**1. Abstract**

**2. Keywords**

**3. Introduction**

While the international image of Buenos Aires, Argentina is of a cosmopolitan city filled with Parisian architecture, wide boulevards, luxurious cafés, gargantuan football stadiums, and vivacious tango parlors, the reality of daily life is very different for most of its thirteen million residents. Socioeconomic inequality is a significant problem in the sprawling metropolis, where millions live in poverty, lacking access to basic services like shelter, water, or electricity (TECHO). These inequalities, in turn, are sometimes prominently manifested on Buenos Aires’ metropolitan landscape, with perhaps no better example than the six hundred plus informal housing communities in its suburban periphery known as *asentamientos*.

Outwardly similar to squatter settlements in any other rapidly urbanizing city in the Global South, the *asentamientos* of Buenos Aires have increasingly garnered the attention of policymakers and academics, a consequence of their swelling populations—estimated at around 1.2 million people—and the unusual circumstances of their origin. Almost exclusively suburban, *asentamientos* originated in the destruction of Buenos Aires’ urban slums in the late twentieth century, after which residents scattered into the metropolitan periphery, self-constructing communities on whatever spaces were available, e.g., wastelands like riverbanks and dumps. Given the degree of self-organization required for initial settlement, many *asentamientos* now appear remarkably formalized, with street grids and utilities, despite their illegal status.

Nevertheless, recent work on the *asentamientos* has shown that most still face the same inequitable provision of critical services, with only the oldest, most well-organized communities exhibiting any traits of formality. Most *asentamientos* have instead been overwhelmed by an influx of low-income migrants, a consequence of the instability plaguing the Argentine economy in recent decades, with most *asentados* lacking basic services like electricity, sewerage, paved roads, and clean water. One critical service that is also presumed to be poor in the *asentamientos*, yet has never been explicitly studied on its own, is *public transportation*. ˜

For low-income people like those in the *asentamientos*, public transportation is the only means for reaching critical activity sites like sites of employment, healthcare, and education. Participation in urban public life is simply not possible without such services, so it is imperative to know which places are accessible to *asentados* via the transportation system in place in Buenos Aires. Found more in the peripheral spaces of the conurbation than its more established neighborhoods, *asentamientos* are, by definition, situated far away from dense, centrally located corridors likely to have fast, reliable public transportation options. As a result, X.

The advent of online mapping tools that interactively query public transportation routes and schedules to provide step-by-step, origin-to-destination directions has facilitated the measure of public transit-facilitated accessibility like never before. This paper utilizes one of those tools, Google Maps and its cache of transit schedules for Buenos Aires, to quantify access from the *asentamientos* to goods and services as an explicit factor of *time*, something largely impossible with existing technology. Framing access through time better approximates accessibility than older distance-based measures given that people, no matter the location, are more like to consider the former over the latter when deciding to make a trip.

Using Google Maps to contrast the accessibility of basic amenities from Buenos Aires’ *asentamientos* with that of its formal neighborhoods, the overarching goal of this paper, accomplishes two tasks. First, it will indicate if there are discrepancies in access, as expected given the *asentamientos’* history and geography. Heavily implied in literature, there are no hard statistics quantifying this claim. Secondly, it will highlight the areas of metropolitan Buenos Aires with the longest travel times to critical services, whether inhabited by *asentados* or not. By indicating those people most likely dealing with the adverse socioeconomic consequences of inadequate transportation, decision makers can target policy interventions to the specific neighborhoods that would benefit most from improvements in access via public transportation.

**4. Study Area and History**

Buenos Aires is the capital and largest city in Argentina, the center of a metropolitan region with over thirteen million people. It is home to all branches of the Argentine federal government and is a domestic and international node of commerce, industry, and culture. Along the eastern coast of Argentina and the South American continent, metropolitan Buenos Aires is tucked alongside the Rio de La Plata estuary, with a large urban landscape sprawling into the Argentine interior. Two centuries of growth, stemming from the city’s status as a major destination for European immigration and as the primary port of exit for the country’s agricultural and industrial largesse, have resulted in the massive urban agglomeration of today.

Politically, metropolitan Buenos Aires is comprised of two entities with similar names: the Autonomous City of Buenos Aires (CABA) and the Province of Buenos Aires. The former serves as Argentina’s federal district – home to the country’s legislature, federal courts, and administrative agencies – and is politically independent of the latter, a federal province that surrounds CABA on all sides and administers nearly all of Buenos Aires’ urban sprawl. In fact, the Province encompasses all of the other departments, or second-level administrative regions, that the Argentine census authority designates as part of “agglomerated Buenos Aires”. The Province, which happens to be Argentina’s most populous province, continues for hundreds of miles to the south and east of CABA. CABA had been part of the Province for much of Argentine history but was broken away in a 1994 constitutional referendum.

Buenos Aires’ urban surface, or *mancha urbana* in Spanish, now encompasses all of CABA part of some component of more than thirty departments in the Province. The product of two-hundred years of growth, Buenos Aires’ irregularly shaped urban growth boundary, however, does not cover all of these units equally. Some departments are fully within the *mancha urbana* while others are on its periphery. In fact, the government categorizes the departments by their histories and relative envelopment: (1) fully urban, old growth; (2) partially urban, old growth; or (3) partially urban, new growth (old and new growth defined relative to the only prior definition of metropolitan Buenos Aires in the 1940s). While *asentamientos* exist in departments falling into each of these categories, distinguishing between them serves to X.

While transportation has played a role in shaping every cities’ urban morphology, public transportation has been especially important in Buenos Aires. During the first half of the twentieth century, urbanization was found around the stations and stops of fixed streetcars and railways. Given the flat topography, railroad lines were built in all directions, creating multiple linear corridors of growth, all of which today still comprise some of the agglomeration’s oldest, densest neighborhoods. The post-World War II proliferation of buses, easily routable over an expanding regional road network and affordable to operators and riders, pushed growth away from railway corridors. With an ever-increasing demand for housing from European immigrants and domestic migrants throughout the mid-twentieth century, coupled with housing policy friendly to the formal development of housing on vacant land, neighborhoods occupied nearly all vacant land in the city and inner suburbs by the 1970s. Any unsettled land was either environmentally hazardous (e.g., flood prone riverbanks, industrial land) or too far away from employment centers for workers to affordably commute on public transit.

