Aerial Cable Cars as Public Transportation:
Examining the Effects of Medellin's Metrocables on Crime

By

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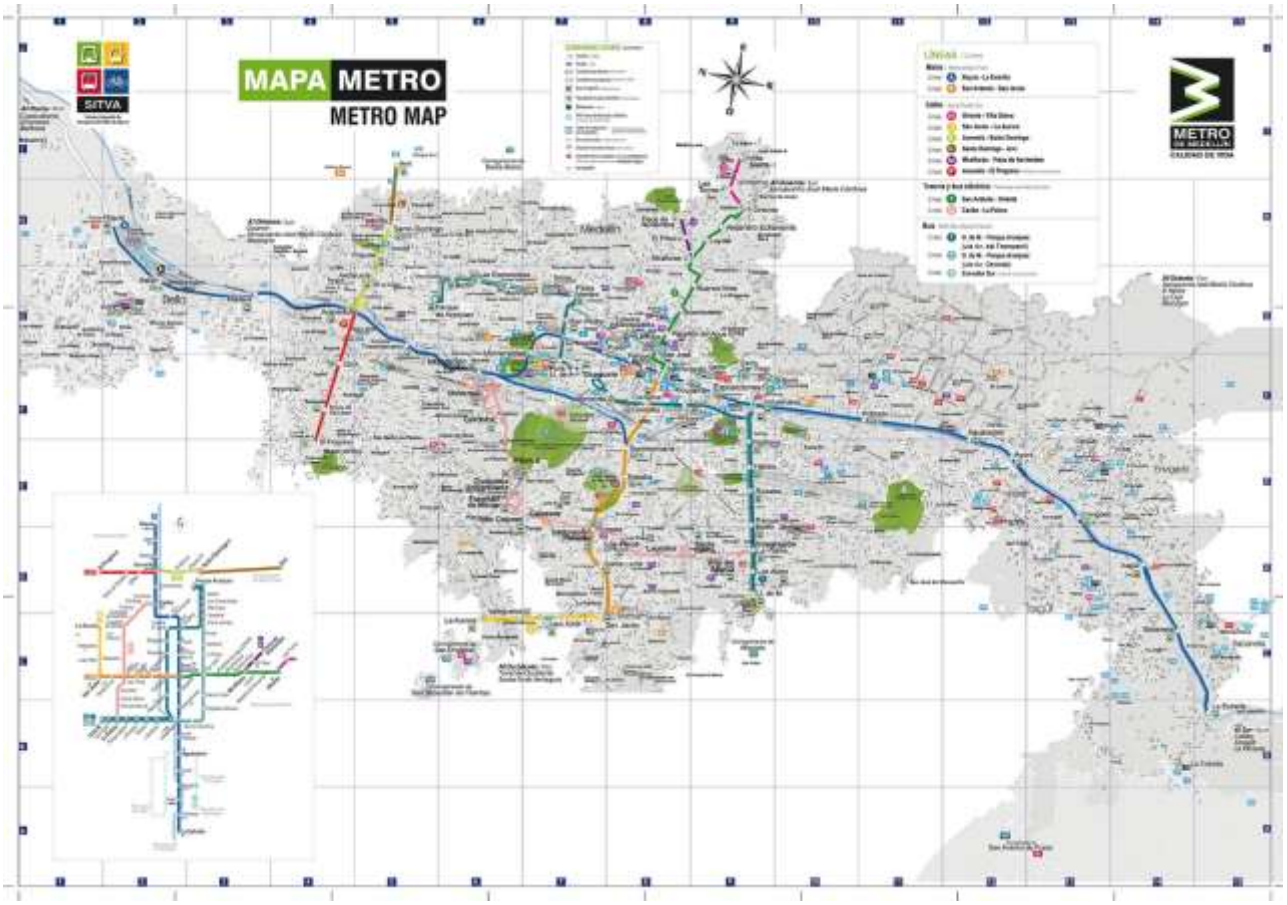
Abstract: This research examines the relationship between the use of aerial cable cars, or metrocables, as public transportation and crime in the city of Medellin, Colombia. A difference in differences analysis is used to compare the difference in crime in an area before and after the construction of metrocable stations and areas of the city who never had a metrocable station built. In this research, Medellin is divided up into both its six urban zones as well as sixteen comunas. Findings show that the amount of homicides that occur in an area of Medellin, and percentage of surveyed residents who said they were the victim of a crime, both have a positive relationship with the presence of a metrocable station within the area. However, the only relationship that was statistically significant was the relationship between the presence of a metrocable station in an urban zone and the percentage of surveyed residents within that zone who said they were the victim of a crime.

Introduction

There has been a lot of debate about how to decrease crime in troubled areas over the years. While the effectiveness of increasing police presence to decrease crimes has been questioned, other methods have been explored. One example of a city that has managed to considerably decrease its levels of crime has been Medellin, Colombia. Once considered one of the most dangerous cities in the world, Medellin has experienced a dramatic decline of crime in the last 30 years. According to the System of Information for Security and Coexistence, in 1991, there were 7,272 murders reported in Medellin, a rate of 266 homicides per 100,000 residents. There have been multiple developments pointed to as causes for the decreased crime in the city. One of these developments was the construction of the public transport system, which first opened in 1995 with the construction of a Metro train service. The public transport system of Medellin currently includes a train, aerial cable cars, a tramway, and bus routes. The aerial cable car system, officially called the Metrocable, was designed to give neglected communities in Medellin a more accessible way to reach the city center rather than having to travel through difficult topography. This likely led to greater access to better jobs and schooling, which are typically located closer the city center. However, there has also been speculation that increased presence of public

transportation decreases travel costs for criminals, therefore giving them easier access to parts of their cities where the returns to crime are higher, therefore increasing the rate of crime. This research will attempt to find a relationship between increased public transportation in Medellin and decreased crime.

