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The Effect of Superblock Urban Form Features on Modal Choice in Barcelona Superblock Residents

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Summary

This master's thesis aims to discover the effect of urban form features on modal choice in the context of superblocks in Barcelona. Superblocks are an urban design intervention that reduce vehicular through-traffic, taking urban street space dedicated to cars and repurposing it for more human-centered uses such as biking, walking, socializing, playing, or exercising. As cities continue to grow faster than ever before, a focus on sustainable urban development is paramount to building a healthy environment for the 2.5 billion additional inhabitants that are estimated to live in urban areas by 2050 (United Nations, 2015). Rapid new urban development must be coupled with the retrofitting, or repurposing, of existing urban forms in order to sustainably accommodate this level of population growth and build a happy, healthy urban future. One way of retrofitting streets for this future vision is through the implementation of superblocks. Reclaiming street space from cars, and thereby reducing both the number of cars in circulation and the demand for cars, helps alleviate the many symptoms of car-heavy societies. These symptoms range from traffic-induced air pollution, which is a main contributor to global warming, to the various negative effects on human health from air pollution, noise pollution, and physical inactivity. Superblocks promise to address these issues using low-cost, tactical urban design and traffic calming interventions. Their implementation has been particularly successful in Barcelona, which is why this research is based there.

The main objective of this research is to better understand how superblocks affect modal choice, or transportation choices, in residents who live in or near them. The research aims to test the hypothesis that appreciating certain urban form features that are related to superblocks can predict more active and sustainable mobility choices such as walking, biking, or using public transport in place of a private car or taxi. This hypothesis was based on findings from an in-depth literature review which compiled the critical determinants of modal choice across both urban form-related and non-urban form related research. Based on the literature review, the three urban form concepts that were found to be most closely related to superblocks were human scale, complexity, and the built form. Thus, the main research question is: "to what extent does appreciation of superblock urban form features relating to the built form, complexity, and human scale predict modal choice in Barcelona superblock residents?" A survey was chosen as the methodology for its wide reach and generalizability about the population in question, which is superblock residents.

Ample data was gathered regarding self-reported modal choices and self-reported appreciation for urban form features. Descriptive summaries are presented and results are discussed. Multiple regression analysis is performed but results are largely inconclusive. Shortcomings of the present research and suggestions for future research are discussed. Findings from this research aim to provide support for the continued implementation of superblocks in Barcelona and for other cities looking to implement superblock programs in the future as part of their sustainable urban development strategies.

Keywords

superblocks, modal choice, urban form, active transport, sustainable urban development

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Abbreviations

IHS	Institute for Housing and Urban Development Studies
WHO	World Health Organization
UHI	Urban heat island effect
EU	European Union
BE	Built environment
WKT	Weekly kilometer travelled
NMT	Non-motorized transport
AT	Active transport
MLR	Multiple linear regression
VMT	Vehicle miles traveled

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Chapter 1: Introduction

1.1 Background Information and Problem Statement

Cities are growing faster than ever: by 2050 our cities will be home to 2.5 billion more people due to urbanization and global population growth (United Nations, 2015). Despite covering only 3% of the world's surfaces, cities are responsible for more than 70% of the world's CO_2 emissions (C40 Cities, 2020). The transport sector makes up an important part of these emissions: in 2014, transport emissions accounted for 23% of the global CO_2 emissions (Wang & Zeng, 2019), and urban traffic is responsible for almost half of those CO2 emissions (as well as for 70% of emissions of other pollutants arising from road transport) (European Commission, 2007). Thus, there is an urgent need for intervention to encourage sustainable modes of urban transport.

Today we are still dealing with the urban form that resulted from the rise of modernism in the mid-20th century (Siu & Huang, 2015). Le Corbusier and other modernists aimed to eliminate the physical complexity of traditional cities by implementing single-use functional zoning, setting the stage for automobile dependency (Hall, 1996). The top-down, polished, geometric vision that modernists executed on lacked practical insight into how the built environment can affect human psychology, behavior, and health. By prioritizing space for cars over space for people, they were setting us up for urban ills.

This worldwide car dependency in cities and thus vehicular emissions have unsurprisingly led to high levels of pollution in the form of air and noise pollution as well as anthropogenic heat (Nieuwenhuijsen & Khreis, 2016). The relationship between air pollution in the form of CO_2 emissions and global warming has been well established. CO_2 is one of the most harmful greenhouse gases: while it absorbs less heat per molecule than methane (CH_4) or nitrous oxide (N_20), it's much more abundant and stays in the atmosphere significantly longer (between 300 and 1,000 years) (Buis, 2019). As such, it's responsible for about 2/3 of the total energy imbalance that is causing Earth's temperature to rise (NOAA, 2020). While global warming has far-reaching implications in every corner of the world, it is especially felt in cities due to the urban heat island effect (UHI). Heat is a silent killer: more than 70,000 people died in Europe during the 2003 heat wave alone, and the WHO expects that heat waves will rise in frequency, duration, and intensity because of global warming (McGregor et al., 2015).

From a human health perspective, automobile dependence is lethal on multiple fronts. The WHO (World Health Organization) cites physical inactivity as the fourth leading risk factor for mortality, estimating that it contributes to around 3.2 million deaths globally each year (WHO, 2018). Air pollution is another silent killer; the WHO estimates that 7 million annual deaths due to air pollution exposure, 4.2 million of which are due to ambient air pollution (e.g. outdoor air). Breathing polluted air increases the incidence of stroke, heart disease, lung cancer, and chronic and acute respiratory diseases such as asthma (WHO, 2018). These illnesses are not only devastating from an interpersonal emotional point of view, but they are also intensely costly to society from a monetary standpoint: cancer cost the EU €126 billion in 2009, with lung cancer alone inciting the highest economic cost of €18.8 billion (Luengo-Fernandez et al. 2013). Noise pollution has similarly tragic consequences on human health. A 2012 WHO assessment of noise pollution in Europe found that at least one million healthy life years are lost annually from traffic-related noise in Western Europe due to cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus, and annoyance (WHO, 2012). Traffic is also expensive; the EU Commission estimates that urban congestion costs nearly 100 billion Euros annually, or 1% of the EU's GDP (EU Commission, 2021).

In more recent years, anti-auto dependency discourse has taken center stage as New Urbanism principles have emerged. New Urbanism is centered on human-scaled design that focuses on 10 key principles: walkability; connectivity; mixed use and diversity; mixed housing; quality architecture and urban design; traditional neighborhood structure; increased density; smart transportation; sustainability; and quality of life (Iravani and Rao, 2020). These principles have multiple interrelated effects that result in a multitude of health benefits for urban residents. The most important of these is physical activity, which is a result of urban design elements that promote higher usage of active transport (e.g. non-motorized transport) and public transport, reduce the need for private cars, and result in less air and noise pollution while also increasing safety in cities (Iravani and Rao, 2020). And finally, cities with highly motorized mobility are fundamentally misusing space: modern cities devote up to 70% of public space to accommodate motor vehicles (Crawford, 2002; Manville & Shoup, 2005), while only 25% is suggested for sustainable urban design (Barcelona Urban Ecology Agency, 2018; Dávalos et al., 2016).

Listed above are some of the many reasons why automobile dependence causes problems for cities and their residents. A car-heavy city is ultimately a city that suffers from poor health outcomes, a lack of social cohesion, safety issues and wasted space. It is widely agreed among planners, urbanists, and (most) politicians that cities and their residents would benefits from having fewer cars in circulation, which can only be achieved by reducing the need for cars while providing convenient and viable alternatives. Urbanists have sought to improve cities to this end by making them "low-car" or "car-free" using different frameworks, concepts, or methods. Some of these concepts include "walkable cities," "compact cities," the "15-minute city," the "1-minute city," and finally the superblock, which is the main topic of interest for this research.

The superblock is an urban design intervention that aims to address these concerns using New Urbanism principles. In the superblock model through-traffic is restricted in certain streets, opening up more of the street to be redesigned for non-motorized mobility options and other street uses. Residents with cars and delivery drivers are still able to access these roads, but traffic-slowing measures are put in place and parking is not as readily available. Through-traffic must use the main thoroughfares that run along the perimeter of the superblock. The aim is to reduce CO_2 emissions while creating more space for people. These uses can include the introduction of green spaces, social spaces, bike lanes, wider sidewalks, and/or recreational spaces. The general objectives include improving mobility, encouraging sustainable transport, improving livability, encouraging green spaces and biodiversity, and integrating governance processes with citizen participation (Mehdipanah et al., 2019). The superblock is recognized as an effective strategy for improving neighborhood livability and urban sustainability (Scudellari et al., 2020).