It may therefore come as little surprise that these peripheral spaces are the home to most of Buenos Aires’ *asentamientos*. Their name derived from the Spanish word for ‘settlement’, they are informal settlements primarily characterized by their locations in Buenos Aires’ suburbs. Numbering in the thousands, and home to more than 1.2 million people, they are an ubiquitous part of contemporary Buenos Aires, the primary housing option for low income migrants, and their families, seeking to make a living in the big city.

They first appeared in the 1970s after the 1976-83 Argentine dictatorship announced plans to raze all informal settlements in the City of Buenos Aires while simultaneously eliminating rent controls. In turn, low-income residents fled to the suburbs, settling on any vacant land available. Given that all land suitable for proper habitation was gobbled up by prior suburbanization—itself aided by lax housing regulations—they illegally settled on the vacant land available: environmentally-hazardous sites or departments at the distant ends of transportation services. Residents’ homes are self-constructed and

Over time, however, many of these communities have begun to take on a degree of permanence, another defining characteristic of an *asentamiento*. As their populations have swelled in subsequent decades—whether through the economic crises of the late 1980s and early 2000s or the booms of the 1990s and late 2000s—many have used their collective human capital to both provide services for themselves (e.g., dividing land into plots, laying out street grids) or pressure local governments to provide rudimentary services (e.g., sewerage, electricity, pavement, water, etc.). In rare cases, settlers acquired the legal rights to their land from the authorities. On the whole, however, conditions are still predominantly poor, with a 2013 study showing many AGBA’s *asentamientos* as lacking electricity, potable water, and paved streets. One service that has never been officially explored vis-à-vis the *asentamientos* is transportation.

By all indications, transportation services in the *asentamientos* can be expected to be as poor as those others deemed insufficient. For one, their peripheral locations inherently place them far away from activity sites in their departments and the metropolitan region at large. Furthermore, public transportation services have deteriorated regionwide as more people have abandoned buses and trains for increasingly-affordable private automobiles; cash-strapped bus operators and newly-privatized railways have drastically cut services. Transportation planning has favored the politically-powerful, i.e., wealthy, car-owning city dwellers who have prioritized road building over transit service; there remains no metropolitan planning authority to represent the mobility needs of the working-class Argentines who dominate the *asentamientos*.

Given the critical role that transportation can play in lifting people out of poverty by providing access to jobs, schools, hospitals, and other daily activity sites, and the fact that the *asentados* of Buenos Aires appear to lack these benefits, several questions are posed. Within agglomerated Buenos Aires, do *asentamientos* enjoy worse public transit-facilitated access to important activity sites than those formal neighborhoods in the conurbation? If so, do the disparities vary between departments characterized by different histories of urbanization (e.g., totally urbanized, mostly urbanized, and newly-urbanized)?

As surveyed above, there is ample evidence to believe that those living in the *asentamientos* of Buenos Aires will have **poorer** transit-based access to daily activity sites than those people living in the formally-established neighborhoods that surround them. Furthermore, there will be inequities in all departments, regardless of the degree of urbanization. As increasingly-permanent fixtures of Buenos Aires’ urban fabric, Argentine authorities must recognize that the *asentamientos* warrant their full attention, not merely brushed aside.

**5. Methods**

What sets this project apart from studies of transportation inequality in Buenos Aires is the adoption of Google’s Distance Matrix API for operationalizing the fundamental notion of *accessibility*. Defined as the “spatial distribution of activities around a point, adjusted for the ability and desire of people or firms to overcome spatial separation,” accessibility, as a characteristic of a transportation system, indicates a system’s performance and equity. When a user can quickly, comfortably, and affordably reach his or her destination, public transportation-facilitated accessibility is high, and the system is performing well. Time, as seen here, is a critical component of evaluating accessibility, yet has historically been difficult to estimate without riding a system in question: modes travel at different speeds (limits of previous methods). With time being difficult to predict, accessibility was commonly measured as X.

Using the API, however, is a game changer. Researchers can query Google Maps’ cache of data on historic traffic congestion and transit network schedules, alongside its shortest-path routing algorithms, for data on travel times and distances between an array of points of interest. All that is required is a valid Google account – a standard account is free – and a computer with a software package enabled to query the API; in my case, I used the statistical program “R”. Code for querying the API is easily found online.

The advantages of the API – over alternate methods for estimating accessibility – are many. For example, their travel time estimates are based on actual schedules, rather than assumptions on travel speed, wait times, or intra- or inter-modal connections. The incorporation of Buenos Aires’ transit schedules into Google’s mapping platform is relatively new, first introduced in 2016.

The tool requires only five parameters: an array of origins, an array of destinations, mode, time of day, and the date. The origins and destinations are entered as latitude and longitude coordinates while the mode of travel can be set to any combination of buses, trains, or trams. Meanwhile, the user can provide a day and time to serve as the time of departure or arrival of a given trip.

There are, however, some limitations to the tool. For one, standard account users are limited to 2,500 daily requests to Google’s server, with each “request” corresponding to each origin-to-destination travel time in the output matrix (20 origins x 20 destinations = 400 requests at a given time-date-mode configuration). Since the tool does not have a way to return the “nearest” destination to an origin, a user needs to request the travel time to *all* potential destinations and then write a separate script to select the minimum. Re-running the same request at a different time, date, or modal selection would drastically increase the total requests. In the name of expediency, I had to significantly narrow my pool of potential origins and destinations before starting with the API.

Another limitation to the API is that it returns only a travel time, with no information on the route or mode of travel. It is impossible to know how much of a given time would be spent in movement or waiting or on any particular mode or route. To the average user, thirty minutes of travel is not the same as thirty minutes of waiting. Relatedly, the tool also provides no cost data, critical in most users’ decisions to travel. Lastly, the results are not easy to verify, with no way to cross-validate travel time estimates without being on the ground. Transit schedules for most buses in Buenos Aires are not made public and there are few existing studies.