Figure 1: Map of Medellin's public transit system



Source: Metro de Medellin (2020)

This research will attempt to answer whether the construction of metrocable lines in Medellin influences crime in the areas where they are constructed. To answer this research question, I will be doing a difference in difference analysis with variable treatment timing, due to the different times that the metrocable lines were constructed. The map above comes from the Metro of Medellin's official website (metromedellin.gov.co). The two metrocable lines that were built during the timeframe of the data are Line J, which was completed in 2008, and Line H, which was completed in 2016. Line J was built in the

Center-West zone (*Centro-occidental*) and Line H was built in the Center-East zone (*Centro-oriental*). As shown in the map, Line J is located close to the western border of the city, and Line H is located close to the eastern border. One difference that Line J & H have from Line K, which was the first metrocable line built in 2004, is that they are not directly connected to Line A, which is the main train of the Medellin Metro system that travels through the center of the city past the northern and southern borders of the city. To reach Line A from Line J, a separate train must be taken after getting off Line J. To reach Line A from Line H, a tramway must be taken after getting off Line H. Line L was also opened in 2009, but it does not serve communal areas. It is instead a tourist-oriented line.

Table 1: Dates of Metrocable construction

Metrocable line	Year construction was completed
Line K*	2004
Line J	2008
Line L**	2009
Line H	2016
Line M*	2019
Line P*	Still under construction
*= Line built outside the timeframe of data **=Line does not serve communal areas	

There have been several studies done on the effects that the access to economic opportunity has on crime. Gillani, Rehman, and Gill (2009) find a relationship between both unemployment and poverty in Pakistan with the rate of crime. Machin and Meghir (2004) find that decreases in the wages of low-wage workers in England and Wales between 1975 and 1996 lead to increase in crime. Islam (2014) uses

data for about 12,000 firms in 27 developing countries in a study that finds that economic growth is negatively associated with crime. These studies are consistent with the idea that if the construction of a metrocable line in Medellin improved the access of economic opportunity for the area's residents, then crime in that area should fall.

Literature Review

The research in this paper on the effects of metrocable stations on crime in Medellin, Colombia relates to a wider literature on the relationship between public transportation and crime (Phillips, 2015; Liu, Jiang, Zhou, Liu, and Du, 2017), although not much research has been done on how the use of aerial cable cars as public transportation relates to crime. The effects of aerial cable cars used as public transportation could differ from other forms of public transportations for reasons that include service areas. Cable cars are specific to steep terrain, and the metrocable in Medellin is especially unique because it is located in a steep terrain with a high population density. It is possible that these conditions make it so using aerial cable cars could be more effective than other forms of public transportation, since riding a cable car may be quicker or more efficient than driving a car or motorcycle. This is different than on flat terrain, where although taking a bus or train may be a cheaper option to get somewhere it is rarely quicker than taking a car or motorcycle.

Some of this related literature focuses on the impact public transportation has on crime spatially. Phillips (2015) finds that temporary closures of train stations in Washington DC generally result in decreased crime around the closed station and the stations around it. A possible reason that this occurs that is cited by Phillips is that the temporary closure of a station raises the transportation costs of criminals to get to parts of the city where the returns to crime are higher. Liu, Jiang, Zhou, Liu, and Du (2017) find differing bus station-burglary relationships between developed and developing urban areas of the DP peninsula in China. In developed urban areas, while burglaries concentrate around bus stations, the

increase of bus service capability has a net impact of slightly depressing the occurrence of burglaries. This relationship does not hold in developing areas, where only a few people can be found on the street.

Other literature that more specifically relates to the research in this paper examines the overall levels of crime and its relationship with public transportation (Billing, Leland, and Swindell, 2011; Ihlanfeldt, 2003). Billings, Leland, and Swindell (2011) find that the announcement of new rail transit leads to a decrease in property crimes in Charlotte, North Carolina. Once train stations are opened, the crime decrease is maintained, and does not return to preannouncement levels. Ihlanfeldt (2003) finds that rail stations have a statistically significant effect on neighborhood crime and that the effect varies with three characteristics of the neighborhood: median income level, density of poverty, and average distance to poor people living outside the neighborhood. The results suggest that the fears expressed by suburban residents over station-induced neighborhood crimes are unfounded and that extensions of rail transit into the suburbs will not cause further decentralization of population and employment. This research is more similar to the research in this paper, which examines public transportation's relationship with the overall levels of crime in a sub-city area, rather than its relationship with the spatial distribution of crime.

Research has also been done on the effects of public transportation in a Latin American and Colombian context (Hernandez, Hansz, and Massobrio, 2020; Heinrichs and Bernet, 2014; Guzman and Oviedo, 2018). Hernandez, Hansz, and Massobrio (2020) examine the relationship between unemployment probability and accessibility to job opportunities via public transport at the individual level in Montevideo, Uruguay. The key findings of this research were that the further an area lies from the central business district, the lower its level of accessibility. Individuals with lower incomes have considerably lower access. Job accessibility is a statistically significant predictor of unemployment.

Guzman and Oviedo (2018) and Heinrichs and Bernet (2014) are two pieces of research done on the effects of public transportation in a Colombian context. Guzman and Oviedo (2018) examine the effects on accessibility to income-gathering opportunities and affordability of the implementation of a

targeted public transport subsidy for low-income populations in the city of Bogota. Results show evidence of higher travel cost parameters in the city expanded center and wealthier zones. Low-income populations proportionally spend 5 times more than the population in wealthy zones on transportation. Heinrichs and Bernet (2014) examine how the first line of the Medellin metrocable system, Line K, influenced accessibility of services or destinations for the residents of Medellin. They do so by using interviews of female residents of Medellin as well as using data on where and from where people were traveling using the metrocable. The key findings from this research were that accessibility constraints such as affordability constraints make it difficult for residents to use the metro and metrocable regularly. However, the construction of metrocable station has made a positive impact on the community, especially by increasing the general security of the area, which has improved accessibility.