Barcelona's continued implementation of superblocks has been very well documented and is perhaps the most well-known example of retrofitting automobile-based urban design into human-centric urban design. As such, it will be the case study for this research. The city's first ever superblock was established in 1993 in the Cuitat Vella (Old City) district followed by a second in 2006. After success in both of those cases, the municipality decided to launch a formal Superblock Programme from 2012 to 2015, with the City Council extending these efforts from 2016 to 2019. The long-term goal is to create 504 superblocks throughout the city. The main objectives for the Superblock program as stated by the municipality of Barcelona are 1) improving the habitability of public spaces, 2) moving towards sustainable mobility, 3) increasing and improving urban greenery and biodiversity and 4) promoting public participation and joint responsibility (Ajuntament De Barcelona, 2014). Between 2016 to 2019 alone, the surface area for pedestrians in Poblenou increased by 80%, space occupied by cars decreased by 48%, green areas increased by almost 100%, and there was economic revitalization thanks to increased activity on the ground floor (SMARTEES EU, 2020). It is important to investigate how these successful spatial changes have influenced mobility patterns in order to better understand their impact and role in the quest for sustainable mobility in urban development.

1.2 Problem Statement

Barcelona is a dense city of 1.6 million inhabitants in the city center and over 3.2 million in the wider metropolitan region (Ajuntament de Barcelona, 2017). It has an average of 15,900 inhabitants per km^2 and its most densely populated neighborhood is even denser than Manhattan, reaching up to 35,600 inhabitants per km^2. Barcelona was among the top 10 worst cities in Europe in terms of air and noise pollution at the turn of the century: in 2004 there were over 3,500 premature deaths in Barcelona due to the poor air quality (Perez et al. 2009). The municipality has since intervened on multiple fronts to help address these urban issues, which is how the superblocks became a central feature of their agenda. Reducing space for cars is a top priority: despite being used for only 25% of trips, they occupy 60% of public space across Barcelona (Casorran, 2019). Yet still, there are high pedestrian mobility rates, with over 47% of all trips in 2017 having been made by foot (Ajuntament de Barcelona, 2018). This shows a strong active mobility culture that has the potential to become even more prominent through the planned city-wide implementation of superblocks. By taking back space from cars and giving it to people, the municipality can stimulate sustainable, active transport while improving public health and the quality of public life. However, the superblock program will only continue if it enjoys continued support from politicians, urban planners, and the public alike. Thus, it is important to understand exactly how the presence of superblocks impacts their residents. Even more specifically, it's vital to understand how superblocks impact travel choices and behaviors in their residents, knowledge which can help encourage sustainable urban development. This relationship has not yet been explicitly studied, which is the driving force behind this study's research.

1.3 Relevance of the Research Topic

1.3.1 Academic Relevance

Academic literature coverage covers superblocks as they relate to health, public life, community participation, social cohesion, energy consumption, and traffic patterns. There is also much research and theory on the relationship between urban form and modal choice (e.g. which method of transportation people choose) in general. Some research assumes increased physical activity as a logical result of superblocks. However, no research exists specifically on the relationship between superblock urban form factors and modal choice. Thus, there is a gap in knowledge as to which features of superblocks increase propensity to pick sustainable transportation choices.

1.3.2 Practical Relevance

Beyond the attention that the superblock model is gaining in academic and urban literature, it is also receiving much interest from multiple cities worldwide that are interested in implementing similar interventions. This research could help provide policymakers in those cities with the tools to push forward superblock agendas by arming them with information about how superblocks impact modal choice. Better understanding whether urban form features can predict sustainable urban mobility choices could have practical benefits for the continued application of superblocks in Barcelona, and for the many cities that are looking to implement similar superblock programs within their own contexts. This research bridges the gap from residents as passive *objects* of study as they relate to superblocks, to residents as the *subjects* of study as they relate to superblocks. Further, this information could be used by transport authorities to better understand and plan for the future of mobility in urban areas, particularly through the lens of creating low-carbon cities.

1.4 Research Objectives

The main research objective is to better understand how superblocks affect modal choice in residents who live in or near them. The research aims to test the hypothesis that appreciating certain features of superblocks can predict more active and sustainable mobility choices (e.g. walking, biking, or using public transport in place of a private car or taxi).

Therefore, the specific objectives are to:

- Identify superblock residents' modal choices and usual trip purpose per modal choice
- Identify superblock residents' appreciation of superblock urban form features
- Understand the relationship between appreciation of superblock urban form features and modal choices in superblock residents

1.5 Main Research Question and Research Sub-Questions

The main research question and sub questions were revised after the completion of the literature review. The revised main research question is: To what extent does appreciation of superblock urban form factors relating to the built form, complexity, and human scale predict modal choice in Barcelona superblock residents?

- Sub-question #1: which modes of transport are most popular among superblock residents and why?
- Sub-question #2: how much do residents appreciate (notice, care about, or enjoy) certain superblock urban form features as they relate to the built form, complexity, and human scale?
- Sub-question #3: how well does appreciation of these urban form features (specifically built form, complexity, and human scale factors) predict modal choice?

For comparison, the preliminary research question was: "to what extent do superblocks impact mobility choices in local urban residents in Barcelona?" However, after a careful literature review it became clear that there are many factors which impact modal choice (these critical determinants are discussed in Section 2.1.8) and many aspects of superblocks, so measuring the impact of superblocks generally would be difficult. Thus, the research question was revised to be more specific and measurable.

Chapter 2: Theory Review

2.1 Literature Review

The literature review was performed to better understand how modal choice has been studied in the past. Two lists of critical determinants were developed: one which compiles the academic literature about critical determinants of modal choice that are *unrelated* to urban form, and one which compiles the academic literature about critical determinants of modal choice that are *related* to urban form. There is commentary on the interplay between these determinants and the usefulness of studying them separately, which is the foundation for this research. The importance of perceptual qualities in modal choice research is made clear, and a need for further analysis is identified. Then comes a review of superblocks as a concept, a summary of superblocks in the context of Barcelona (complete with photos), a review of literature as it relates to superblocks in Barcelona, and some discussion of the effectiveness of these superblocks by economic, health, and sustainable development measures.

2.1.1 Modal Choice

Humans are complex beings that make thousands of conscious and unconscious daily choices on a daily basis. Those about mobility make up only a small subsection of these daily choices, but they have a disproportionately large effect in terms of individual carbon footprints: about a third of all CO_2 emissions in the Earth's atmosphere can be traced to urban transportation (Urry, 2004). As such, finding ways of encouraging sustainable modes of transport is an urgent challenge to be solved in the quest for sustainable urban development.

Modal choice can be defined as "the decision process to choose between different transportation alternatives determined by a combination of individual socio-demographic factors and spatial characteristics, and influenced by psychological factors" (Hollevoet et al. 2011, p. 132). There are many factors that go into modal choice, and much research has delved deeply into this topic. This research can be mostly grouped into three categories: the rationalist approach, the socio-geographical approach, and the psychological approach. The rational approach is seen as the "mainstream" approach and assumes that travelers make decisions based on maximizing their utility by minimizing travel time and costs. It is a microeconomic approach that assumes perfectly rational behavior and does not leave much space for subjective factors. The socio-geographical approach explicitly includes spatial components into modal choice and views this choice from the perspective of derived demand for travel as it relates to the social activities they must pursue that are distributed in time and space. The psychological approach explains modal choice through individual attitudes as well as concepts such as intentions and habits (Hollevoet et al. 2011). While each of these approaches helps uncover certain elements of modal choice, it is essential to retain a holistic understanding of the interplay *between* these elements to fully understand modal choice.

Throughout this chapter conceptual frameworks that have been used previously in relevant research will be shared, then specific effects that researchers have discovered will be discussed. Determinants of modal choice are discussed. Two lists are presented: a list of non-urban form-related critical determinants and a list of urban form-related critical determinants of modal choice, as they were discovered throughout the literature review. Lastly, the conceptual framework which integrates all the above findings and which was used to guide this research is presented.

2.1.2 Objective and Subjective Modal Determinants

Every trip outside the home is influenced by a myriad of considerations and factors. Many transportation researchers have divided these factors into a *objective* and *subjective* categories to explore and explain travel behaviors (Scheiner and Holz-Rau 2007; De Vos et al. 2012). The objective, or "hard" factors include urban form. The concept of the 3 D's, namely density, diversity, and design, coined by Cervero and Kockelman (1997) is an important cornerstone for this research. "Soft" or subjective factors include social trends such as modernization (Giddens, 1990) and attitudes and preferences towards certain modes of travel or neighborhood characteristics (Fujii and Gärling 2003; Gatersleben 2007; Salomon and Ben-Akiva 1983). For the purpose of this research, relevant literature and conceptual frameworks will be explored and reviewed, and the critical determinants of modal choice for both those that are directly related to urban form and those that are not will be compiled.

2.1.3 Kurt Lewin's Theory on Behavior and Travel Patterns

Kurt Lewin's "Theory on Behavior as a Consequence of Personal Characteristics and Perception of the Environment," one of the earliest relevant pieces of research, combines both "hard" and "soft" factors into the mobility decision-making process. He identifies three main inputs that determine travel behavior, namely environmental preconditions to travel, environmental perception, personal characteristics, and travel patterns (Lewin, 1935).