Selecting coordinates to represent the *asentamientos* required multiple steps. I first acquired a polygon shapefile of the known *asentamientos* from TECHO, an international housing NGO whose Argentine branch maintains a web map of the 600 communities in agglomerated Buenos Aires. *Asentamientos* are not a governmentally-recognized geographic unit, so I had to rely on the polygons drawn by the TECHO staff. Furthermore, their sizes greatly vary (X to X) and do not universally cohere to any other unit.

With the goal of comparing travel times between the *asentamientos* and the formal neighborhoods that surround them, I needed a new geographic unit that could easily facilitate the construction of a control group alongside my study areas. In turn, I adopted the geographies utilized by Argentina’s census, seeing as their smallest unit – known as the *radio* – was, on average, similar in size to an average *asentamiento* (X to X). There are no authoritative maps of Buenos Aires’ *asentamientos*, so I relied on digital maps published by TECHO, an Argentine housing NGO. Owing to their varied sizes, the *asentamientos* did not universally align with an existing unit of geography in Buenos Aires.

To compensate for *asentamientos* varying in size relative to the *radios*, I instead classified all of AGBA’s *radios* by their overlap with an *asentamiento*. Overlap of 50% or greater designated a *radio* as an “informal neighborhood”, 1%-49% as “semi-formal neighborhood”, and <1% as a “formal neighborhood.” While not a perfect characteriziation, this system equated the overlap with the likelihood that a given *radio* actually represented an *asentamiento*, with those with no overlap constituting the control group. Across AGBA, the vast majority of *radios* (n=17,000) were classified as “formal”, with X deemed “semiformal”, and X as “informal.”

I took multiple steps to narrow the pool of *radios* to a level manageable for the API. First, I selected three AGBA departments as case studies, basing my choice on two criteria: the department belonging to each category of “urbanization” as dictated by INDEC (e.g., entirely urban, partially urban-old growth, and partially urban-new growth) with the greatest number of families living in its *asentamientos*. The resulting departments were Quilmes, La Matanza, and Pilar. With more 1,000 *radios* across the three case studies alone, I took an additional random sample from within each departments’ pool of “formal”, “informal”, and “semiformal” *radios*. Where possible, I drew a sample of 30 *radios* from these first two categories (if 30 were not available, as happened in Pilar and Quilmes, all were taken) and then drew a separate sample of “formal” *radios* equal in size to the sum of the other two (e.g., six “informal” + thirty “semi-formal” = thirty-six “formal”). The pool of *radios* narrowed down to a manageable 284, I finished by determined the mean population center of each of these radios and used the coordinates of these points as inputs for the API.

Destinations were selected based on ethnographic research and data availability. The work of sociologist Cravino, et al. (2007) has revealed that X. Representing the most common trip type in Buenos Aires, home-to-work, was complicated by a lack of employment location data and that *asentados* work jobs that are not location-specific. As such, I proxied these locations using departments’ central business districts, places most likely to feature the informal employment associated with *asentados*: X.

For each sample *radio*, I requested the travel times to three separate central business districts (CBD). First, the CBD of its respective department: Quilmes, La Matanza, or Pilar. Second, the closest CBD of any department; for some *radios*, especially those on the edges of a department, another department’s urban center may be closer and better representative of the place the *asentados* might travel to seek work or help. Third, the downtown CBD of the City of Buenos Aires; while commuting data and previous ethnographic work shows that *asentados* are unlikely to travel into the city center, I included these potential trips to capture X.

The next destination category was railroad stations. Buenos Aires’ commuter railways, despite substantial cuts in service quality over the past half-century, remain a popular way for low-income suburbanites to travel inter-departmentally within AGBA, especially into and out of CABA. Furthermore, railway stations, similar to central business districts, also sport high concentrations of informal work, especially those catering to commuters. Indicative of the prior importance of railroads in shaping urban development in Buenos Aires, the areas around stations are some of the densest residential and commercial spaces outside of departmental CBD’s.

The remaining destination types, health centers and schools, reflect the second- and third-most common trip types, per ENMODO. To represent trips *asentados* might take concerning their healthcare, I selected three location types, all publicly-operated: hospitals, diagnostic-treatment centers, and urgent care units. Personal correspondence revealed that *asentados* were unlikely to seek treatment in any private healthcare facility, especially given government programs intended for the poor. All data was sourced from either the Province of Buenos Aires or the federal planning ministry. The last of these three, the “urgent care units”, were part of an early-2010s program from the Province to improve healthcare in underserved areas.

School location data, available through the data portal at the Province of Buenos Aires, reflects similar ethnographic findings on *asentados*: they are likely to attend public schools and unlikely to progress beyond a secondary-level education. As such, I limited the destinations to the nearest public (1) kindergarten, (2), primary school, and (3) secondary school. These also reflect how many *asentamientos* are inhabited by young families.

With the destinations set, I lastly established the three remaining parameters. First, I included all potential modes of transit: rail, bus, and subway. Second, I used a generic Wednesday as my travel day, the day of the week least likely to see transit schedules interrupted by a holiday. Third, I selected travel times that corresponded to each trip type, using data from a 2010 commuter survey: work trips at 7:00am, healthcare at 10:30am, and education at 12:00pm.

Given the daily limit of the API, I had to make my requests (283 origins and 10 destinations) across multiple weeks of February and March 2018. All requests were made with the “ggdist” package in “R”, where all results—returned by the API as origin-destination times-tables—were initially stored. For destinations where the “nearest” instance of a destination was needed, I applied the “min” tool within “R” to select the minimum travel time to all instances of a destination category; without an API tool for automatically selecting the “minimum” value, I had to request a travel time to all candidate destinations first. This dramatically increased my total number of requests. All the while, the final result was a 283 row-by-10 column matrix, indicating the travel time from each *radio* to its nearest amenities.