Data

There are two primary datasets being used. The first is the Medellin Citizen Perception Survey (*Encuesta de Percepción Ciudadana de Medellín*). These are surveys given out to residents of Medellin on an annual basis by an organization called Medellin Como Vamos. This organization is private and is made up of multiple partners, which include entities such as the University of EAFIT and El Colombiano, which is a local newspaper. The first perception survey was given out in 2006. This means that the first metrocable line, which is Line K and was built in 2004, was constructed before the time frame of our data. The unit of observation in the dataset published from the perception survey is an urban zone. When all the surveys for each year are combined, each observation will be a given zone each year. Therefore, the universe in our dataset will be every zone in each year within the timeframe of our data. The variable within this dataset that measures crime will be the zone's response to the survey question "Have you been a victim of a crime within the past year?" For example, in 2006 8% of the Nororiental zone, or Zone 1,

said they had suffered a crime within the past year. Using this as the crime data is advantageous because it breaks down crime geographically at a sub-city level.

Figure 2: Zones and Comunas of Medellin

Source: Alcaldía de Medellín (2010)

The second dataset being used is the Survey of Quality of Life (*Encuesta de Calidad de Vida*). This dataset contains sub-city level data as well, but unlike the Citizen Perception Survey each observation is a different comuna instead of a zone. Each of the six zones in Medellin contain multiple comunas, except for the Southeast (*Sur-oriental*) zone, which only contains one comuna. The map in Figure 2 comes from the official website of Medellin's city government (medellin.gov.co) and shows all of Medellin's 16 comunas. Each of the comunas that are shown in the same color belong to the same

zone. In a regression using the data from this survey, the variable that will measure crime will be the homicide rate per 100 thousand residents of the comuna. An observation in this case is a given comuna each year. Data used to construct controls for regressions whether they are from the data using zones or comunas will be taken from the Survey of Quality of Life, where the unit of observation is a comuna in a given year. One of these controls is the average socioeconomic status of a person's household of the comuna. In Colombia, households are classified into different levels (estratos) based on different aspects such as the material the roof is made up of. The scale for socioeconomic status goes from 1-6, with 6 being the wealthiest level. Since the unit of observation in the Survey of Quality of Life is comunas each year and not zones like the Citizen Perception survey, and there are no comuna identifiers in the Citizen Perception Survey, controls had to be constructed to have the same unit of observation as the data from the Citizen Perception Survey. This was done by taking the weighted averages of comunas belonging to a specific zone. Comunas were weighted differently based on their total population the year of the observation. For example, the equations below were used to construct the control for occupation rate in 2007 for the Southwest (*Sur-Occidental)* zone, which contains the comunas Guayabal and Belen.

(1) $(Weighted\ Occupation\ Rate\ Belen\ 2007) = (Occupation\ Rate\ Belen\ 2007) * (Total\ Population\ Belen)$

(2) $(Control\ for\ Occupation\ Rate\ Southwest\ Zone) = \frac{(Weighted\ Occupation\ Rate\ Belen\ 2007)+(Weighted\ Occupation\ Rate\ Guayabal\ 2007)}{(Total\ Population\ Belen\ 2007)+(Total\ Population\ Guayabal\ 2007)}$

Methodology

To assess the relationship between the presence of a metrocable station and crime, I use the following regression model:

(3) $$y_{it} = \beta(Has\ Station_{it}) + \alpha_i + \tau_t + X_{it} + e_{it}$$

This regression will be run with both the data on zones as well as the data on comunas. The regression should be interpreted differently depending on what geographical areas are being used. For the data regarding zones, y_{it} can be interpreted as the percentage of surveyed residents of zone i in year t who said they had been the victim of a crime within a year of responding to the Citizen Perception survey.

The coefficient of interest is β. This coefficient in this regression measures the effect that the presence of a metrocable line had on the percentage of people in zone i in year t that said they had been a victim of a crime within a year of taking the survey. β is the coefficient of dummy variable ($Has\ Station_{it}$), which equals 1 if there is a metrocable line present in zone i in the year t, and 0 if there is no metrocable line present. α_i is a fixed effect meant to account for the permanent differences between zones. τ_t is a time fixed effect meant to account for differences between each year in the data that all zones are affected by.

For data regarding comunas, y_{it} can be interpreted as the homicide rate of comuna i in year t per 100 thousand residents. The coefficient of interest is still β, which in this case measures the effect the presence of a metrocable station has on the homicide rate within comuna i in year t. ($Has\ Station_{it}$) equals 1 if there is a metrocable present in comuna i in year t and 0 if there is no metrocable present. In a regression using comunas, α_i is a fixed effect meant to account for the permanent differences between comunas. Other than the interpretation of y_{it}, β, ($Has\ Station_{it}$), and α_i, the regression works the same whether it uses data for comunas or zones. τ_t is a time fixed effect meant to account for the differences between years that all comunas or zones are affected by.

x_{it} represents the control variables included in the regression. These include the controls meant to account for income, employment, and education. These controls have both fixed effects for zone and year, or comuna and year, depending on what regression is being run. The control variable for income comes from the average socioeconomic status in zone/comuna i in the year t. The control variable meant to account for differences in employment is the rate of occupation of each zone/comuna. Rate of occupation is given by the percentage of people who are over 12 years old who have a job. Illiteracy rate is used as a proxy to account for the education levels of each zone and comuna. e_{it} is an error term.

Summary Statistics

Comuna Data:

The table below shows statistics regarding yearly homicide rates by each comuna. The table is broken up into three groups. The first of these groups are the comunas who have stations belonging to Line K, meaning they have had a metrocable station constructed before the timeframe of our data. The second group includes the comunas that have stations belonging to Line J or Line H. This means they had a metrocable station constructed within the timeframe of our data, from 2007 to 2017. The last group contains comunas that by the end of the timeframe of the dataset never had a metrocable constructed.

