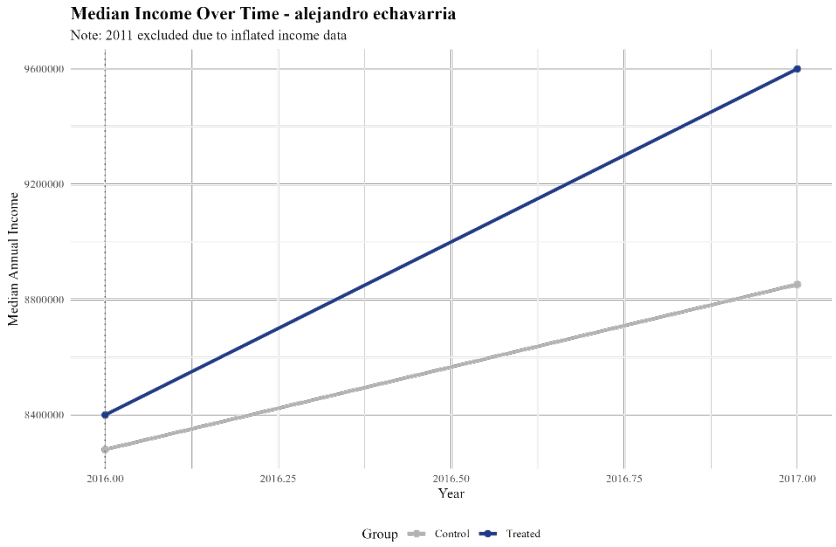
A3:



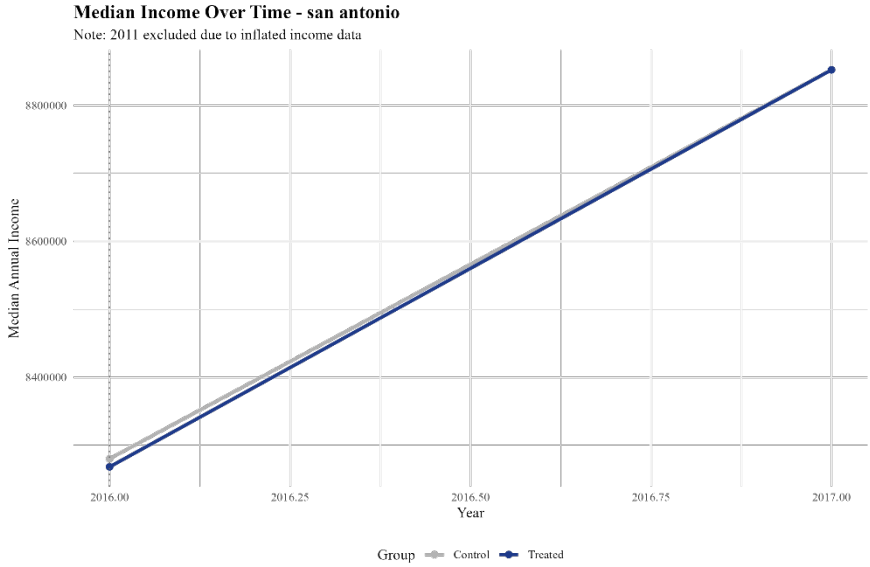
A4:

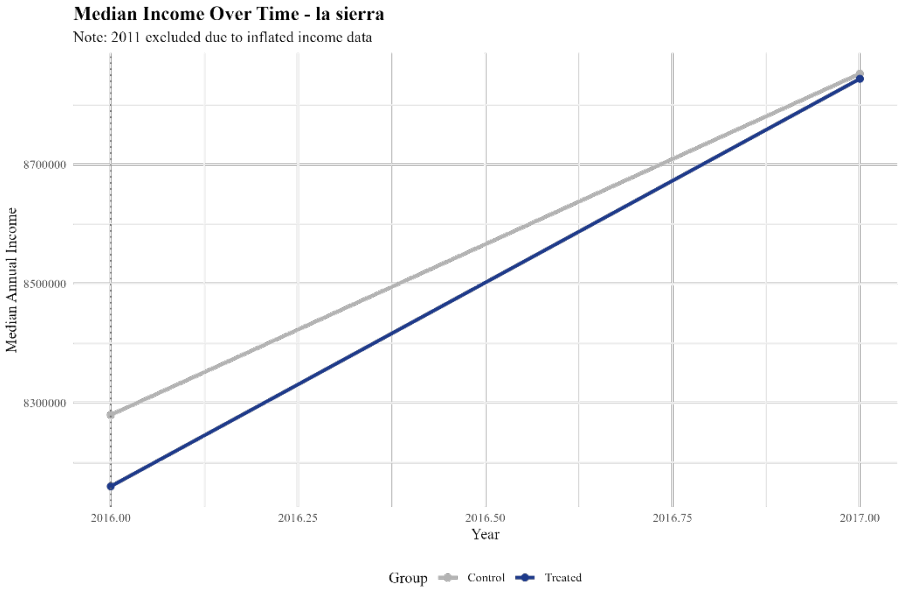
<u>2016 Cohort:</u>

A5:


Median Income Over Time - alejandro echavarria
Note: 2011 excluded due to inflated income data
9600000
9200000
8800000
8400000
Median Annual Income
2016.00
2016.25
2016.50
2016.75
2017.00
Year
Group
Control
Treated

A6:

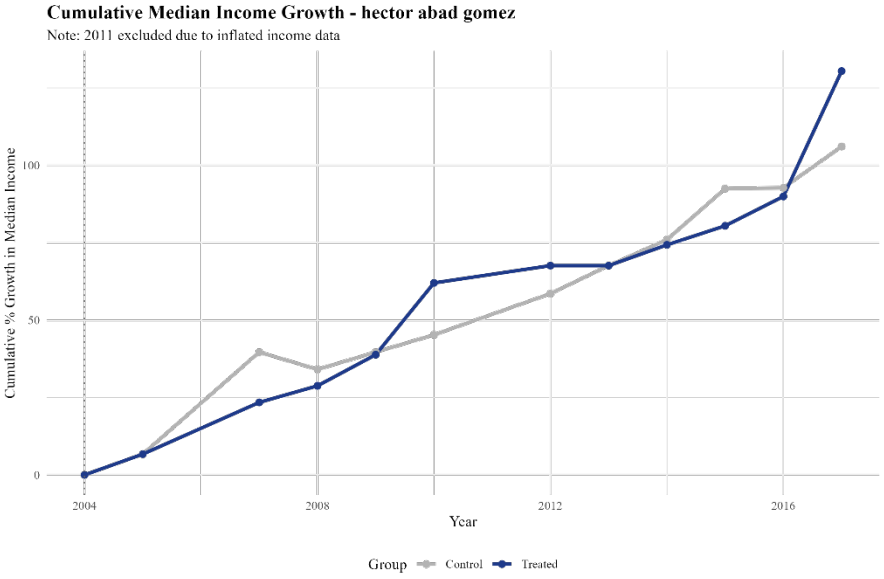

Median Income Over Time - san antonio
Note: 2011 excluded due to inflated income data
8800000
8600000
8400000
Median Annual Income
2016.00
2016.25
2016.50
2016.75
2017.00
Year
Group
Control
Treated



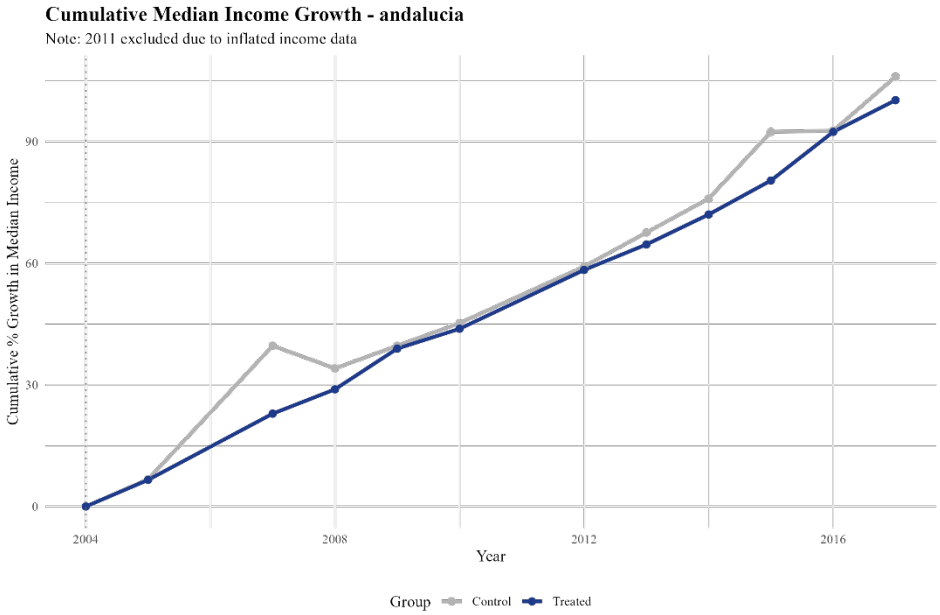
A7:

Appendix B: Cumulative Median Income Growth Graphs

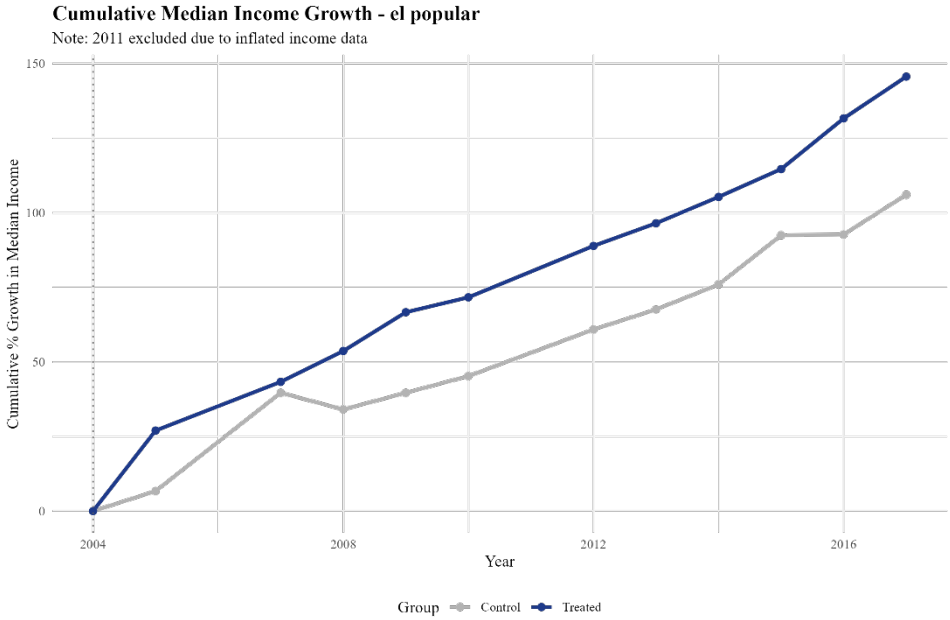
2004 Cohort:



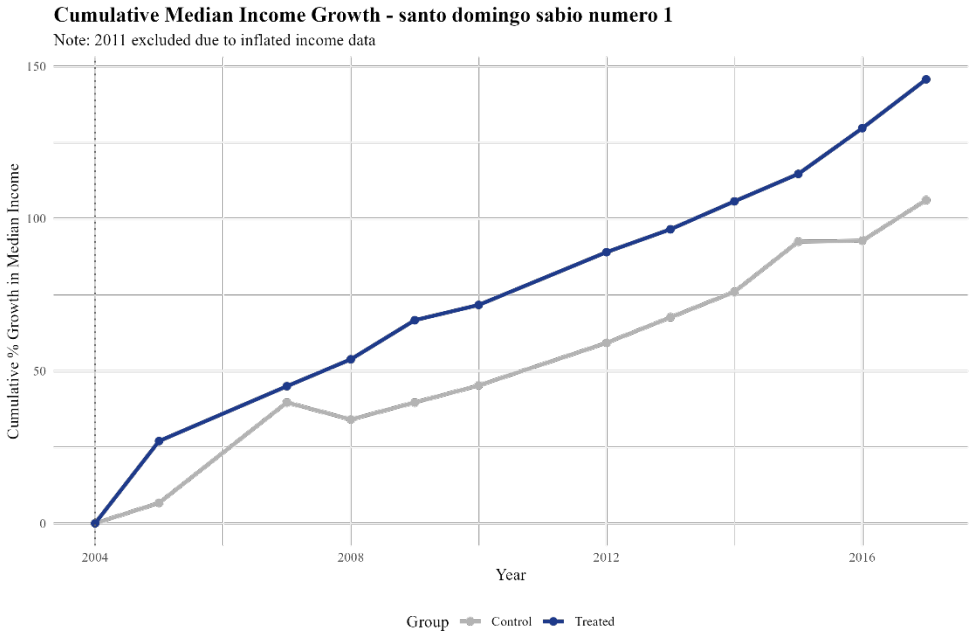
B1:


Cumulative Median Income Growth - andalucia
Note: 2011 excluded due to inflated income data
Cumulative % Growth in Median Income
0
30
60
90
2004
2008
2012
2016
Year
Group
Control
Treated

B2:

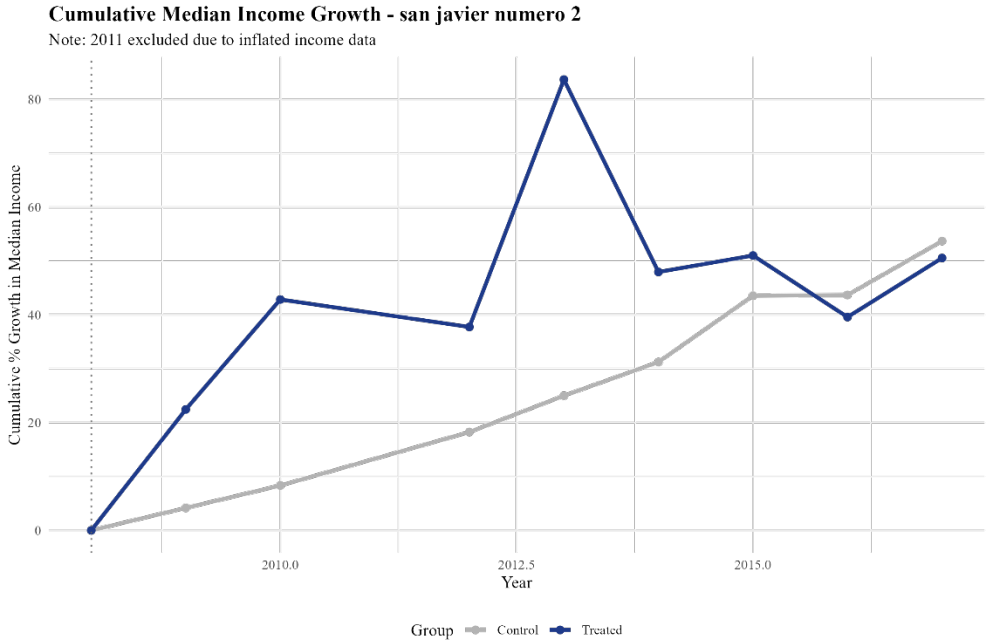

Cumulative Median Income Growth - el popular
Note: 2011 excluded due to inflated income data
Cumulative % Growth in Median Income
0
50
100
150
2004
2008
2012
2016
Year
Group
Control
Treated

B3:

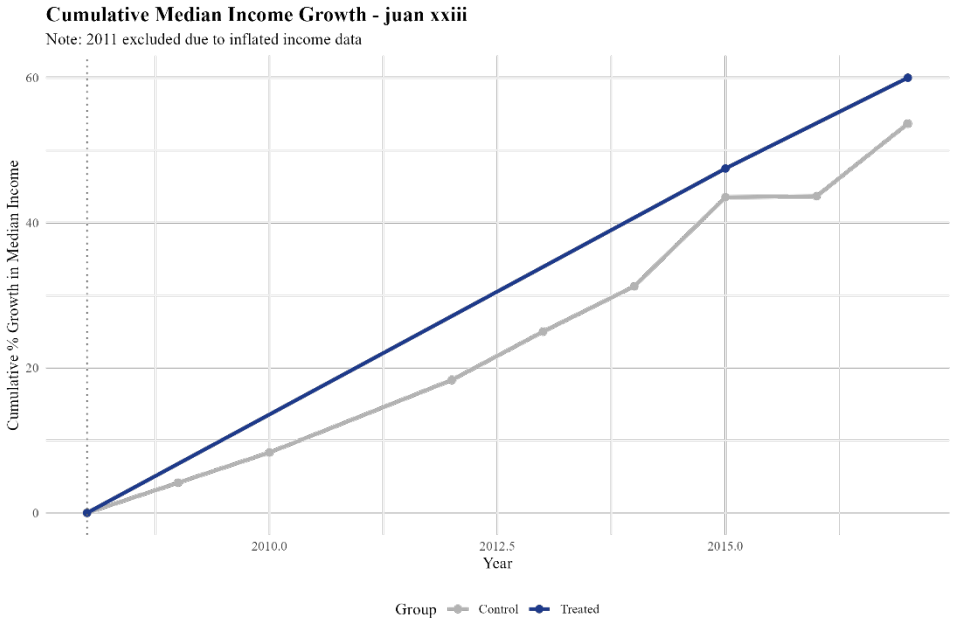


B4:

2008 Cohort:

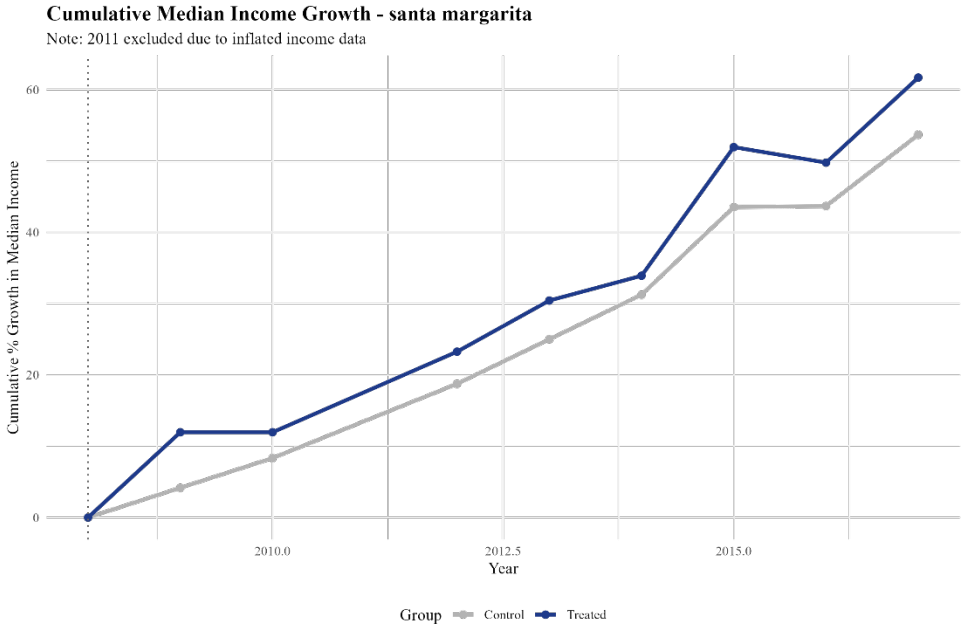


B5:

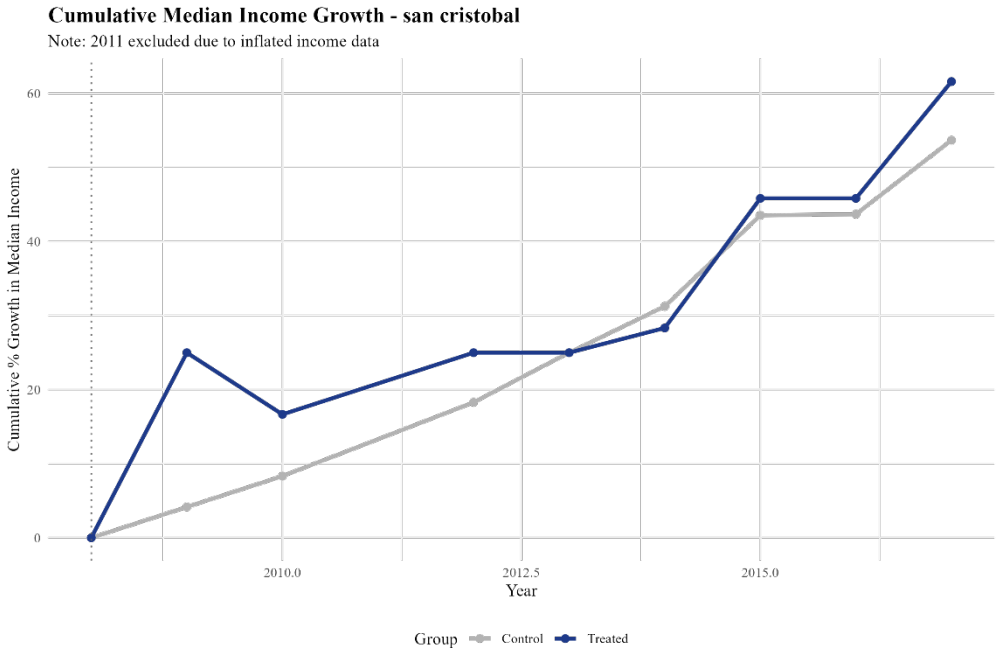


B6:

Note: Juan XXIII was missing data in several years, as shown by the graph

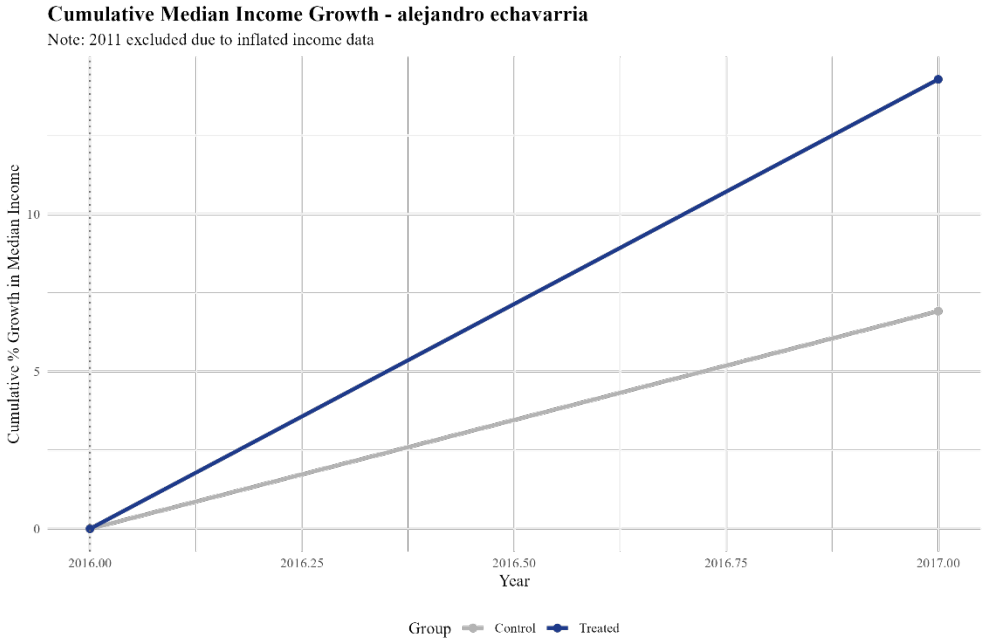


B7:

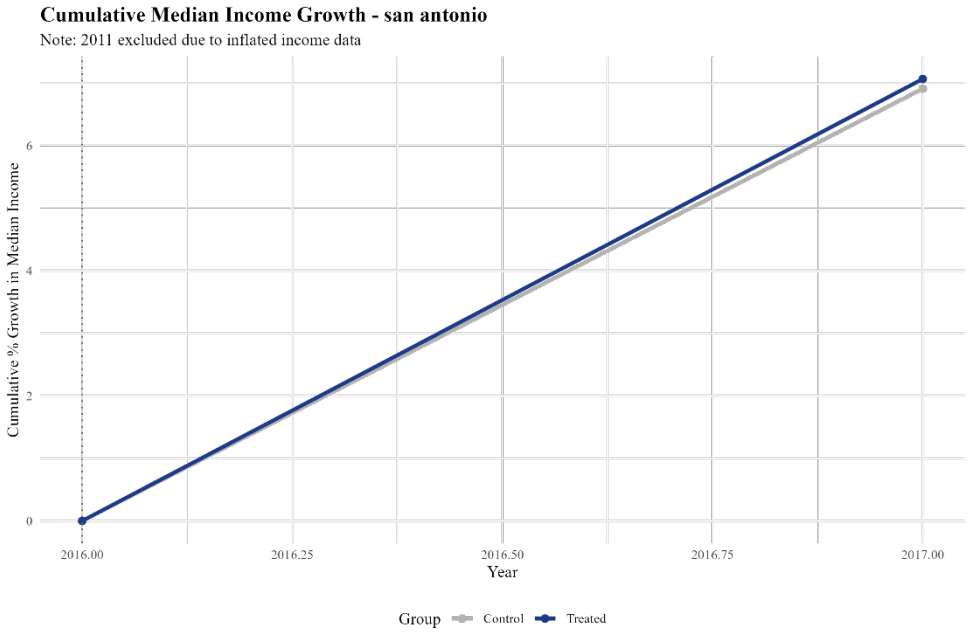


B8:

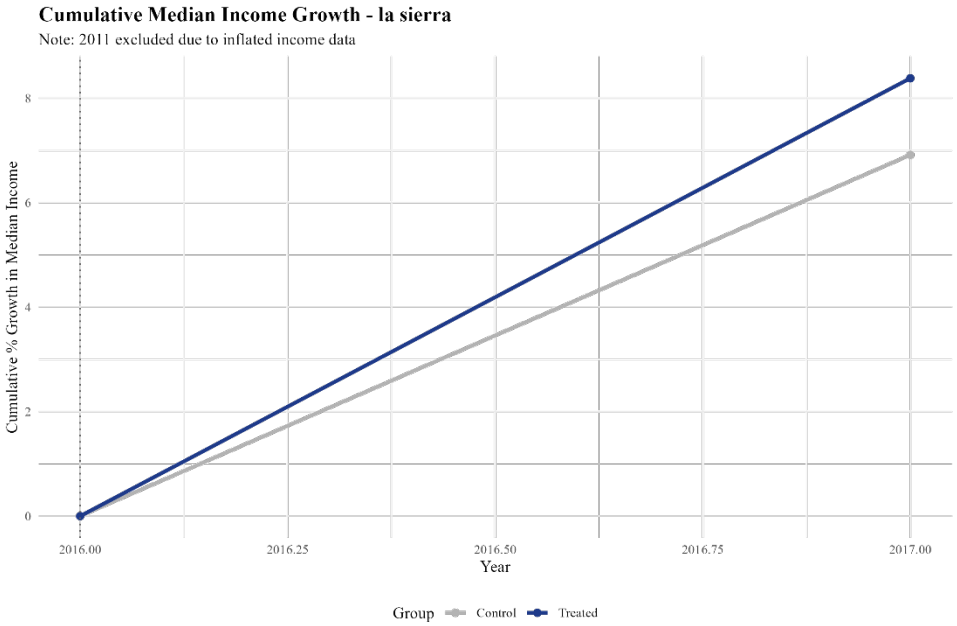
2016 Cohort:


Cumulative Median Income Growth - alejandro echavarria
Note: 2011 excluded due to inflated income data
Cumulative % Growth in Median Income
0
5
10
2016.00
2016.25
2016.50
2016.75
2017.00
Year
Group
Control
Treated

B9:


Cumulative Median Income Growth - san antonio
Note: 2011 excluded due to inflated income data
Cumulative % Growth in Median Income
0
2
4
6
2016.00
2016.25
2016.50
2016.75
2017.00
Year
Group
Control
Treated

B10:



B11:

Appendix C: Barrios & Comunas

C1:

popular	santa cruz	manrique	aranjuez	castilla	doce de octubre	robledo
santo domingo sabio numero 1	la isla	la salle	berlin	toscana	santander	cerro el volador
santo domingo sabio numero 2	el playon de los comuneros	las granjas	san isidro	las brisas	doce de octubre numero 1	san german
el popular	pablo vi	campo valdes numero 2	palermo	florencia	doce de octubre numero 2	barrio facultad de minas universidad nacional
granizal	la frontera	santa ines	bermejal – los alamos	tejelo	pedregal	la pilarica
moscu numero 2	la francia	el raizal	moravia	boyaca	la esperanza	bosques de san pablo
villa guadalupe	andalucia	el pomar	sevilla	hector abad gomez	san martin de porres	altamira
san pablo	villa del socorro	manrique central numero 2	san pedro	belalcazar	kennedy	cordoba
aldea pablo vi	villa niza	manrique oriental	manrique central numero 1	girardot	picacho	lopez de mesa
la esperanza numero 2	moscu numero 1	versalles numero 1	campo valdes numero 1	tricentenario	picachito	el diamante
el compromiso	santa cruz	versalles numero 2	las esmeraldas	castilla	mirador del doce	aures numero 1
la avanzada	la rosa	la cruz	la pinuela	francisco antonio zea	progreso numero 2	aures numero 2
carpinelo		oriente	aranjuez	alfonso lopez	el triunfo	bello horizonte
		maria cano – carambolas	brasilia	caribe		villa flora
		san jose la cima numero 1	miranda	el progreso		palenque
		san jose la cima numero 2				robledo
						cucaracho
						fuente clara
						santa margarita
						olaya herrera
						pajarito
						monteclaro
						nueva villa de la iguana