With the goal of this thesis to compare travel times between informal and formal neighborhoods, my statistical analysis rested on two rounds of difference-of-means tests: analysis of variation (ANOVA) and one-directional T-tests. The first, ANOVA, reveals whether there are statistically-significant differences in the means of three or more sample datasets. ANOVA will help me tell if there are differences in the average travel times between the “formal”, “informal”, and “semiformal” *radios*. According to my hypothesis, there ANOVA test statistic (the F-value) should show significant differences in the average travel times between the three *radio*-types, regardless of which department to which they belong.

To compensate for the fact that an ANOVA test cannot alone reveal which of the sample datasets are significantly different from one another, I added a set of one-directional T-tests for robustness. T-tests compare the means of just two samples, rather than three or more with ANOVA; a significant test statistic (T-statistic) indicates that there is a statistically-significant difference in the two samples’ means. For this project, five T-tests were performed on the sampled *radios’* travel times: (1) “informal” vs. “formal”, (2) “semiformal” vs. “formal”, (3) “informal” and “semiformal” vs. “formal”, (4) “informal” vs. “semiformal”, and (5) “informal” vs. “semiformal” and “formal”. Significant gaps between “formal” and any combination of the “non-formal” *radios* would support my hypothesis, especially if corroborating a significant ANOVA result.

Insignificant F- or T-statistics would show that there are likely no differences in the average travel times to activity sites between *formal* and *informal* neighborhoods in AGBA.

**6. Results and Analysis**

Intriguing results from this study came from analyzing the three case studies individually, although some conurbation-wide trends should be noted.

First, the longest absolute travel times to lower-order destinations with fewer locations, e.g., central business districts, railways, and hospitals. All of the amenities’ travel time distributions have rightward skews with numerous outliers. These findings are largely similar to those found by ENMODO in 2010; higher-order destinations have shorter travel times and vis-versa (e.g., school trips 10-20 and work trips 30+).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Radios*** | **Statistic** | Buenos Aires CBD | Department CBD | Nearest Dept. CBD | Railway Station | Urgent Care Center | Diagnosis Center | Hospital | Kindergarten | Primary School | Secondary School |
| *Summary Statistics* | | | | | | | | | | | |
| All | Avg. | **114** | **65** | **60** | **35** | **64** | **45** | **15** | **12** | **10** | **11** |
| *Min.* | *42* | *2* | *2* | *3* | *9* | *2* | *0* | *0* | *0* | *0* |
| *Max.* | *275* | *233* | *233* | *183* | *189* | *196* | *72* | *55* | *51* | *58* |
| Informal  *(IF)* | Avg. | **123** | **81** | **77** | **42** | **57** | **54** | **14** | **10** | **9** | **11** |
| *Min.* | *67* | *13* | *13* | *13* | *18* | *11* | *4* | *2* | *2* | *3* |
| *Max.* | *275* | *233* | *233* | *183* | *130* | *196* | *39* | *40* | *43* | *42* |
| Semi-formal  *(SF)* | Avg. | **123** | **72** | **67** | **40** | **65** | **52** | **16** | **14** | **12** | **12** |
| *Min.* | *57* | *8* | *8* | *11* | *11* | *9* | *0* | *2* | *2* | *1* |
| *Max.* | *241* | *199* | *199* | *134* | *189* | *158* | *43* | *42* | *49* | *41* |
| Formal  *(F)* | Avg. | **105** | **54** | **49** | **28** | **65** | **37** | **14** | **10** | **11** | **9** |
| *Min.* | *42* | *2* | *2* | *3* | *9* | *2* | *1* | *0* | *0* | *0* |
| *Max.* | *239* | *194* | *194* | *129* | *188* | *155* | *72* | *58* | *55* | *51* |
| *Difference of Means Tests* | | | | | | | | | | | |
| IF, SF,  and F | F-stat. | 6.8  \*\*\* | 11.2  \*\*\* | 12.9  \*\*\* | 9.8  \*\*\* | 1.1 | 12.8  \*\*\* | 1.4 | 2.4  \* | 4.9  \*\*\* | 3.9  \*\* |
| Informal, Formal | T-stat. | 2.9  \*\*\* | 4.2  \*\*\* | 4.7  \*\*\* | 3.6  \*\*\* | -1.6 | 4.0  \*\*\* | 0.3 | 0.4 | 0.4 | -0.6 |
| Semiformal,  Formal | 3.2  \*\*\* | 3.5  \*\*\* | 3.6  \*\*\* | 3.8  \*\*\* | 0.0 | 4.4  \*\*\* | 1.6 | 2.7  \*\*\* | 3.0  \*\*\* | 1.7 |
| Informal,  Semiformal | 0.1 | 1.2 | 1.4 | 0.5 | -1.4 | 0.4 | -1.1 | -1.9  \* | -2.2  \*\* | -2.3  \*\* |
| IF+SF,  Formal | 3.7  \*\*\* | 4.6  \*\*\* | 4.9  \*\*\* | 4.4  \*\*\* | -0.7 | 5.1  \*\*\* | 1.3 | 2.2  \*\* | 2.4  \*\* | 1.0 |
| Informal,  SF+F | 1.8  \* | 3.2  \*\*\* | 3.5  \*\*\* | 2.5  \*\* | -1.5 | 2.7  \*\*\* | -0.2 | -0.5 | -0.8 | -1.2 |