Table 2: Homicide Statistics by Comuna

Comuna	**Average Homicides/100k residents (2007-2017)**	**2007 Homicides/100k residents**	**2017 Homicides/100k residents**	**Change 2007-2017**	**Standard Deviation**
Group 1: Line K (Constructed 2004)					
Popular	35.51	14.3	9.1	-5.2	43.18
Santa Cruz	27.46	10.8	14.2	3.4	23.46
Castilla	49.03	37.3	21.2	-16.1	28.11
Average Group 1	37.33	20.8	14.8	-6.0	32.91
Group 2: Lines J & H (Constructed 2008 & 2016)					
Robledo	44.35	29	40.9	11.9	17.79
Villa Hermosa	48.73	22.9	15.2	7.7	32.73
San Javier	82.45	38.8	34.5	-4.3	56.40
Average Group 2	58.51	30.2	30.1	-0.1	41.55
Group 3: No Metrocable Station					

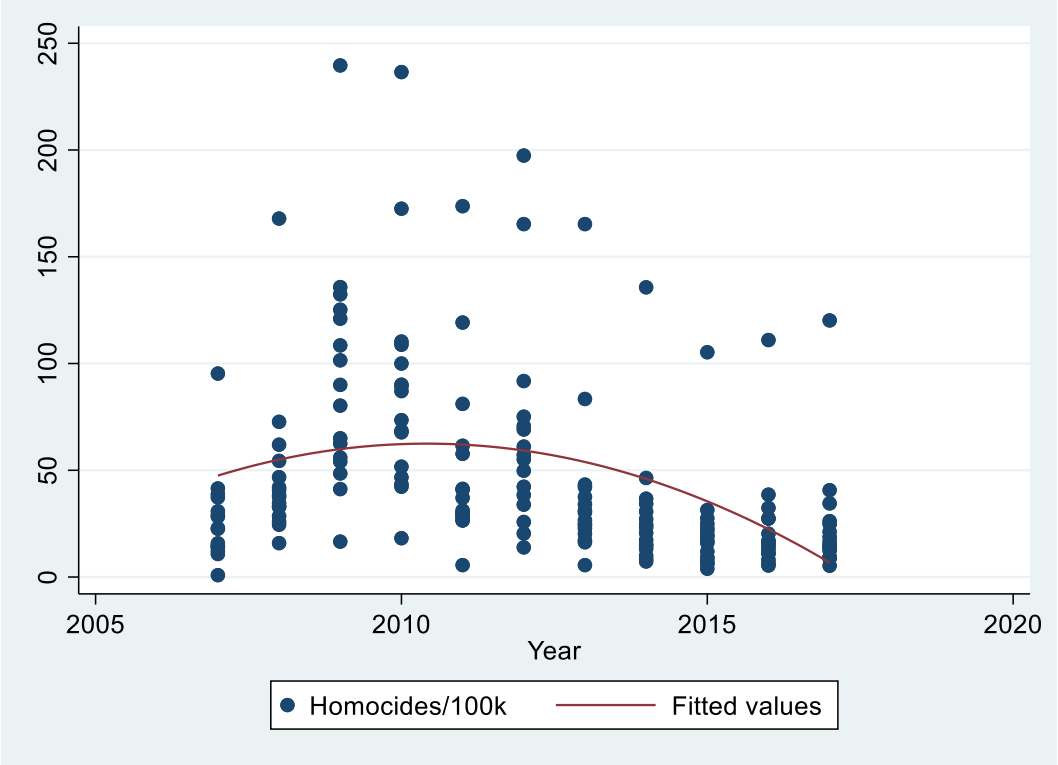
Manrique	39.16	12.3	8.7	-3.6	41.71
Aranjuez	52.32	41.5	16.6	-24.9	35.30
12 de Octubre	35.02	14	13.9	-0.1	28.31
Buenos Aires	24.73	22.6	9.5	-13.1	13.59
La Candelaria	158.9	95.3	120.2	24.9	50.60
Laureles	31.18	15.8	18.7	2.9	14.23
La America	24.57	14.5	12.4	-2.1	14.67
El Poblado	9.07	0.9	5.3	4.4	5.96
Guayabal	45.87	28.3	26.2	-2.1	19.71
Belen	34.16	30.8	24.8	--6.0	15.61
Average Group 3	45.50	27.6	25.6	-2.0	26.36

This table provides insight into the differences in homicide rates that each comuna experiences in comparison with each other. One outlier is La Candelaria. One possible explanation for La Candelaria's exceptionally high average homicides per year per 100 thousand residents is that although La Candelaria does not have a high number of residents, it is located in the center of the city meaning that many of the residents from other comunas travel through La Candelaria throughout the day. This means that relative to the number of residents of La Candelaria, there are more potential perpetrators and victims of homicide within La Candelaria throughout the year. Another outlier is El Poblado, which is a comuna in the southeast corner of Medellin that experiences exceptionally low homicide rates. A possible explanation for this is that El Poblado is by far the wealthiest comuna in Medellin.

In isolation it may appear that comunas where lines J and H were constructed suffered from the construction of the metrocable stations. However, it must be considered that Line H, which was built exclusively in Villa Hermosa, was not built until 2016. There were 0.8 less deaths per 100 thousand

residents in Villa Hermosa in 2017 than 2015, the year before the construction of Line H. It must also be considered that most comunas experience a lot of variation in homicide rates year to year. It is entirely possible that any given comuna could have happened to have a considerably good or bad year in 2007 or 2017, meaning that the simple comparison between the two years is not as reliable than if the variation year to year were not as great. The scatter plot below shows homicide rates per 100 thousand residents in every year of the data, each point being a different comuna.

Figure 3: Homicides per 100 thousand residents in each year



Note: Fitted values show quadratic fit.

Comunas generally had relatively low homicide rates in 2007. Homicide rates then generally increased in 2008 & 2009 before beginning to decline again. A possible explanation for the increase is the global financial crisis in 2008. The decrease in available economic opportunities may have led some people in Medellin into violent crime. Time fixed effects for each year are meant to account for these types of circumstances that affect all comunas.