The first level, environmental preconditions to travel, speaks to the urban form: how concentrated destinations are, how available public transportation is, how much parking is nearby, and so forth. Specific indicators include density, building heights, building orientation, street widths, design of sidewalks, bike lanes, bus stops, and access to different locations (Stojanovski, 2019). Research has shown that these variables indeed have a strong effect on modal split (e.g. how use of each mode of transport is divided). For example, a network of bike lanes at close distances increases cycling in cities (Pucher & Buehler 2008, 2011, 2011, 2012). Research has also shown that the number of generated passengers for bus and tram spots within 100-200m is almost double than those within 300-400m, indicating a clear threshold for travel to public transport that should be respected by urban designers who are trying to impact modal choice (O'Sullivan & Morrall 1996, Daniels & Mulley 2013).

Environmental perception includes the interpretation of sensory information from the physical and social surroundings, as well as the emotional responses they elicit (Stojanovski, 2019). In practice this could mean benches, bus stops, subways stations, kiosks, and sidewalks being within visual distance (100-200m), or whether there are bike lanes nearby (Stojanovski, 2019). These visual cues serve as unconscious reminders that sustainable modes of transport exist and are available. The absence of these visual cues in favor of cars, parking lots, and garages give the opposite message by keeping private automobiles top of mind. Thus, these urban elements have the power to prioritize some modes of transport by making them more visually present and easily perceived than others.

Personal characteristics include personality traits, ego, attitudes, habits, defaults, commitments, social norms, and other personality-related features (Stojanovski, 2019). This can include the cultural elements of what mobility represents, for instance the car as a status symbol, which relates to ego and attitudes. Habits and defaults are also a strong pull, as habits can be difficult to change. Commitments and social norms could include, for instance, driving an elderly neighbor to a weekly doctor's appointment. These factors all come together to influence travel patterns or behaviors, which can be measured as modal split, trip frequency, trip length, etc.

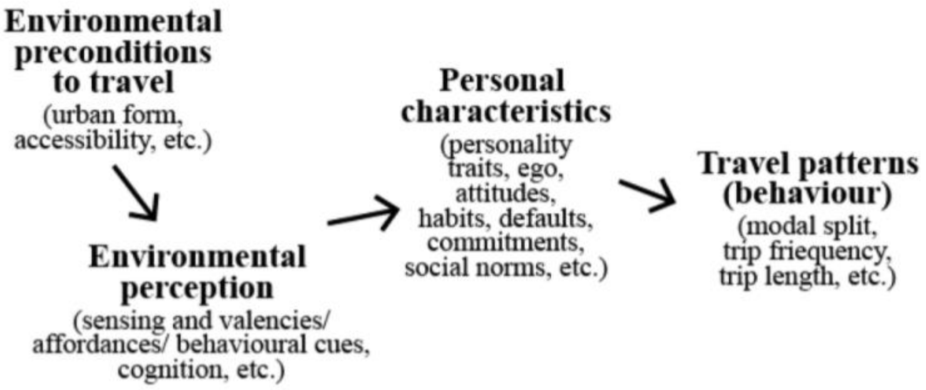


Figure 1. Kurt Lewin's Theory on Behavior as a Consequence of Personal Characteristics and Perception of the Environment in Stojanovski (2019)

2.1.4 Foundational Modal Choice Framework

A more recent and concrete conceptual framework came out of Hollevoet et al. (2011)'s review of 37 articles studying the determinants of modal choice. They found that the main determinants were (1) spatial determinants, (2) socio-demographic determinants, (3) travel mode and journey determinants and finally, (4) psychological determinants. Within spatial determinants are density, diversity, proximity to infrastructure, parking, frequency of public transport, and integration of public transport (i.e. the ability to avoid interchanging). Socio-demographic determinants include car availability, gender, employment status, income levels, lifestyle choices, education, and household type/size. Travel mode and journey determinants include travel motive, distance, travel time, travel cost, departure time, and trip chains (i.e. trips with multiple stops). Finally, the psychological determinants encompass habit, positive or negative past experiences, and perception with regards to different means of travel. The conceptual framework based on all these components can be seen below. This framework provides a very solid foundation with which to examine the rest of the relevant literature and will ultimately feed into the conceptual framework which is presented at the end of this section.

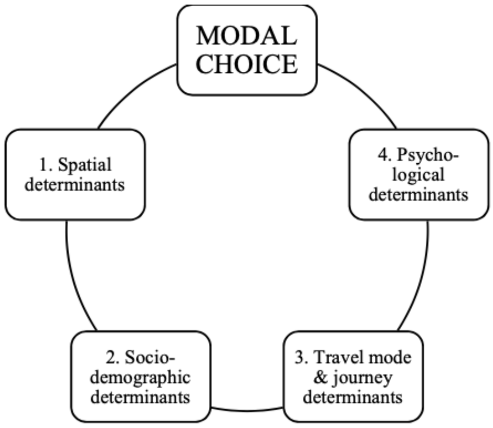


Figure 2: Modal Choice Framework, Hollovoet et al. 2011

2.1.5 Mobility Cultures

Mobility cultures can also impact modal choice and exist at the national and urban scale. For example, the Netherlands is known for its cycling culture and Los Angeles is known for its car culture. There are many factors that influence mobility culture, including political decisions and urban planning, lifestyle milieus and the city's socio-economic situation, as well as communication, and historically produced space (Deffner et al. 2006, Götz & Deffner 2009). This conceptual framework of mobility culture takes a holistic view on the objective and subjective components that together influence mobility culture. Societal values, which feed into mobility cultures, are also incredibly important: a study of travel behavior in five San Francisco Bay Area neighborhoods in California showed that societal values and individual lifestyles (as measured by many attitudinal variables) explain the highest proportion of variation in travel behavior (Kitamura et al., 1997).

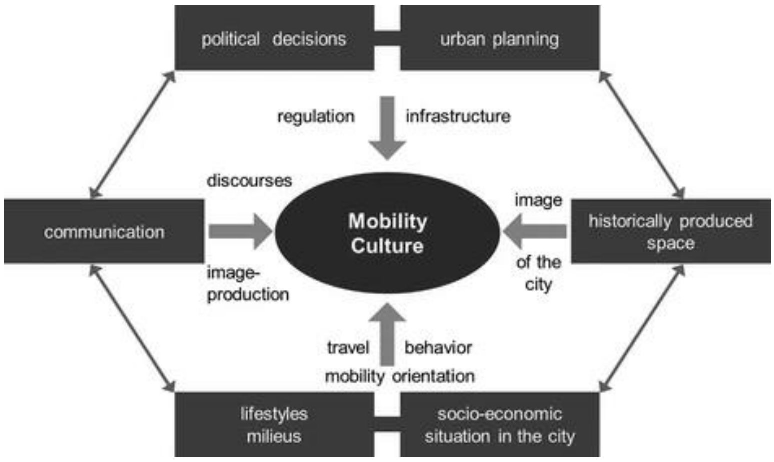


Figure 3: Mobility Cultures Conceptual Framework from Götz and Deffner 2009, p. 41 (translated and modified in Klinger & Lazendorf 2015)

2.1.6 Mobility Subcultures

Personal characteristics can also influence mobility subcultures, called mobility classes by Stojanovski (2019). Researchers have also used the terms "mobility styles (Lanzendorf 2002) and "travel behavior segments" (Anable 2005) using factor and cluster analysis based on socio-demographics, attitude and travel-related variables (see also Götz and Ohnmacht 2011; Hunecke et al. 2010; Prillwitz and Barr 2011; Pronello and Camusso 2011; Steg 2005). Mobility subcultures are also influenced by environmental preconditions, but less strongly than Lewin's model suggests. These mobility classes have a strong cultural push and can sometimes counteract expected patterns. In other words, a city with a strong bus enthusiast mobility class or train spotting class may boost public transport usage despite poor integration of transit stops (Stojanovski, 2019). Stojanovski maps the interactions between mobility classes along renewable/fossil-dependent and public/private axes as follows:

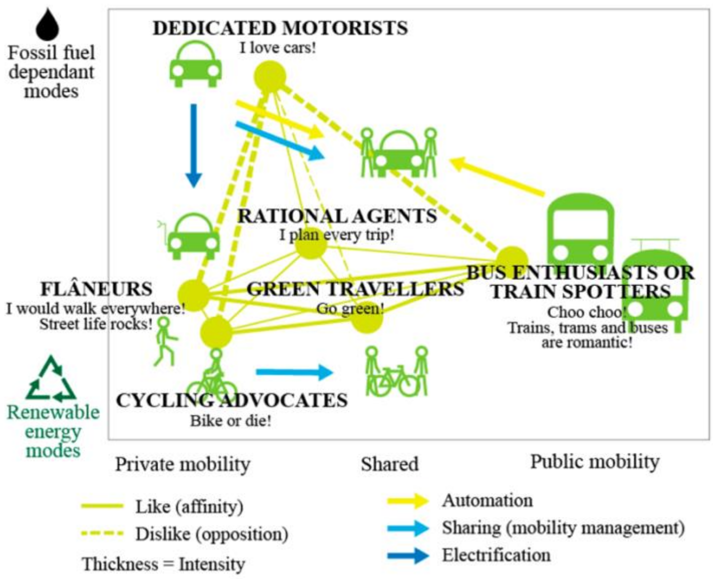


Figure 4: Mobility Subculture Interactions by Stojanovski (2019)

These people can sometimes cluster together, wanting to live with like-minded people, known as the "social network effect" and often choose to live in neighborhoods that facilitate their preferred mode of transport, also called the "residential self-selection effect" (Handy & Clifton 2001, Cao et al. 2009, Scheiner 2006, Schwanen & Mokhtarian 2005, Kamruzzaman et al. 2020).