C2:

villa hermosa	buenos aires	la candelaria	laureles	la america	san javier	el poblado
villa hermosa	juan pablo ii	la candelaria	los conquistadores	la america	san javier numero 1	castropol
la mansion	barrios de jesus	prado	laureles	ferrini	san javier numero 2	barrio colombia
san miguel	bombona numero 2	jesus nazareno	carlos e. restrepo	calasanz	el pesebre	villa carlota
la ladera	los cerros el vergel	el chagualo	suramericana	los pinos	blanquizal	lalinde
batallon girardot	alejandro echavarria	estacion villa	naranjal	la floresta	santa rosa de lima	manila
llanaditas	barrio caicedo	san benito	san joaquin	santa lucia	los alcazares	las lomas numero 1
los mangos	buenos aires	guayaquil	bolivariana	el danubio	metropolitano	las lomas numero 2
enciso	miraflores	corazon de jesus – barrio triste	las acacias	campo alegre	la pradera	altos del poblado
sucre	cataluna	calle nueva	la castellana	santa monica	juan xxiii	el tesoro
el pinal	la milagrosa	perpetuo socorro	lorena	barrio cristobal	la divisa	los naranjos
trece de noviembre	gerona	barrio colon	el velodromo	simon bolivar	veinte de julio	los balsos numero 1
la libertad	el salvador	las palmas	estadio	santa teresita	belencito	los balsos numero 2
villatina	loreto	bombona numero 1	los colores	calasanz parte alta	betania	san lucas
san antonio	asomadera numero 1	boston	cuarta brigada		el corazon	el diamante
las estancias	asomadera numero 2	los angeles	florida nueva		las independencias	el castillo
villa turbay	asomadera numero 3	villa nueva			nuevos conquistadores	alejandria
la sierra	ocho de marzo	san diego			el salado	la florida
villa lilliam					eduardo santos	el poblado
					penitas	astorga
					antonio narino	patio bonito
					el socorro	la aguacatala
					calasania	santa maria de los angeles

C3:

guayabal	belen	san sebastian de palmitas	san cristobal	altavista	san antonio del prado	santa elena
tenche	belen	corregimiento palmitas	area de expansion pajarito	aguas frias	area expansion san antonio de prado	barro blanco
trinidad	cerro nutibara	el yolombo	area de expansion san cristobal	altavista central	astillero	cabecera sta elena
santa fe	fatima	la aldea	area expansion pajarito	altavista sector central	cabecera san ant de pr.	corregimiento santa elena
campo amor	rosales	la frisola	boqueron	altavista sectro central	el salado	el cerro
cristo rey	granada	la sucia	cabecera san cristobal	area de expansion altavista	la florida	el llano
guayabal	san bernardo	la suiza	cabecera urbana corregimiento	area de expansion belen rincon	la verde	el placer
la colina	las playas	palmitas sector central	ciudadela nuevo occidente	buga patio bonito	montanita	el plan
	diego echavarria	potrera miserenga	corregimiento san cristobal	cabecera altavista	potrerito	la avanzada
	la mota	sector central	el carmelo	corregimiento altavista	san jose la cima numero 1	las palmas
	el rincon	urquita	el llano	el corazon el morro	yarumalito	mazo
	la hondonada	volcana guayabal	el patio	el jardin	san antonio de prado	media luna
	la loma de los bernal		el picacho	la esperanza		piedra gorda
	la gloria		el uvito	san jose del manzanillo		piedras blancas
	altavista		la cuchilla	san pablo		sector central
	la palma		la ilusion			
	zafra		la loma			
	los alpes		la palma			
	las violetas		las playas			
	las mercedes		naranjal			
	nueva villa de aburra		pajarito			
	miravalle		pedregal alto			
	el nogal		san cristobal			
			san jose de la montana			
			travesias			
			yolombo			