Zone Data:

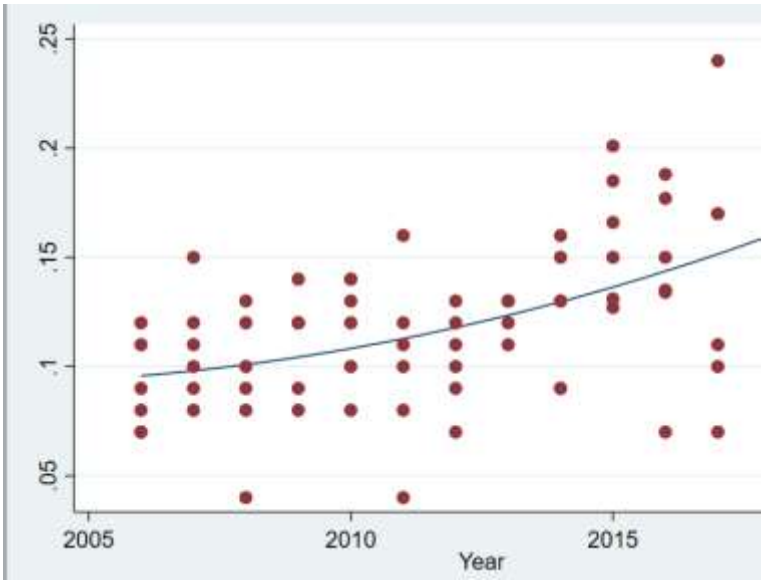
The following table shows statistics regarding responses to the question “Have you been a victim of a crime within the last year?” in the Citizen Perception Survey. Once again, the table is broken up into three groups. The first group is urban zones that have metrocable stations belonging to Line K, which was constructed before the timeframe of the data. The second group is made up of the urban zones where Lines J and H were constructed in 2008 & 2016. The third and final group is made up of urban zones that never had a metrocable station constructed.

Zone	**Average Percentage who said they were a victim of a crime (2007-2017)**	**2007 Percentage who said they were a victim of a crime**	**2017 Percentage who said they were a victim of a crime**	**Change 2007-2017**	**Standard Deviation**
Group 1: Line K (Constructed in 2004)					
Nor-oriental	10.89%	10%	10%	0%	3.19%
Group 2: Lines J & H (Constructed 2008 & 2016)					
Centro-occidental	15.07%	15%	17%	2 percentage points	4.02%
Centro-oriental	14.83%	12%	24%	12 percentage points	3.80%
Group 3: No Metrocable Stations Present					
Nor-occidental	10.78%	11%	17%	6 percentage points	3.55%
Sur-occidental	11.38%	8%	11%	3 percentage points	2.70%
Sur-oriental	10.08%	9%	7%	-2 percentage points	3.17%

Immediately it is clear that metrocable lines J & H were built in the two zones with the most crime. Both of these zones saw an increase in the percentage of surveyed residents that said they were the victim of a crime between 2007 & 2017. The Centro-oriental zone, where Line J was constructed,

doubled the percentage of surveyed residents who said they suffered a crime between 2007 and 2017. Unlike the comuna data, the majority of zones experienced an increase in crime between 2007 & 2017. Only one of the six zones saw crime decrease. The scatter plot below shows percentages of surveyed residents who said they were a victim of a crime in every year of the data, each point being a different zone.

Figure 4: Percentage of surveyed residents who said they were the victim of a crime in each zone in each year



Note: Fitted values show quadratic fit

The percentages shown from the survey clearly show a different pattern than the homicide rates of comunas. Rather than increasing and then decreasing like the homicide rates, the percentages of surveyed residents who said they suffered a crime increased before increasing at a faster rate. One possible explanation for this is that asking residents "Did you suffer a crime in the past year?" includes all types of crimes rather than just homicides. It could be that criminals transitioned from violent crimes to less serious crimes.

Control Variables:

The table below shows the values of the control variables in comunas in the year of 2007, the first year of the data. The table is split into two groups. The first group is made up of comunas that would go on to have a metrocable constructed by 2017. The second group is made up of comunas that at no point in the timeframe of the data had a metrocable station. Again, in Colombia occupation rate is defined as the portion of the population of a working age that have some type of work. For urban areas such as Medellin, working age is considered 12 years or older. Illiteracy rate is taken from the population between 15 and 24 years old. To be considered "illiterate", a person must lack the ability to write or read a paragraph of Spanish.

Table 3: Values of control variables from 2007

Comuna	Average Socioeconomic Status (2007)	Occupation Rate (2007)	Illiteracy Rate (2007)
Group 1: Lines J & H			
Robledo	2.31	45.65%	3.55%
Villa Hermosa	1.98	44.59%	2.39%
San Javier	2.01	41.89%	2.55%
Group 2: No Metrocable Line			
Manrique	2.02	42.10%	3.34%
Aranjuez	2.49	41.99%	3.16%
12 de Octubre	2.15	43.39	3.99%
Buenos Aires	2.59	43.89%	2.73%
La Candelaria	3.38	50.43%	1.77%
Laureles	4.70	45.12%	1.95%
La America	3.72	44.53%	1.88%
El Poblado	5.58	54.93	1.90%

Guayabal	3.04	44.40%	1.45%
Belen	3.08	45.97%	3.21%

The table above shows the three comunas where Line J and H were built having low average socioeconomic statuses in 2007 compared to the comunas that never got a metrocable station. This may be because the government aimed to build metrocable stations in poorer parts of the city that could benefit the most from having access to economic opportunities. It is also likely that the steep terrain and distance from the center of the city led to adverse economic conditions in the comunas where metrocables were built. If these comunas had flatter terrain or were close to the center of Medellin, then it would not have made sense to have metrocable lines built in those areas.