2.1.7 Individual Key Modal Determinants and Travel Purpose Types

Aside from cultural influences, socioeconomic status is also related to commuter habits. For example, longer commutes are more common in highly educated populations, as well as affluent, male, and dual-earner populations (Green et al. 1996, White 1986). Travel purpose and travel cost have also been shown to influence modal choice (Crane 1996). Trip length is also a determinant; the longer the trip is, the lower the propensity to use active transport (Crane 1996, Haixiao et al. 2009).

Employment density has been found to impact modal choice (Levinson & Wynn 1963, Naess 2005). If people work close to where they live, they are more likely to use active transport. Similarly, proximity of grocery stores (and other consumer services) was found to have an impact on modal choice in encouraging public transport, walking and biking (when controlling for residential density and vehicle ownership) (Cervero, 1996). As discussed above, personal attributes, mobility culture, and mobility subculture also play important roles in determining modal choice.

Travel purpose is also an important determinant of modal choice. Although there are many ways of categorizing travel purpose that have been used in this body of research, the distinction that Qian et al. (2018) make is the one that will be used in this research. The three types of travel purpose are classified as "commuter (go to work)" travel, "utilitarian (go-to-store)" travel, and "recreational (strolling)" travel. These categories will be used later in the study to help identify what superblock residents in Barcelona use each mode of transport for.

2.1.8 Critical Determinants of Travel Choices (Non-Urban Form Related)

Below is a summary of the critical determinants of modal choice from the above literature review that do *not* directly relate to urban form. The next section will discuss how research has addressed the relationship between urban form and modal choice.

Table 1: Critical Determinants of Travel Choices (Non-Urban Form Related)

Study	**Determinant**
Crane 1996, Hollevoet (2011), Qian et al. (2018)	Travel purpose
Crane 1996, Hollevoet (2011), Frank & Engelke (2001)	Travel cost
Crane 1996, Hollevoet (2011)	Travel opportunities
Crane 1996, Hollevoet (2011)	Socioeconomic Characteristics
Pushkarev and Zupan (1977), Holtzclaw (1994)	Employment density
Pushkarev and Zupan (1977), Holtzclaw (1994), Levinson and Wynn (1963), Naess (2005), Hollevoet (2011)	Neighbourhood/ population density
Cervero (1996)	Proximity of grocery stores and other consumer services within 300 feet
Dieleman et al (2002), Lewin (1935), Hollevoet (2011), Frank & Engelke (2001)	Personal attributes
Haixiao et al (2009), Hollevoet (2011), Frank & Engelke (2001)	Trip length (time)
Frank & Engelke (2001), Haixiao et al (2009), Hollevoet (2011)	Trip length (distance)
Hollevoet (2011)	Departure time
Hollevoet (2011)	Trip chains
Best and Lanzendorf (2005), Scheiner and Holz-Rau (2012), Green et al. (1999), White (1986), Hollevoet (2011)	Gender
Green et al. (1999), White (1986), Hollevoet (2011)	Education level
Green et al. (1999), White (1986), Hollevoet (2011)	Earner status
Götz and Deffner (2009), Frank & Engelke (2001)	Mobility culture

Stojanovski (2019), Frank & Engelke (2001)	Mobility subculture
Hearst et al. (2013), Lee et al. (2007), Hollevoet (2011), Frank & Engelke (2001)	Household composition
(Beige and Axhausen 2012; Grimsrud and El-Geneidy 2014; Verhoeven et al. 2005)	Lifecycle stage
Hollevoet (2011)	Lifestyle choices
Hollevoet (2011)	Car availability
Hollevoet (2011)	Employment status
Hollevoet (2011)	Perception of means of travel
Hollevoet (2011)	Past experiences
Hollevoet (2011), Frank & Engelke (2001)	Habit
Frank & Engelke (2001)	Traffic safety
Frank & Engelke (2001)	Physical condition
Frank & Engelke (2001)	Weather
Frank & Engelke (2001)	Convenience

2.1.9 Urban Form and Modal Choice

2.1.9.1 Urban Form and Modal Choice (Meta-Analyses Research)

There are also many determinants of modal choice that are directly related to the urban form. However, there is some conflicting evidence as to how strong this relationship really is, as it is difficult to measure the effect of urban form in isolation. Ewing and Cervero (2001) performed a meta-analysis to estimate the elasticities for VMT (vehicle miles traveled) and vehicle trips using four measures of the built environment (density, diversity, design, and regional accessibility) based on the results of published studies. They found that there was a statistically significant, but weak, connection between urban form variables and travel behavior, whereby a 10% increase in local density and local design was associated with a 0.5% decline in vehicle trips (Leck, 2006).

Ewing (2005) did another meta-analysis focusing on the effect of the built environment on physical activity levels and health-related issues (such as obesity) and found that for every 1% increase of measures of density or design, the percentage of trips made on foot rises by approximately 0.45%. The researchers admit that these results, although statistically significant, are not particularly large in absolute terms, and thus do not imply a strong relationship between the built environment and travel choices. But still, the cumulative effects over time and throughout the population are quite large (Leck, 2006).

Leck's own 2006 meta-analysis on the linkage between urban form and travel behavior reaffirmed that residential and employment density are the most important built environment element that influence travel choices (even when controlling for socio-demographic variables such as income or age), while street pattern (specifically grid layout of blocks and continuous sidewalk design) was not found to be a significant predictor (Leck, 2006). However, the author acknowledges that few studies have successfully investigated the impact of street pattern configuration on travel behavior. Also, there are also limitations to meta-analyses that must be considered, such as sometimes questionable use of data mixing that compares "apples and oranges" (Leck, 2006) and the mixing together of "good and bad" studies (Hunt, 1997).

Aside from the pitfalls of meta-analyses, there are also some key challenges to studying urban form and travel behavior. Many studies that have shown a correlation between urban form and travel behavior have been criticized for their lack of ability to determine causality, for example by failing to account for the residential self-selection effect (Handy et al., 2006; Singleton and Straits, 1999). It is difficult for them to assess causality because of the temporal conditions of the data, as changes in urban form would necessarily have to precede behavioral changes. To effectively determine causality, researchers would need panel data directly comparing travel behavior before and after urban form interventions, and this type of data is very hard to obtain (Handy et al., 2005; Knuiman et al., 2014).

2.1.9.2 Urban Form and Modal Choice (Cross-Sectional Data Research)

Still, many other (and more recent) studies have found important links between urban form and modal choice, mostly using cross-sectional data (Kamruzzaman et al., 2016). The conclusions these studies have drawn is that people living in moderate- to high-density neighborhoods with diverse land use patterns, well-connected street networks, good active transport infrastructure and good public transport options are more likely to use sustainable modes of transport (Boarnet and Crane 2001; Ewing and Cervero 2001; Timmermans et al. 2003; Hickman and Banister 2005; Frank et al., 2005; Handy et al., 2005; Brownson et al., 2009).

Part of the problem is that few studies get into measuring the granular details of urban form, instead asserting or assuming their importance (Ewing & Handy, 2009). To be more concrete, urban form is the "geometric composition of the elements that make up the city (streets, buildings, blocks, facades, street furniture, vegetation, etc.), in terms of their dimensions and proportions (geometric framework)" (Barros et al. 2017, p. 134). In a study about the effect of urban form on walkability, Barros found that, in ranked order, proximity to subway station, presence of stairs, slope of street, entropy, width of sidewalk, trees, proximity to bus lines, connectivity, presence of bus stop, and street compactness all impacted the pedestrian flow, albeit some of these factors with a negative relationship, for example presence of stairs or narrow sidewalks having a limiting effect on the pedestrian flow (Barros et al., 2017).

A study by Stojanovski (2019) compiled a list of the most important elements of urban form as they relate to sustainable mobility, weighing their importance for each modal choice according to empirical research. In this analysis we can see that there are many more factors that relate to walking as compared to cycling, public transport, or private car usage. This may provide clues on how urban designers can encourage walking in neighborhoods as compared to other methods of transport.