When considering the *asentamientos*, there is initial evidence that the informal neighborhoods are worse off. Informal and semiformal *radios* had longer travel times to the six highest-order destinations: central business districts, railways, and hospitals. It was for these destinations that the ANOVA tests confirmed the statistical significance of these differences and whose T-tests additionally showed the largest differences to exist between non-formal and formal *radios*. Central business districts, it seems, are the amenities with the greatest variation in time-based access. Curiously, public schools were also statistically implicated for being inequitably accessible, albeit less so, despite having smaller absolute ranges (e.g., 15-45 minutes from all 283 *radios* instead of 30 minutes-4 hours). Schools, it should be noted, instead saw their greatest differences between the *semi*formal and formal neighborhoods.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Dept.** | ***Radios*** | **Statistic** | Buenos Aires CBD | Department CBD | Nearest Dept. CBD | Railway Station | Urgent Care Center | Diagnosis Center | Hospital | Kindergarten | Primary School | Secondary School |
| Quilmes | Informal | Avg. | **1:30** | **53** | **51** | **42** | **51** | **38** | **9** | **9** | **8** | **13** |
| Min. | 1:07 | 13 | 13 | 18 | 18 | 11 | 4 | 2 | 2 | 4 |
| Max. | 1:49 | 1:21 | 1:21 | 1:10 | 82 | 65 | 15 | 17 | 16 | 22 |
| Semi-  formal | Avg. | **1:25** | **:56** | **:49** | **:38** | **:41** | **:37** | **:08** | **:08** | **:07** | **:12** |
| Min. | 57 | 8 | 8 | 12 | 11 | 9 | 0 | 2 | 2 | 2 |
| Max. | 119 | 83 | 73 | 59 | 101 | 54 | 31 | 16 | 15 | 25 |
| Formal | Avg. | **75** | **43** | **37** | **29** | **48** | **30** | **9** | **8** | **6** | **10** |
| Min. | 42 | 8 | 8 | 3 | 11 | 7 | 3 | 2 | 0 | 3 |
| Max. | 109 | 95 | 77 | 68 | 77 | 59 | 24 | 24 | 20 | 28 |
| La Matanza | Informal | Avg. | **143** | **97** | **96** | **46** | **53** | **65** | **18** | **10** | **10** | **10** |
| Min. | 103 | 49 | 49 | 13 | 18 | 17 | 4 | 3 | 3 | 3 |
| Max. | 275 | 233 | 233 | 183 | 130 | 196 | 39 | 40 | 42 | 43 |
| Semi-  formal | Avg. | **144** | **103** | **99** | **48** | **55** | **72** | **22** | **13** | **13** | **13** |
| Min. | 94 | 35 | 35 | 11 | 20 | 28 | 4 | 1 | 2 | 2 |
| Max. | 240 | 199 | 199 | 134 | 91 | 158 | 43 | 36 | 35 | 34 |
| Formal | Avg. | **116** | **60** | **59** | **28** | **56** | **42** | **15** | **8** | **7** | **7** |
| Min. | 58 | 2 | 2 | 7 | 9 | 2 | 1 | 0 | 0 | 0 |
| Max. | 239 | 194 | 194 | 129 | 83 | 155 | 72 | 40 | 42 | 34 |
| Pilar | Informal | Avg. | **118** | **79** | **57** | **26** | **92** | **48** | **10** | **9** | **12** | **11** |
| Min. | 104 | 45 | 45 | 16 | 49 | 38 | 7 | 4 | 7 | 6 |
| Max. | 134 | 134 | 70 | 34 | 128 | 58 | 15 | 14 | 21 | 21 |
| Semi-  formal | Avg. | **144** | **55** | **51** | **33** | **107** | **46** | **18** | **16** | **17** | **17** |
| Min. | 106 | 19 | 19 | 12 | 35 | 19 | 3 | 2 | 2 | 2 |
| Max. | 241 | 105 | 78 | 54 | 189 | 63 | 43 | 41 | 42 | 49 |
| Formal | Avg. | **130** | **60** | **46** | **27** | **109** | **37** | **19** | **17** | **17** | **16** |
| Min. | 96 | 3 | 3 | 7 | 51 | 10 | 4 | 2 | 2 | 1 |
| Max. | 203 | 149 | 116 | 54 | 188 | 111 | 57 | 58 | 55 | 51 |

Examining a map of travel times from all of the sampled neighborhoods from across the conurbation, we see initial evidence of one of this paper’s major conclusions: there are distinct patterns of transit-facilitated access in each of the three study areas, especially when comparing formal and informal settlements. It does not seem that all three departments’ neighborhoods are equally contributing to the differences observed in the statistical tests above.

For instance, the two outer departments, Pilar and La Matanza, exhibit large ranges, with some *radios* requiring hours of additional travel to reach certain amenities when compared against departmental neighbors. Conversely, relatively short travel times – regardless of destination – are found all across Quilmes. While informal neighborhoods look to represent many of the longest travel times, or largest circles, on the map, this is not always the case; Pilar, for example, has a few *formal* neighborhoods that appear inaccessible. The importance of land use and geography implied by these findings makes clear the need to test for differences-in-means within each of the three case study departments. Without further local characterization, any and all results for the entire metropolitan area are to be taken with caution.

In fact, the three departments’ statistical tests produced curiously distinctive results. A majority of the difference-of-means tests were significant in La Matanza, nearly half were in Quilmes, and almost none were for Pilar. Accessibility in La Matanza, at least initially, looks to be much more inequitable then either of the other two, with Pilar *appearing* to have no problems at all. Somewhat contradicts expectations from the distributions, where the absolute differences in Quilmes are less than those in Pilar.

La Matanza’s results characterize a department with significant inequalities in access. While higher-order destinations were more likely to return significant ANOVA or T-tests in all departments, La Matanza is unique in that nearly every amenity appears to be inequitable accessible to informal neighborhoods. Substantially longer travel times are required to reach not only business districts, hospitals, and railroad stations, but also schools and diagnostic treatment centers. Alongside the nine significant or very-significant ANOVA tests, the department’s T-tests furthermore confirmed these gaps to exist specifically between formal and informal radios. The only destination that appears equitably accessible are the urgent care units, which were intended to serve lower-income areas of Buenos Aires Province; the locational planning for these facilities looks to have been quite good.

Quilmes, meanwhile, showed moderately inequitable results, with only higher-order destinations returning significant results. Residents of informal radios in Quilmes have significantly worse access to business districts, railroad stations, and hospitals, with all lower-order amenities, save secondary schools, more equitably accessible between neighborhood types. For those destinations with significant ANOVA results, the neighborhood categories exhibiting the differences were again informal/formal and semiformal/formal. Quilmes is an interesting case because it still displayed statistically-significant differences despite its smaller total size limiting the range of possible travel times (i.e., none longer than 90 minutes to any amenity).