Results

Table 4: Relationship between Metrocable and homicides per 100 thousand residents

VARIABLES	(1) Homocides/100k	(2) Homocides/100k	(3) Homocides/100k	(4) Homocides/100k
Station	-5.011	4.034	-4.605	2.786
	(6.687)	(5.797)	(15.30)	(10.61)
Average Socioeconomic Status	30.60***	7.338	-16.42	-15.00
	(5.653)	(6.167)	(46.06)	(30.25)
Illiteracy Rate	49.54***	-54.89***	53.10***	-13.07
	(11.51)	(19.25)	(12.04)	(14.18)
Occupation Rate	-4.373***	-2.849**	-1.925*	-1.427*
	(1.136)	(1.184)	(0.995)	(0.849)
Men to Women Ratio	7.679***	8.052***	4.591***	0.282
	(0.912)	(0.871)	(1.169)	(1.112)
		-490.2***	-152.1	98.39
	No fixed effects	Year fixed effects	Comuna fixed effects	Year and Comuna fixed effects
Observations	176	176	176	176
R-squared	0.386	0.609	0.661	0.864

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 above shows results using equation (3) using data from the Survey of Quality of Life. A negative relationship is shown between the presence of a metrocable station in a comuna and homicides in the regression with no fixed effects as well as the regression with only Comuna fixed effects. The regressions with Year fixed effects and both Year and Comuna fixed effects show a positive relationship. None of these coefficients are statistically significant at conventional levels. An especially surprising result is that if Comuna fixed effects are not used, the average socioeconomic status of a comuna is shown to have a positive relationship with the number of homicides in the comuna. Regression (1), which has neither Comuna nor Year fixed effects, predicts that if the average socioeconomic status of a comuna is

increased by one (on a scale of 1-6) it would result in 30.6 more homicides per 100 thousand residents. One reason that the relationship goes from positive to negative when comuna fixed effects are added may be that there are comunas with higher average socioeconomic statuses that have higher levels of homicide for reasons that are unique to them. La Candelaria, for example, as noted in the Summary Statistics section has a location that is especially prone to more homicides per resident.

The relationship the presence of a metrocable station in a comuna has with the number of homicides in the comuna goes from negative to positive after Year fixed effects were added. Regression (4), which includes both Comuna and Year fixed effects expects the presence of a metrocable station to contribute 2.786 additional homicides per 100 thousand residents in a comuna. However, the relationship is not statistically significant and has a very high standard error. The reason that the relationship goes from negative to positive could be that comunas with metrocable stations saw a lower number of homicides largely because of circumstances that were affecting all comunas at a given time, and not as much because of the presence of a metrocable station. Another explanation is that comunas without metrocable stations saw larger homicide numbers because of circumstances specific to a certain period. For example, for whatever reason in 2009 comunas experienced on average 65.57 more homicides per 100 thousand residents than in 2007.

Table 5: Gradual inclusion of control variables in regressions on homicides

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Homicides	Homicides	Homicides	Homicides	Homicides
Metrocable	0.879	0.709	0.618	2.563	2.411
	(10.23)	(10.28)	(10.22)	(10.42)	(10.48)
Average Socioeconomic Status		-8.683	-11.33	-14.75	-14.69
		(29.96)	(29.81)	(30.03)	(30.13)
Occupation Rate			-1.418*	-1.447*	-1.450*
			(0.838)	(0.839)	(0.842)
Illiteracy Rate				-10.667	-10.786
				(11.198)	(11.249)
Men to Woman Ratio					0.225
					(1.088)
Observations	176	176	176	176	176
R-squared	0.861	0.861	0.864	0.864	0.864

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The table of regressions above shows how the predicted effect of the metrocable on homicides per 100 thousand residents in a comuna is impacted by the inclusion of control variables. All regressions shown in the table include both Year and comuna fixed effects. Without any controls outside of fixed effects, the presence of a metrocable station is predicted to contribute 0.879 additional homicides per 100 thousand residents. The inclusion of average socioeconomic status as a control makes this relationship

less positive. This is because average socioeconomic status is negatively correlated with the presence of a metrocable, and also has a negative relationship with homicides, which leads to a positive bias when average estratos are omitted from the regression. This negative correlation most likely comes from the government aiming to build metrocable stations in poorer parts of the city with less access to transportation. This negative correlation can be confirmed in the data. A bivariate regression on the probability of a comuna having a metrocable station predicts that an increase of one in the average socioeconomic status of a comuna decreases the probability of having a metrocable station by about 20.12 percentage points.

The predicted effect of the presence of a metrocable station on homicides changes the most when illiteracy Rate is added as a control variable. In column (3), which includes average socioeconomic status and occupation rate as control variables, it is predicted that the presence of a metrocable station would contribute 0.618 additional homicides per 100 thousand residents in a comuna. This prediction changes to 2.563 additional homicides per 100 thousand residents when illiteracy rate is introduced as a control variable in column (4). However, these are not statistically significant coefficients and have very large standard errors. There is a negative bias when illiteracy rate is left out because illiteracy rate has a negative effect on homicides, and positively correlated with having a metrocable station within the comuna. This positive correlation is confirmed by the data. It is likely that this positive correlation, like average socioeconomic status, comes from the government aiming to build metrocable stations in poorer parts of the city where education is less accessible.

Table 6: Regressions on percentage of surveyed residents who said they were a victim of a crime

VARIABLES	(1) Victimization	(2) Victimization	(3) Victimization	(4) Victimization
Metrocable	0.0143	0.0199	0.0442**	0.0398*
	(0.0130)	(0.0129)	(0.0196)	(0.0198)
Average Socioeconomic Status	-0.0300**	-0.0168	0.188*	0.157
	(0.0133)	(0.0156)	(0.111)	(0.110)
Occupation Rate	0.000537	-0.00246	0.00144	0.000645
	(0.00210)	(0.00291)	(0.00203)	(0.00289)
Illiteracy Rate	-0.0281**	-0.0114	-0.0174	0.00319
	(0.0133)	(0.0146)	(0.0150)	(0.0207)
Men to Women Ratio	-0.000129	0.000832	0.00174	0.00281
	(0.00200)	(0.00262)	(0.00230)	(0.00376)
	No fixed effects	Year fixed effects	Zone fixed effects	Zone & Year fixed effects
Observations	66	66	66	66
R-squared	0.280	0.473	0.478	0.630

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regardless of whether there are fixed effects included in the regression or not, the presence of a metrocable station in a zone is shown to have a positive relationship with the percentage of surveyed residents who said they suffered a crime. Column (4), which includes both Year & Zone fixed effects, expects that the presence of a metrocable station in an urban zone increases the percentage of the surveyed residents from that zone that say they have suffered a crime by 3.98 percentage points. This is statistically significant at the 10% level. This is contrary to the common perception of the metrocable, which is that it makes surrounding areas safer, and less crime ridden. One possible explanation is that the metrocable decreases transportation costs for criminals and therefore makes crime more profitable.