	Sustainable Mobility Indicators/Urban Form and Accessibility Factors	Scale	Walking	Cycling	Public Transportation	Private Car
1	Sidewalk design and continuity	Visual	(3) 5 [1]			
2	Street segment length/city block width	Visual	(7) 15			
3	Speed limit	Visual	(3) 5 [1]			
4	Bike parking	Visual		(3) 10		
5	Cycling lanes on street/cycleways	Visual		(3) 10		
6	Bus line/busway/tramway on street	Visual			(3) 5	
7	Transit stop/station exit on street	Visual			(3) 5	
8	Parking	Visual				(9) 60
9	Undisturbed circulation (no congestion)	Visual				(3) 10
10	Building setback	Visual	(3) 5 [1]			
11	Building height to street width ratio	Visual	(3) 5 [1]			
12	Building façade activity/openness	Visual	(9) 20 [1]			
13	City block density (residents and jobs)	Local	(9) 20 [2]		(3) 5	
14	City block land use mix (entropy of residents and jobs)	Local	(9) 20 [2]		(3) 5	
15	Neighbourhood topography (slope)	Local		(9) 40		
16	Access to everyday activities	Local	(9) 20			
17	Access to event-type activities	Local	(3) 5			
18	Access to a mix of activities	Local	(9) 20			
19	Access to a local transit stop	Local			(9) 30	
20	Access to a regional transit stop	Regional			(9) 30	
21	Access to an expressway	Regional				(5) 30
22	Bikable location	Regional		(9) 40		
					Walking (7) 20	
	Sums		(42) 100	(24) 100	(27) 100	(15) 100

[1] assigned to street space/open spaces between building façades; [2] assigned to city blocks/constructed and open within the parameter of the building façades.

Figure 5: "Sustainable Mobility Indicators/Urban Form and Accessibility Factors" at scales of visual perception, local accessibility, and regional connectivity, weighted by importance per modal choice (Stojanovski, 2019)

The factors that most closely relate to superblocks are sidewalk design and continuity, speed limit, bike parking, cycleways, and undisturbed circulation, which all fall under the visual scale category. Visual scales are very important in determining modal choice and can be understood through various dimensions or measures, which will be elaborated on in the following section. These under-studied measures are the lynchpin of the present research.

2.1.9.3 Dimensions of Urban Form as related to Modal Choice

For example, a study on urban design qualities that influence walkability performed a literature review and identified 51 relevant perceptual qualities (full list in Annex A), of which eight were selected for further study based on how prominently they feature in literature, and five of which were operationalized: imageability, enclosure, human scale, transparency, and complexity (Ewing and Handy, 2009). These five qualities of urban design are highly relevant to the superblock design and are foundational to this thesis research.

Imageability can be defined as "the quality of a place that makes it distinct, recognizable, and memorable" (Ewing and Handy 2009, p. 73). Furthermore, a place has high imageability when "specific physical elements and their arrangement capture attention, evoke feelings and create a lasting impression." Specific indicators (in order of significance) include number of people, proportion of historic buildings, number of courtyards, plazas, and parks, and presence of outdoor dining (Ewing and Handy, 2009).

Enclosure refers to "the degree to which streets and other public spaces are visually defined by buildings, walls, trees, and other vertical elements" (Ewing and Handy 2009, p. 75). The idea of enclosure is basically to make outdoor spaces feel like indoor ones – safe, defined, and enclosed. The proportion of height of vertical elements relative to the width of space between them is an important feature, but continuity of buildings and framing of trees can also play a big role in creating enclosure.

The term human scale refers to “a size, texture, and articulation of physical elements that match the size and proportions of humans and, equally important, correspond to the speed at which humans walk” (Ewing and Handy 2009, p. 77). Physical elements such as building details, pavement textures, street trees, and street furniture all contribute to human scale by giving pedestrians a sense that the city was designed for them (as opposed to for cars speeding through at 60 km per hour).

Transparency in the urban design sense refers to “the degree to which people can see or perceive what lies beyond the edge of a street and, more specifically, the degree to which people can see or perceive human activity beyond the edge of a street” (Ewing and Handy 2009, p. 78). Physical elements such as windows, doors, fences, landscaping, and openings into mid-block spaces all influence transparency by creating a sense of visual openness. Walls influence transparency by doing the opposite.

The final element is complexity, which refers to how visually varied, rich, and stimulating a place is. Complexity depends on “number and types of buildings, architectural diversity and ornamentation, landscape elements, street furniture, signage, and human activity” (Ewing and Handy 2009, p. 81). The idea behind complexity is striking the right balance between sensory deprivation and overstimulation. These concepts are tied together in Ewing and Handy’s 2009 conceptual framework, which is presented below. Although many of these studies are focused directly on walkability, they can give us an idea as to how urban form and urban design impact modal choice.

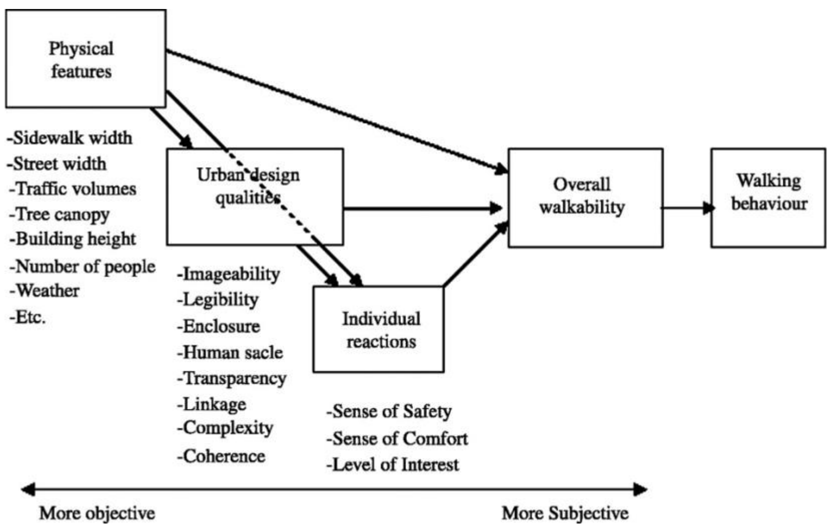


Figure 6: Walkability Conceptual Framework Ewing and Handy (2009)

The perceptual qualities under “Urban Design Qualities” in the framework above are the main focus of the independent variable, which is “urban form features,” in the present research. The individual contributions of these qualities to modal choice are under-studied and therefore of high interest. The most relevant qualities in the context of superblocks and superblock features are complexity and human scale, which can be measured through different specific features. The relationship between these features and superblocks will be further elaborated on below.

2.1.9.4 Critical Urban Form Determinants of Modal Choices

Below is a summary of all the critical determinants of modal choice that are directly related to urban form as gathered from the literature review above.

Table 2: Critical Urban Form-Related Determinants of Modal Choice

Study	Determinant
Crane 1996	Street layout
Crane 1996	Composite measures of density
Crane 1996	Mixed use
Crane 1996	Pedestrian Features
Crane 1996; Ryan and McNally 1995; Plaut and Boarnet 2003	Smaller blocks
Crane 1996; Ryan and McNally 1995; Plaut and Boarnet 2003	Continuous sidewalks
Crane 1996; Ryan and McNally 1995; Plaut and Boarnet 2003, Frank & Engelke (2001)	Highly connected roads (grid layout)
Cervero (2002)	Sidewalk infrastructure
Rodriguez and Joo (2004)	Sidewalk availability
Rodriguez and Joo (2004)	Presence of walking paths
Rodriguez and Joo (2004)	Presence of cycling paths
Leck (2006), Stojanovski (2019)	Residential density
Leck (2006)	Employment density
Leck (2006)	Land use diversity
Dieleman et al (2002)	Characteristics of residential environments
Stojanovski (2019)	Building heights
Stojanovski (2019)	Building orientation
Stojanovski (2019)	Street widths
Stojanovski (2019)	Design of sidewalks
Pucher & Buehler (2008, 2011, 2011, 2012), Frank & Engelke (2001), Stojanovski (2019)	Bike lane network
Barros et al. 2017	Trees
Barros et al. 2017, Frank & Engelke (2001)	Slope/topography
Barros et al. 2017	Width of sidewalk
Barros et al. 2017, Frank & Engelke (2001), Stojanovski (2019)	Bus stops
Barros et al. 2017	Doors
Barros et al. 2017, Frank & Engelke (2001)	Proximity to subway
Barros et al. 2017, Frank & Engelke (2001)	Proximity to bus

Barros et al. 2017	Stairs
Barros et al. 2017	Compactness
Ewing & Handy, 2009	Imageability
Ewing & Handy, 2009	Enclosure
Ewing & Handy, 2009	Human Scale
Ewing & Handy, 2009	Transparency
Ewing & Handy, 2009	Complexity

2.1.2.1 Main Findings on Critical Determinants of Modal Choice

Understandably there is much overlap between many of these critical determinants. There is wide consensus among researchers that mixed land use, density, and proximity to public transport impact modal choice. However, some of the "softer" determinants (such as those listed from Ewing & Handy 2009) are not as well studied, mostly due to the fact that it's difficult to measure their impacts on laypeople (e.g. people who do not work in mobility or urban design and who perhaps do not consciously consider imageability or transparency when making modal choices). Still, in the case of superblocks, these influences are extremely important as they relate directly to the changes that superblocks bring about, such as more trees, more sidewalk space, etc.