The most interesting results, however, come from Pilar. Remarkably, only one ANOVA test was significant to any degree (hospitals), and none of the T-tests significantly supported the hypothesis that there would be accessibility gaps between informal and formal neighborhoods. Despite absolute travel times more similar to La Matanza and much longer than Quilmes, all ten amenity types appear to be equally as transit-accessible to Pilar’s formal, semiformal, and formal neighborhoods. Unlike the other two departments, most destinations require similar travel times to all radio types, with some clearly requiring longer travel from *formal* neighborhoods (Buenos Aires’ CBD and secondary schools).

Comparing the histories of the three departments—both before and after the first appearance of the *asentamientos* in the 1970s—provides critical context to these findings. La Matanza and Quilmes, for instance, were both substantially urbanized by the mid-twentieth century. As a result, nearly all of the highest-quality land was settled by formal neighborhoods prior to the emergence of *asentamientos*. In both cases, informal settlements appeared in the departments’ most peripheral spaces: industrial wastelands and flood-prone riverbanks.

That the inhabitants of the formal neighborhoods in La Matanza and Quilmes are largely working or middle class, and that neither counts as one of metropolitan Buenos Aires’ wealthier departments, did not stop these informal settlements from appearing.

* + LMZ History
    - Historic GABA but still not fully urbanized, especially to the SW
    - Urbanization to the east; agrarian/ranching to the west
    - Along the La Matanza River/Riochuelo
    - More than 1 million people, primarily in the east; 700K in 1970; 1M in 1990 and 1.8M in 2010
    - High density along railroad lines, along a grid pattern
    - Western half dedicated to agriculture
    - All *asentamientos* outside of the dense east/north; vacant land near the center presumably taken by formal neighborhoods during 19th century
    - All communities far from urban centers, railroads, and highways (south and north; SE is along the polluted river); especially isolated from job centers
    - a northern department would look a lot like Quilmes and the southern one would appear more like Pilar
    - Supports hypothesis more then Q
    - Q is more compact size and full urbanization seems to help its *asentamientos*, at least relatively (sig differences for a smaller set of destination types)
    - Leftover land in LM is much more peripheral; both on poor-quality lands/spaces (highways/creeks) but LM’s further from its center and urban amenities
    - LM inherently has longer absolute travel times but these are largely the burden of *asentados*; transport, which has greatly shaped LM’s history, appears to neglect its citizens
    - Widest range of values; large, elongated shape
    - 5 minutes-3 hours
    - Longest values are to the one-off, higher-order destinations, unsurprisingly (worst were CBD’s and hospitals, with less-bad times to UPA’s and railway stations) – perhaps not frequent trips but still burdensome to those needing to visit their municipal centers
    - Less absolute variation to DTC’s and schools; none more than 60 minutes
    - All destinations showed rightward skews and outliers
    - Spatially, longest travel times are almost all in the south
* QLM
  + History adds context to these values:
    - Q first settled during the 1950s as BsAs expanded to the east
    - Factory workers; commuted along railways
    - Rapid urbanization in 1960s and 70s; land filled with low-cost housing
    - 300K in ’70, 500K in ’91 and 600K in 2010
    - Working class; lower- and middle-incomes; poorest departments; unusually high number of asentamientos given its size
    - Struggled to provide services even to formal neighborhoods
    - Proximate to CABA and its industrial plants
    - Compact size naturally reduces travel times
  + Looking at a map of values, we see that the largest travel times are for in- and semi-formal radios, especially for CBD’s, urgent care, and hospitals, although some formal radios still have long travel times themselves
    - Schools all showed low values, although some of the longer times were still for in/semi formal radios
  + PLR History
    - Most distinct urban-historic-geographic story of the three cases
    - Often cited as an example of spatial inequality in GABA
    - Contrasting ends of BsAs wealth spectrum
    - Wealthy gated communities and poor squatters coinhabit
    - Boom of gated communities after upgrade of the northern access highway during the 1990s
    - Middle- and upper-income Buenos Aires residents moved north to escape crime in the city; built on former agricultural lands
    - North American-style developments; previously nothing more than a few small towns along a railroad line, far removed from CABA at the far end of its commuter railway lines
    - Other low-density land uses have followed the suburbs: industrial plants, office parks, strip malls, golf courses, private universities
    - Built away from the railroad-centric towns previously in Pilar and instead along highways; catered to the families living in the developments and people driving to and from jobs in CABA
    - 50% growth from 1980 to 1991; 47K in 1970 to 200K in 2010
    - Communities outside the suburbs’ walls have not seen much development; many lack basic utilities like clean water, plumbing, or telephone service
    - High rates of car ownership and university attendance but lowest among service provision
    - *Asentamientos* exist along the edges of these communities, with their inhabitants providing low-skill, low-wage labor / services to these families
    - All developments are automobile-centric; large distances between homes, shopping centers, and job sites; not near the historic towns in the district
    - Low quality, infrequent transit services, which low-earners must be using
    - Walking and bicycling, perhaps options in LMZ/QLM, are not easy, especially to the gated communities where the poor work
  + Results *context*
    - Most formal neighborhoods are far from PLR’s central axes; inherently longer times than the relatively centrally-located asentados
    - Many of these are suburban neighborhoods built on former farmland
    - People in these communities do not require transit, so the extended travel times are irrelevant
    - While an initial reaction is to dismiss the notion of transit access in these places, they are still employment destinations for low-wage workers, who cannot afford the cars that their employers use to access destinations
    - The same system that enables the employers disadvantages the employees
    - Travel times become much more relative since the two groups of people are operating on separate scales (1 hour to BSASCBD is not an advantage when the other side is just taking their car)
    - The results show there to be relative equality but the context shows this to not be the case
    - Modes and amenities are group-specific; accessibility therefore is different to each
    - Inequities in access and mobility are omnipresent even if they take slightly different forms