As with the regressions on homicides, one of the surprising results taken from these regressions is the relationship the average socioeconomic status of a zone has with the percentage of surveyed residents who said they suffered a crime once Zone fixed effects are added in Column (3) & (4). Something that needs to be considered is that the average estrato of a zone or comuna does not vary much year to year. The results given for the effect of average socioeconomic status should therefore be skewed by collinearity when Zone fixed effects are added. There is also the possibility that crime is more profitable in places where the potential victims are wealthier.

Table 7: Gradual inclusion of control variables in regressions on percentage of surveyed residents who said they were a victim of a crime

VARIABLES	Victimization	Victimization	Victimization	Victimization	Victimization
Metrocable	0.0371**	0.0417**	0.0411**	0.0402**	0.0397**
	(0.0147)	(0.0188)	(0.0192)	(0.0195)	(0.0196)
Average Socioeconomic Status		0.165	0.163	0.156	0.170
		(0.0993)	(0.101)	(0.103)	(0.106)
Occupation Rate			0.000525	0.000630	0.000369
			(0.00272)	(0.00276)	(0.00280)
Illiteracy Rate				0.008370	0.004659
				(0.019374)	(0.020249)
Men to Women Ratio					0.00247
					(0.00366)
Observations	78	66	66	66	66
R-squared	0.651	0.623	0.623	0.625	0.629

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The table of regressions above shows how the predicted effect of the metrocable on surveyed residents who said they were the victim of a crime in a zone is impacted by the inclusion of control variables. All regressions shown in the table include both Year and comuna fixed effects. Unlike the regressions on homicides, there is a negative bias when average socioeconomic status is omitted as a control variable, instead of a positive one. This is because while average socioeconomic status is still negatively correlated with the presence of a metrocable station, the average socioeconomic has a positive relationship with the percentage of surveyed residents who said they were the victim of a crime. This is unlike the regressions on homicides where average socioeconomic status had a negative relationship with homicide.

Robustness

Figure 5: Dropping outlying comunas from regressions

VARIABLES	(1) Homicides	(2) Homicides	(3) Homicides	(4) Homicides
Metrocable	2.786	2.479	4.157	3.607
	(10.61)	(10.14)	(10.54)	(10.12)
Average Socioeconomic Status	-15.00	-28.98	-14.65	-27.25
	(30.25)	(29.65)	(30.47)	(29.98)
Occupation Rate	-1.427*	-1.446*	-1.139	-1.182
	(0.849)	(0.848)	(0.898)	(0.912)
Illiteracy Rate	-13.07	-3.427	-21.50	-10.23
	(14.18)	(13.83)	(16.00)	(15.79)
Men to Women Ratio	0.282	-0.754	0.358	-0.557
	(1.112)	(1.228)	(1.103)	(1.221)
	All Observations	La Candelaria dropped	El Poblado Dropped	La Candelaria & El Poblado Dropped
Observations	176	165	165	154
R-squared	0.864	0.770	0.871	0.777

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table above shows how the results of the main regression respond when observations from La Candelaria and El Poblado are dropped. The reasons these comunas were chosen to be dropped is because they face vastly different circumstances than the other comunas. La Candelaria, as stated before, is especially prone to having more homicides proportional to its population due to its location. El Poblado was chosen due to the fact that it is far wealthier than any of the other comunas. The mean of the average socioeconomic status for the 11 observations pertaining to El Poblado comes out to 5.58, while the mean for all the comunas over the 11 years comes out to 2.86. Again, the scale for socioeconomic status goes from 1-6, with 1 being considered the poorest level and 6 being the riches. The lowest number of homicides per 100 thousand residents experienced by a comuna over the 11 years of data is 0.9 in El Poblado in 2007.

Regardless of whether La Candelaria or El Poblado are dropped from the regression, there remains a positive relationship between the presence of a metrocable station and homicides per 100 thousand residents. The magnitude of the relationship weakens when La Candelaria is dropped from the regression. This must be because the number of homicides that occurred in La Candelaria either increased more or decreased less before and after metrocable lines were constructed than the comunas where the lines were constructed. The opposite is true about El Poblado, where the magnitude of the relationship between the presence of a metrocable station and homicides per 100 thousand residents becomes more positive. When both comunas are dropped the regression associates the presence of a metrocable station with 3.607 additional homicides per 100 thousand residents in the comunas, as opposed to just 2.786 additional homicides per 100 thousand residents before the comunas are dropped. Another interesting result is that the magnitude of the effect of the average socioeconomic status of a comuna almost doubles once La Candelaria is dropped from the regression. This makes sense because La Candelaria suffers from many more homicides than would be expected from a comuna with an average estrato as high as it is. The mean average estrato of the 11 observations pertaining to La Candelaria was 3.46. Still, none of these relationships are statistically significant and have large standard errors.