The most relevant critical determinants in the case of superblocks can be summarized in three main groups: the built form, human scale, and complexity. The following most relevant features for each category will ultimately be used in the conceptual framework below. The built form as it relates to superblocks refers to sidewalk width, sidewalk continuity, shared space, biking lane networks, and bike parking and car parking. The human scale as it relates to superblocks refers to number of trees, number of planters, and presence of street furniture. Complexity as it relates to superblocks refers to the number of people on the street, the number of cars on the street, the presence of street decoration and the presence of outdoor recreational areas (e.g. outdoor dining, plazas, parks, playgrounds, and courtyards). These are the urban form factors that are present throughout superblocks and which will be measured in relation to modal choice in this research (more details in the operationalization table, Table 3). The next section will dive more deeply into exactly what superblocks are, what goals they aim to address, and how the urban form addresses these goals.

2.1.2.2 Superblocks in Barcelona

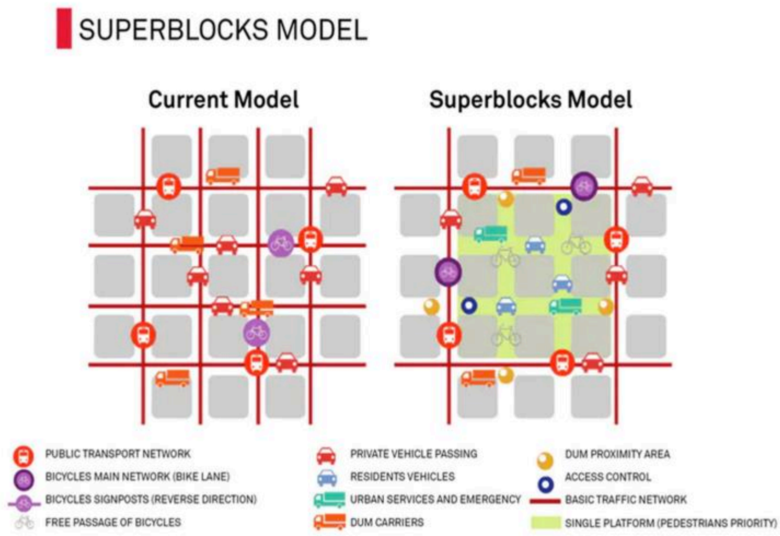


Figure 7: Superblock Model from Lopez (2020), reproduced from BCNEcologia's Superblocks Conceptual Model (2014)

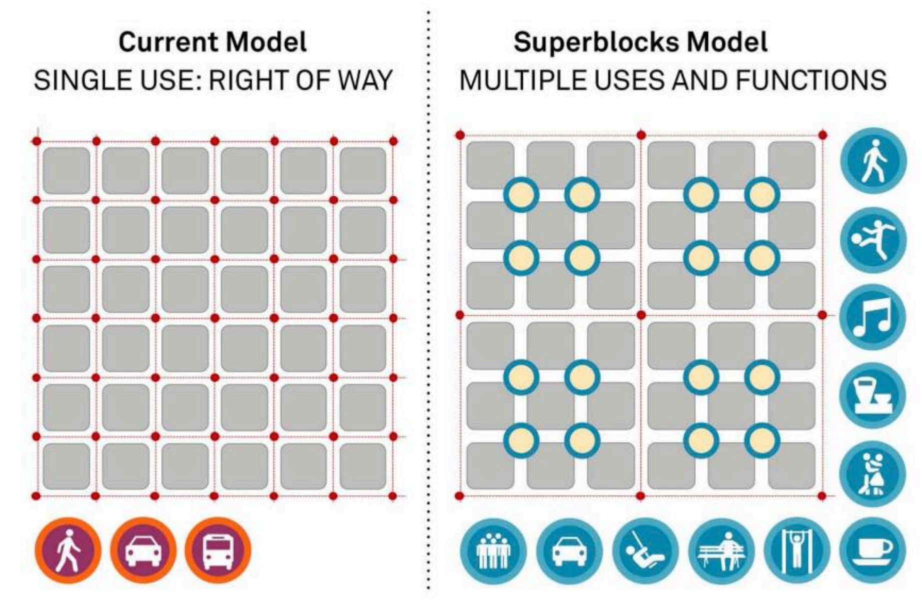


Figure 8: Superblock Model, Ayuntament de Barcelona (2014)

Theses graphic shows a visual representation of how blocks can be transformed into superblocks and the many alternate uses that can take place when people reclaim space from cars. The Urban Mobility Plan of Barcelona 2013-2018 showed 66 actions within their modal hierarchy, of which 7 were to improve walkability (as a top priority), 13 were to improve bicycle-mobility (as a second priority), 19 were to improve mobility through public transport, 9 were to improve urban distribution of goods, and, as a last priority, 18 actions to help manage private transport (Ayuntament de Barcelona, 2014). Superblocks act as a solution that can simultaneously address many of these actions across different modal goals.

Some of the municipality's relevant walkability goals include improving accessibility and comfort of sidewalks and pedestrian areas, expanding area devoted to pedestrians, increasing pedestrian safety and developing more efficient and effective pacified (e.g. reduced automobile speed, priority given to pedestrians) areas. The relevant bicycling goals include expanding and improving the network of bike lanes, increasing the supply of bicycle parking on public roads, promoting the use of electric bicycles, and improving the efficiency of public bicycle services in the city, as 44% of the bikes circulating in Barcelona in 2011 were public, amounting to 34,000 trips on any given weekday (Ayuntament de Barcelona, 2014). In terms of public transport, goals include implementing a new bus network, improving the service of bus lines, improving connectivity within the network, and ensuring accessibility to public transport. Finally in terms of private vehicles, the municipality's strategy includes encouraging modal shift from private vehicles to public transport or shared vehicles, adapting urban design to improve security and reduce traffic victims, promote systems for sharing and pooling of vehicles, and promoting electric (and other alternative fuels) vehicles (Ayuntament de Barcelona, 2014). These goals from the overall mobility strategy have helped shape the implementation of superblocks in Barcelona since 2013. Below are a series of 9 pictures that showcase these changes through current pictures as well as before-and-after comparisons.

Photograph 1

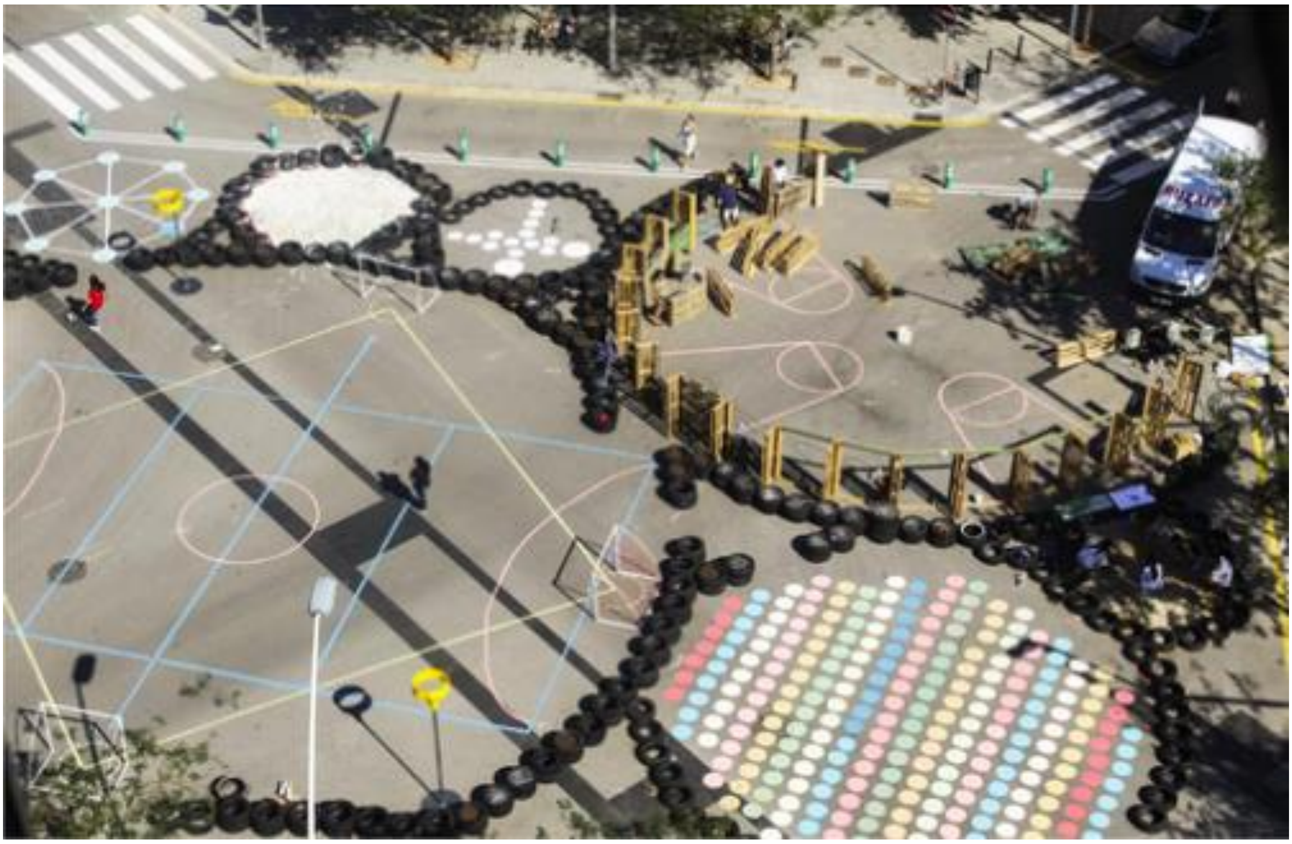
Image from "A Study of Public Life in Barcelona," Duchêne (2019)