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| **Dept.** | ***Radios*** | **Statistic** | Buenos Aires CBD | Department CBD | Nearest Dept. CBD | Railway Station | Urgent Care Center | Hospital | Diagnosis Center | Kindergarten | Primary School | Secondary School |
| Quilmes | IF, SF,  and F | F | 5.5  \*\*\* | 3.7  \*\* | 4.8 \*\* | 6.0  \*\*\* | 1.9 | 3.9  \*\* | 0.3 | 0.2 | 1.8 | 3.0  \* |
| Informal, Formal | T | 2.9  \*\*\* | 1.6 | 2.3  \*\* | 2.9  \*\*\* | 0.6 | 2.0  \*\* | -0.2 | 2.1  \*\* | 1.7 | 0.5 |
| Semiformal,  Formal | 2.3  \*\* | 2.6  \*\* | 2.7  \*\*\* | 2.5  \*\* | -1.5 | 2.5  \*\* | -0.8 | 2.0  \*\* | 1.3 | 0.3 |
| Informal,  Semiformal | 1.1 | -0.4 | 0.3 | 1.0 | 1.5 | 0.1 | 0.5 | 0.4 | 0.6 | 0.3 |
| IF+SF,  Formal | 3.2  \*\*\* | 2.7  \*\*\* | 3.1  \*\*\* | 3.3  \*\*\* | -0.8 | 2.8  \*\*\* | -0.7 | 2.4  \*\* | 1.8 | 0.5 |
| Informal,  SF+F | 2.3  \*\* | 0.8 | 1.6 | 2.3  \*\* | 1.2 | 1.3 | 0.1 | 1.5 | 1.4 | 0.5 |
| La Matanza | IF, SF,  and F | F | 7.8  \*\*\* | 12.7  \*\*\* | 11.2  \*\*\* | 5.0  \*\*\* | 0.3 | 10.0  \*\*\* | 4.5  \*\* | 4.8  \*\*\* | 7.2  \*\*\* | 6.1  \*\*\* |
| Informal, Formal | T | 3.2  \*\*\* | 3.7  \*\*\* | 3.7  \*\*\* | 2.5  \*\* | -0.8 | 3.0  \*\*\* | 1.4 | 1.8  \* | 1.9  \* | 1.4 |
| Semiformal,  Formal | 3.2  \*\*\* | 4.3  \*\*\* | 4.0  \*\*\* | 2.9  \*\*\* | -0.2 | 4.2  \*\*\* | 2.8  \*\*\* | 3.6  \*\*\* | 4.0  \*\*\* | 3.2  \*\*\* |
| Informal,  Semiformal | -0.0 | -0.5 | -0.3 | -0.2 | -0.6 | -0.9 | -1.4 | -1.4 | -1.4 | -1.3 |
| IF+SF,  Formal | 4.0  \*\*\* | 5.0  \*\*\* | 4.7  \*\*\* | 3.2  \*\*\* | -0.6 | 4.4  \*\*\* | 2.7  \*\*\* | 3.2  \*\*\* | 3.4  \*\*\* | 2.7  \*\*\* |
| Informal,  SF+F | 2.1  \*\* | 2.2  \*\* | 2.3  \*\* | 1.5 | -0.8 | 1.7  \* | 0.4 | 0.6 | 0.7 | 0.4 |
| Pilar | IF, SF,  and F | F | 2.1 | 1.2 | 0.9 | 2.1 | 0.4 | 2.7  \* | 1.6 | 1.3 | 0.6 | 0.4 |
| Informal, Formal | T | -1.7 | 1.1 | 1.1 | -0.2 | -1.1 | 1.4 | -1.7  \* | -0.9 | -0.8 | -3.1  \*\*\* |
| Semiformal,  Formal | 1.5 | -0.6 | 0.8 | 1.9  \* | -0.2 | 2.0  \* | -0.1 | -0.2 | 0.5 | -0.4 |
| Informal,  Semiformal | -3.0  \*\*\* | 1.3 | 1.0 | -2.0  \* | -0.7 | 0.6 | -1.9  \* | -1.4 | -1.9  \* | -3.3  \*\*\* |
| IF+SF,  Formal | 1.0 | -0.0 | 1.1 | 1.6 | -0.5 | 2.3  \*\* | -0.6 | -0.5 | 0.2 | -0.9 |
| Informal,  SF+F | -2.9  \*\*\* | 1.4 | 1.0 | -1.1 | -0.9 | 1.1 | -1.8  \* | -0.9 | -1.0 | -1.6 |

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| ***Radios*** | **Dept.** | **Statistic** | Buenos Aires CBD | Department CBD | Nearest Dept. CBD | Railway Station | Urgent Care Center | Hospital | Diagnosis Center | Kindergarten | Primary School | Secondary School |
| Informal, Semiformal, Formal | Quilmes | F (ANOVA) | 5.5  \*\*\* | 3.7  \*\* | 4.8 \*\* | 6.0  \*\*\* | 1.9 | 3.9  \*\* | 0.3 | 0.2 | 1.8 | 3.0  \* |
| La Matanza | 7.8  \*\*\* | 12.7  \*\*\* | 11.2  \*\*\* | 5.0  \*\*\* | 0.3 | 10.0  \*\*\* | 4.5  \*\* | 4.8  \*\*\* | 7.2  \*\*\* | 6.1  \*\*\* |
| Pilar | 2.1 | 1.2 | 0.9 | 2.1 | 0.4 | 2.7  \* | 1.6 | 1.3 | 0.6 | 0.4 |
| Informal, Formal | Quilmes | Two-directional T-Test | 2.9  \*\*\* | 1.6 | 2.3  \*\* | 2.9  \*\*\* | 0.6 | 2.0  \*\* | -0.2 | 2.1  \*\* | 1.7 | 0.5 |
| La Matanza | 3.2  \*\*\* | 3.7  \*\*\* | 3.7  \*\*\* | 2.5  \*\* | -0.8 | 3.0  \*\*\* | 1.4 | 1.8  \* | 1.9  \* | 1.4 |
| Pilar | -1.7 | 1.1 | 1.1 | -0.2 | -1.1 | 1.4 | -1.7  \* | -0.9 | -0.8 | -3.1  \*\*\* |
| Semiformal, Formal | Quilmes |  |  |  |  |  |  |  |  |  |  |
| La Matanza |  |  |  |  |  |  |  |  |  |  |
| Pilar |  |  |  |  |  |  |  |  |  |  |
| Informal + Semiformal, Formal | Quilmes |  |  |  |  |  |  |  |  |  |  |
| La Matanza |  |  |  |  |  |  |  |  |  |  |
| Pilar |  |  |  |  |  |  |  |  |  |  |
| Informal, Semiformal | Quilmes |  |  |  |  |  |  |  |  |  |  |
| La Matanza |  |  |  |  |  |  |  |  |  |  |
| Pilar |  |  |  |  |  |  |  |  |  |  |
| Informal, Semiformal + Formal | Quilmes |  |  |  |  |  |  |  |  |  |  |
| La Matanza |  |  |  |  |  |  |  |  |  |  |
| Pilar |  |  |  |  |  |  |  |  |  |  |