Table 8: Regressions using different time periods on homicides per 100 thousand residents

VARIABLES	(1) Homicides	(2) Homicides
Metrocable	17.68	7.147
	(16.48)	(11.26)
Average Socioeconomic Status	-40.75	63.47
	(41.35)	(60.06)
Occupation Rate	-1.615	0.380
	(1.696)	(0.782)
Illiteracy Rate	7.173	-51.47
	(19.45)	(35.57)
Men to Women Ratio	3.630**	-23.01***
	(1.393)	(4.839)
	2007-2012	2012-2017
Observations	96	96
R-squared	0.886	0.922

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table above shows two different regressions that use observations from different time periods. Regression (1) uses observations from 2007 to 2012 and regression (2) uses observations from 2012 to 2017. The reason the periods are split up this way is to isolate the effects of the two different lines. Splitting up the time periods this way also allows for each regression to have the same number of observations. Column (1) is meant to show the effect of metrocable stations belonging to Line J and Column (2) is meant to show the effect of metrocable stations belonging to Line H. Again, the results for both lines show positive relationships between the presence of a metrocable station and homicides per 100 thousand residents, although neither relationship is statistically significant. The regressions show that the metrocable stations belonging to Line J contributed more homicides per 100 thousand residents than Line H. The regression pertaining to the time period Line J was built shows that the presence of those metrocable stations contribute 17.68 additional homicides per 100 thousand residents in the comuna. An interesting difference between the two regressions is the signs of the relationships the control variables

have with homicides per 100 thousand residents. All of the control variables either go from having a negative to positive relationship with homicides per 100 thousand residents, or positive to negative between the two different time periods. This may be the result of collinearity with comunas that were going through different developments during the two time periods.

Table 9:Regressions using different time periods on percentage of surveyed residents who said they were the victim of a crime

	(1)	(2)
VARIABLES	Victimization	Victimization
Metrocable	-0.00739	0.103***
	(0.0364)	(0.0354)
Average Socioeconomic Status	0.0413	0.494
	(0.130)	(0.350)
Occupation Rate	-0.00644	-0.000985
	(0.00665)	(0.00451)
Illiteracy Rate	-0.00141	0.00658
	(0.0470)	(0.0260)
Men to Women Ratio	-0.000358	0.00536
	(0.00451)	(0.0363)
	2007-2012	2012-2017
Observations	36	36
R-squared	0.556	0.714

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Just like Table 8, Table 9 shows two regressions showing two different time periods split up the same way. These regressions show Line J and Line H having different relationships with the percentage of surveyed residents who said they were the victim of a crime. Regression (1) shows the presence of metrocable stations that belong to Line J contributed to a decrease of 0.739 percentage points of the

surveyed residents of the zone who said they were the victim of a crime. On the other hand, Regression (2) shows the metrocable stations belonging to Line H increasing the percentage of surveyed residents of the zone who said they were the victim of a crime by 10.3 percentage points. This was statistically significant at the 1% level, which is especially worrying given the fact that there were only 36 observations used in the regression.

Conclusion

The results of my difference in differences analysis comparing comunas/zones with and without metrocable stations shown in the results section suggest that the presence of a metrocable station has a positive relationship with crime. This relationship may be the result of lowered transportation costs for criminals. This relationship seems to be stronger with crime in general than with homicides specifically. The regressions on homicides showed a positive relationship if year fixed effects were included, although no regression showed this relationship at a statistically significant level. All regressions on the percentage of surveyed residents who said they were the victim of a crime showed a positive relationship from the presence of a metrocable. These regressions were statistically significant when zone fixed effects were included. These positive relationships may be the result of lower transportation costs for criminals. It may also be true that the Lines J & H were not as successful in increasing the accessibility to better economic opportunities to residents within the areas as perceived. The difference in relationships the presence of a metrocable has with homicides per 100 thousand residents in a comuna and surveyed residents who said they were the victim of a crime could be attributed to crimes outside of homicide, such as theft and property crimes, increasing more because of the construction of metrocable stations than homicides did.

This research could be improved with official data at the comuna level for all types of crime. This would be preferable to avoid biased survey responses. However, there is an advantage to using

victimization surveys, as they can account for crimes that go unreported. It would also be preferable to using just homicide data to get a better idea on what the relationship is between the presence of metrocable stations and crime in general instead of just homicides. Using data that is broken up by comunas is preferable to using data broken up by zone because there are 16 comunas and only 6 zones. This would allow for more observations per year of data. There could also be improvement in the controls used. The average socioeconomic status of a zone/comuna especially, was used due to the lack of income data available. However, there is little year-to-year variation in average socioeconomic status due to it being based on the characteristics of each person's home. This leads to covariance with zone/comuna fixed effects as well as a lack of ability to account for year-to-year variation in income.

Another way this research would be improved would be to have data over enough years to measure the effects of metrocable lines outside of Line J & Line H. The effects of Line K (which was constructed before the timeframe of my data) and Line P (constructed after timeframe of data) may especially have different effects on crime than Lines J & H. This is because Lines K & P are directly connected to Line A, which is a train and most important piece of the Medellin Metro system and moves through the center of the city past the northern and southern borders of the city. This is unlike Lines J & H, where another train or tramway must be taken after riding the metrocable in order to have access to Line A. This direct access to Line A from Lines P & K may lead to different results.

The last improvement I would make to this research would be some type of control that accounts for the effect the construction of a metrocable station on comunas/zones outside of where it was constructed. The metrocable makes other comunas/zones more accessible to the residents of the area where the metrocable was built, as well as making that area more accessible to residents of other comunas/zones. The metrocable is just one part of Medellin's public transit system that connects to buses, trains, and tramways. Since metrocables are part of a larger system of public transportation, it is likely that in some way residents in other comunas/zones were affected by the metrocable. The bias that comes from not controlling for the way neighboring zones/comunas are impacted by the construction of a

metrocable depends on the relationship between the construction of a metrocable and crime in neighboring zones/comunas. If the relationship was positive, then there would be a negative bias in my results. If the relationship was negative, then there would be a positive bias in my results. This is because the methodology I used in this research was set up as if the zones/comunas without metrocable stations were not impacted in anyway by the construction of metrocable stations in other parts of the city.

In summary, there seems to be a positive relationship between the construction of a metrocable station and the amount of crime in the area that it is located in. I hope that this research can provide some insight into the dynamics between crime and aerial cable cars as a form of public transportation, as well as public transportation in general.

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