A recreational running track was created in the middle of a Poblenou superblock street using low-cost materials such as paint, with planters for protection, air purification, and cooling.

Photograph 2

Image from "A Study of Public Life in Barcelona," Duchêne (2019), credit: BCNUEJ

A playground and recreational area in the Poblenou superblock made from low-cost, tactical urbanism materials such as paint and tires.



Photograph 3

Image from "A Study of Public Life in Barcelona," Duchêne (2019)

A playground in the Poblenou superblock.

Photograph 4

Image from "A Study of Public Life in Barcelona," Duchêne (2019)

Multiple street uses can be seen here, such as a traffic-calmed road, bike parking, picnic tables, planters, and trees.

Photograph 5

Image from "A Study of Public Life in Barcelona," Duchêne (2019) via Google Street View

A before and after picture of the same street corner in Poblenou from 2008 to 2017.

Photograph 6

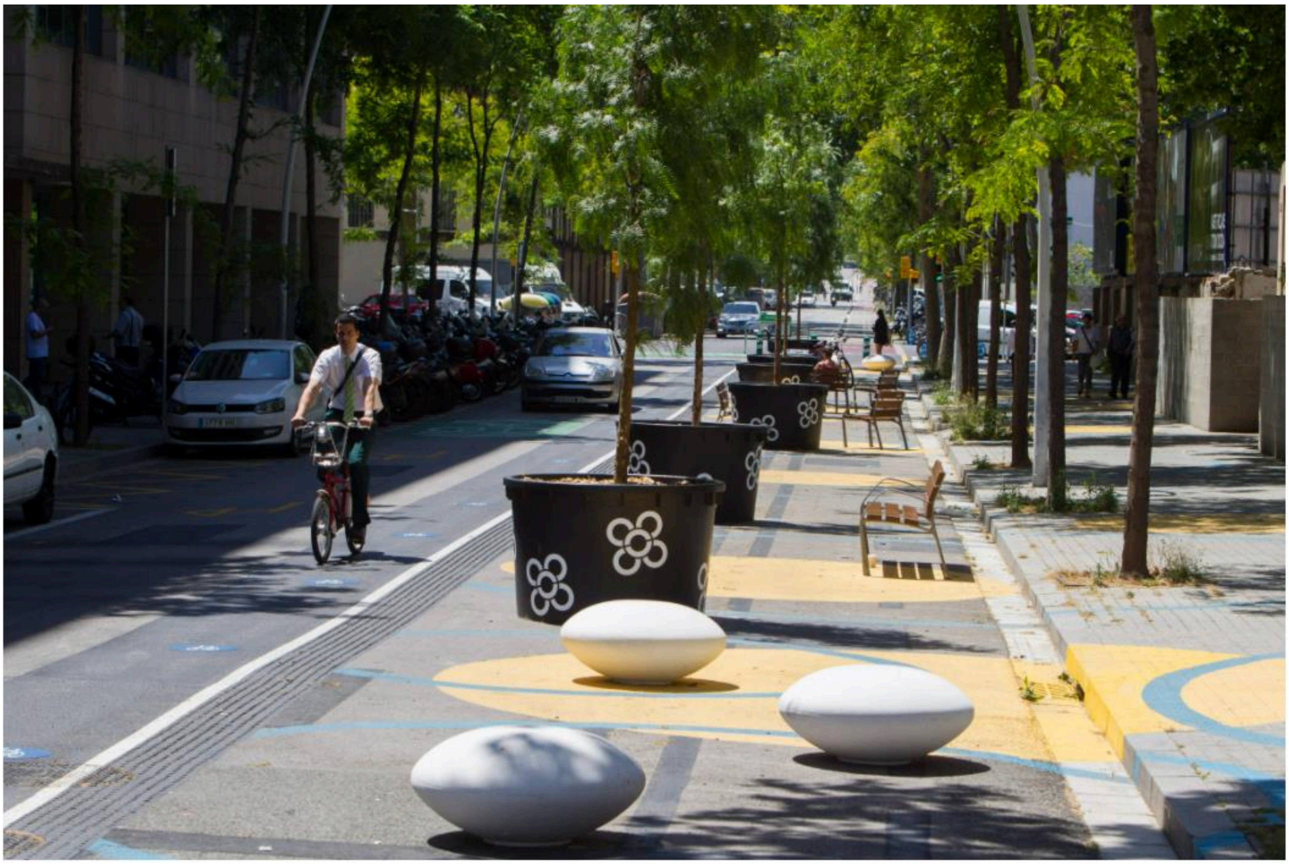
Image from "A Study of Public Life in Barcelona," Duchêne (2019)

An entrance to the Poblenou Superblock, where traffic calming measures are clearly indicated.

Photograph 7

Image from Public Space Org (2017)

A view of bikes, cars, trees, planters, and street furniture peacefully coexisting.



Photograph 8

Image from "The Barcelona Superblock of Poblenou" (Bicycle Dutch, 2017)

A view of street decoration, planters, bike parking, and street furniture being used.

Photograph 9

Image from “The Barcelona Superblock of Poblenou” (Bicycle Dutch, 2017)

Google Streetview comparing before and after views of the Carrer de Roc Boronat inside the Superilla del Poblenou from 2008 to October 2017. The superblock view shows bike parking, scooter parking, planters, and street furniture.

Since their implementation, some research has been done to study the various effects of superblocks, particularly on health. A quantitative health impact assessment study for Barcelona residents over 20 years of age by Mueller et al. (2020) found that 667 premature deaths could be prevented annually through the implementation of all 503 planned superblocks, mostly attributable to the reduction in air pollution (NO_2 specifically), noise reduction, and green space development. The superblocks were estimated to increase life expectancy for the adult population by 200 days and result in annual economic impact of 1.7 billion Euros. Most relevant to this research, however, was that physical activity was estimated to increase for an estimated 65,000 people who would shift from car or motorcycle trips to public and active transport, which resulted in 36 preventable deaths (Mueller et al., 2020). There is also existing research on the political and governance challenges that the Superblock project in Barcelona brought about as it relates to climate-related transformational adaptation (Zografos et al. 2020). Scudellari et al. (2020) have also written about the limitations in implementing the superblock approach at the local and urban level.

Lopez et al. (2020) analyzed mobility infrastructure in cities through the lens of climate change, touting superblocks as a form of effective "low tech urbanism" which do not require investment in hard infrastructure, nor demolishing buildings, or undertaking large developments (Lopez, 2020). This study analyzes superblocks as a "new model of mobility that restructures the typical urban road network, which provides solutions to the main problems of urban mobility and improves both the availability and quality of the public space for pedestrian traffic results in decreased traffic, and as such lower emissions of greenhouse gases" (Lopez 2020, p.2). Lopez argues that the superblock is one of the main technical instruments of urbanism with an ecosystemic approach, which is of upmost priority when crafting solutions to tackle climate change. He also asserts that superblocks enable achievement of the Sustainable Development Goals as proposed by the United Nations in the 2030 Agenda, specifically SDG 11, which aims to "make cities inclusive, safe, resilient, and sustainable," especially with regards to affordable and sustainable transport systems, reducing environmental impact of cities, providing access to safe and inclusive green and public spaces, and focusing on inclusive and sustainable urbanization (UN, 2015).