* Pilar vs. Quilmes/La Matanza
  + La Matanza 🡪 large population; SW of the city; largest quantity of asentados
    - Commuter suburb for industrial/service workers
    - Any and all rail- and highway-accessible spaces were developed well before the 1970s
    - Only land available to asentados was in the far south and along the department’s borders, far from the core and all major transportation
    - Asentamientos relegated to the department’s most isolated locations; formal settlements had occupied all the most accessible sites
  + Pilar 🡪 dispersed population; NW of the city; largest quantity of asentados
    - Primarily agricultural until the 1990s
    - Too far from the city to easily commute by train
    - Early asentamientos formed close to town
    - Highway to Buenos Aires upgraded in the 1990s
    - Former farmland developed into gated communities for wealthy families from the city
    - Asentamientos developed in relatively central locations, whereas the department’s formal neighborhoods are quite far from its core
* Statistical results
  + La Matanza
    - Transit-based travel times are drastically longer for radios that overlap with an asentamiento
    - Differences apply to nearly all amenities
    - Accessibility appears inequitable
  + Pilar
    - Transit-based travel times are fairly similar from all origin-types, with non-overlapping radios actually having longer travel times to some amenities
    - Accessibility appears equitable
  + Maps
    - Even if the absolute differences aren’t great, there are still discernable variations
    - What can be said to explain some of these cross-variations in travel times?
  + Explanations
    - La Matanza
      * Supports my hypothesis
      * In more urbanized departments, asentamientos require significantly longer ravel times on transit to reach critical activities
    - Pilar
      * Refutes my hypothesis
      * In urbanizing departments, where the asentamientos preceded later development, access to these cities is equitable across neighborhoods
    - Caveat: Pilar’s greater socio-territorial configuration is far from equitable
      * Car-based travel renders these scores particularly meaningless
      * Travel is not being made with the same mode for all travelers

**Part VII: Conclusions**

* According to Google’s travel time data for agglomerated Buenos Aires, public transportation services are not being provided equitably to both its asentamientos and its traditional neighborhoods, thus hindering the asentados’ access to critical urban amenities. Furthermore, these disparities appear to be exacerbated within certain historically-defined socio-territorial configurations of urban and suburban space
  + Substantial differences appear to exist, although context is important
  + Travel times are longer from informal neighborhoods to many amenities
  + Differences vary based on the context: historic, geographic, socioeconomic
  + Land use, policies (hostile govt), activity site locations, macroeconomic forces/uneven growth, route networks/slashed funding/privatizations, and schedules have all contributed to inequities
  + Lost market share; old vehicles/crowded/unreliable
  + Quantifying/operationalizing accessibility/these differences can be done more concisely than ever; enables time-based analysis
  + System advantages some and disadvantages other; facilitates the problem; promotes access of some over others
  + Access looks to be erstwhile worst in the asents
  + Results largely confirmed these opinions/expectations; worse in certain urban environments and to certain destinations
  + Results in the outer departments were inverse expectations but could be contextualized by Pilar’s socioterritorial landscape
  + Accessibility needs to be considered relative to land use and transportation
* Policy changes are difficult to recommend, although there is a problem that must be addressed; planners/policy makers/academics can pinpoint problem spots and spatially target responses in places where the poor are most adversely affected

Mapping these phenomena makes it possible to ensure that everyone—regardless of where they live—has the mobility assets, whether public or private, required to access the array of economic, social, and cultural benefits provided within their cities.

* + Any new public policies need to consider local socio-territorial contexts
    - Mixes not the same for each department
    - Simply adding new routes is likely not as easy as it seems
  + Planning should incorporate all users, including the transit-captive asentados
    - Improved political representations; give them and other transit-deprived people a voice – one thing in their control
    - Land use-related solutions could be considered, too (moving low income housing or building new amenity locations)
  + Changes can be made to either land uses or the travel system (or both)
    - Previous studies and historiographies have shown that the effective formulation and implementation of transportation policy in Argentina is an extraordinarily obscure, difficult process, complicated even further when applied across multiple jurisdictions. Understanding the mechanisms that connect these policy disruptions with regional inequalities is needed first, especially through a spatial context.
  + Limits of Google Distance Matrix API data must be acknowledged, perhaps with ground-truthing
    - New data, modes, times, route data; different times of day; more requests can ease concerns; need leg and route and transfer and walking data for a full picture; knowing proportion of travel/waiting/walking could add context
    - Values are merely predicted; miss issues of congestion, overcrowding, and other delays; underestimations; no way to ground truth outside actual monitoring of travelers and vehicles
    - Places and modes of non-asentados are also missed (cars or private schools); unrealistic travel for these people is being captured
  + Considerations of women and other groups
* Nonetheless, this thesis produced hard data illustrating the widely-suspected, yet hitherto unproven, existence of the inequitable provision of public transportation services to the asentamientos in AGBA
  + Project validates a previous unknown – not much more to say

While not the focus of this thesis, land-use adjustments like relocating lowincome

housing to transit-accessible locations or constructing schools and health centers

on well-situated parcels of land could be the ideal solution for improving accessibility in

some municipalities, while fixing aspects of the travel system (i.e., adding a new stop,

* + increasing frequencies, or building bus shelters) the best for another.