Already the Superblock program has seen positive results, with a 67.2% increase in pedestrian space in superblocks to date, with the potential of a 270% increase upon completion of all 504 superblocks (Lopez, 2020). Despite a few social risks, most notably the risk of gentrification in superblock areas, superblocks bring multiple interrelated benefits for a healthier, more socially and ecologically sustainable Barcelona, with reduced emissions being a central part of this web. It is therefore important to better understand how superblocks impact modal choices as a lynchpin to the progress towards sustainable urban development.

2.1.2.3 Superblock Urban Form and Theory

As discussed above, superblocks aim to increase walkability, encourage biking, and discourage private vehicle use through several urban design interventions. Among these are the widening of sidewalks, the reduction of street space for cars, and the addition of traffic calming measures, planters, street furniture, bike lanes, and recreational spaces. As such, the most relevant superblock-specific critical determinants can be summarized by the three categories mentioned above, which are the (1) built form, (2) human scale, and (3) complexity.

While well-known factors such as trip length or trip purpose have been proven to be causal determinants of modal choice from a rational perspective, there is still room for exploration on how objective spatial components and subjective factors play into modal choice. Hollevoet et al.'s (2012) review of modal choice determinants found that modal choice is ultimately determined by a "whole range of factors which are interrelated to a larger or smaller extent" and thus that modal choice is "often the result of a very compound choice process that can take place consciously or unconsciously and can include objective as well as subjective determinants" (Hollevoet et al. 2011, p. 129).

This research aims to explore this underdeveloped area of research. I do not aim to imply direct causality between the built form, human scale, complexity and modal choice (e.g. claim that the addition of trees will *cause* people to walk), but simply aim to determine whether there are statistically significant relationships between appreciation of certain urban form factors and kilometers travelled on different modes of transport. The research aims to discover whether appreciating certain urban form features can predict higher usage of sustainable modes of transport.

2.2 Conceptual Framework

A conceptual framework is a visual representation of the key concepts within a research topic. Maxwell (2012) defines the conceptual framework as "a system of concepts, assumptions, expectations, beliefs, and theories that supports and informs a research". As such, the following conceptual framework aims to support and inform the present research. It shows how the three chosen components of urban form (built form, human scale, and complexity) impact modal choice, which is the primary relationship in the conceptual framework and is depicted by the thick arrow. This relationship is supported by the existing academic literature which was outlined in Section 2.1.9.3. entitled Dimensions of Urban Form as They Relate to Modal Choice. The literature supports a relationship between these dimensions of urban form and modal choice, although it has been difficult to prove causality due to the types of transportation data that can be gathered (e.g. panel data before and after urban form interventions are very rare). However, it is clear from the literature review that a relationship exists. That's why this research aims to discover if appreciation for certain urban form features can predict higher usage of NMT/active transport and otherwise more sustainable modes of transport. This is the underlying assumption behind this research. These specific elements of the urban form were chosen because of their relevance to superblocks in a practical sense; in other words, they are what superblocks consist of. Therefore, this is the most appropriate foundation for this research. This framework also considers secondary forces in the form of control variables. The control variables are classified as personal characteristics (e.g. age, gender, gross annual income, number of children, household size, car ownership, and bike ownership). The impact of the controls is depicted by the thinner, downwards-pointing arrow.

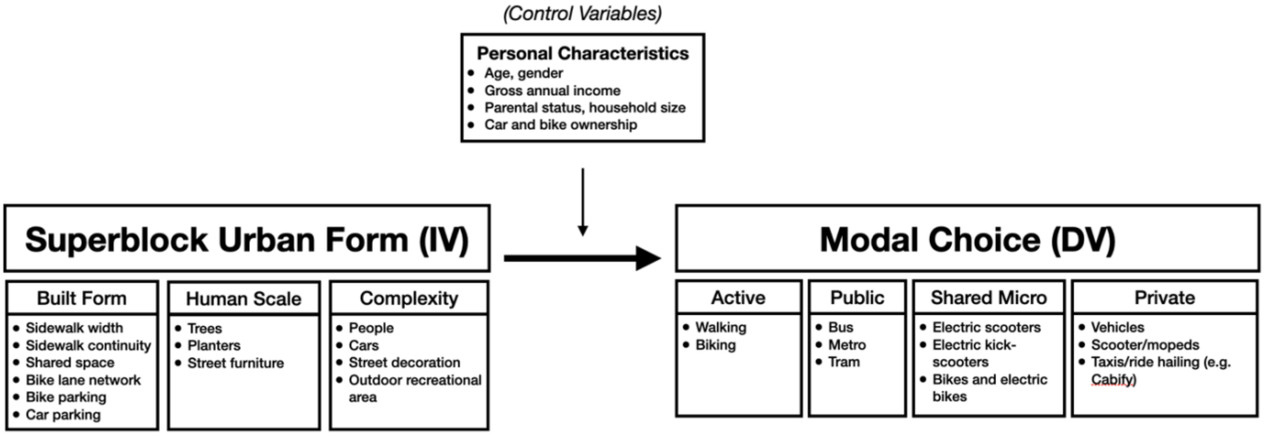


Figure 9: Conceptual Framework

Chapter 3: Research Design and Methods

3.1 Description of the Research Design and Methods

3.1.1 Survey Research Strategy

The research strategy is a survey that was conducted online. A survey was used in order to reach as many respondents as possible in a time-efficient manner. According to Van Thiel, surveys are "especially suitable for theory-driven or deductive forms of research" (Van Thiel 2014, p.74). This is indeed the case of this research, where the aim is to explore the motivations and attitudes about how urban form factors affect modal choice in Barcelona residents. Van Thiel also posits that the survey is an effective strategy for "the collection of new data, as opposed to the research strategy of desk research" (Van Thiel 2014, p.74). There has been little to no research done on this specific topic, which provides further support for the survey as the chosen method for this research. Surveys also provide data that is highly generalizable, due to their large scale and high level of standardization, which results in a high level of external validity (Van Thiel, 2014). This is important because one of the main uses of this research is to help provide support for superblock implementation in other areas of Barcelona as well as other cities that are looking to improve livability through the creation of superblocks.

3.1.2 Sampling

The survey population is residents in the commuting age group living in superblocks in Barcelona. Thus, the sample will be adults above the age of 18 living in or near superblocks in Barcelona. The two most developed superblocks are the San Antoni superblock in Eixample and the Poblenou Superblock. The Poblenou superblock is in a mixed-use area and houses around 1500 inhabitants, while the Sant Antoni superblock is in a much more residential area and houses around the same number of inhabitants in each block (Casorran, 2019). As such, the assumption was that the survey would reach around 200 people with a response rate of about 30%, resulting in 60 expected responses. The end result was higher than expected, with 120 responses. It is important to note that responses were not separated by superblock.

Since there is a specific criterion (e.g. living in the superblock) that must be met for this sample, the research used *non-probabilistic* purposive sampling and snowball sampling. In other words, the research did not use random sampling because it did not aim to have a representative sample of all Barcelona residents, but instead a specific sample of superblock residents. Thus, residents were selected (purposive sampling) and recruited by each other (snowball sampling) as they were encouraged to forward the survey link to their neighbors.

3.1.3 Data Collection Strategy

Contact was made with people who are affiliated with the superblock project and who have contacts with residents there via LinkedIn. They were asked to send the survey to superblock residents. Personal contacts in Barcelona were also contacted and asked to share the survey with friends or acquaintances who live in or near superblocks. There were many Superblock association groups and neighborhood resident groups on Facebook that provided digital access to superblock residents. The survey link was posted there and generated much support but also controversy (some comments are included in the analysis). There was a message at the start of the survey encouraging participants to share it with their fellow superblock neighbors, adding to the snowball effect. The criteria for participating in the survey was age (above 18) and residence within or near a superblock (self-reported). There were no other restrictive criteria; all types of superblock residents were welcome to participate.

3.1.4 Data Collection Tools

The survey was an online survey and was administered through Qualtrics. The type of data collected was mostly qualitative (asking participants to rank how much they appreciate certain urban form features on a scale of 1-10) with a few qualitative questions to add context and color to the findings (e.g. open-ended free response questions). The collected data was then analyzed using STATA multiple linear regression analysis to determine if there are statistically significant relationships between appreciation of urban form factors and self-reported weekly kilometers travelled per each modal choice.

3.1.5 Validity

As discussed above, there is high external validity for this research. In terms of internal validity, or to what degree the research measures what it is aiming to measure, there are a few limitations to be aware of. Firstly, there will naturally be participant self-selection bias, in that only those who are highly engaged, motivated, informed, or passionate about mobility and the superblock project will participate (i.e. the respondent sample may not be truly "representative" of all superblock residents). Unfortunately, this bias is unavoidable. There may also have been sampling bias where the respondents tend to be younger, more tech-friendly (given the digital distribution of the survey), and more connected to each other via digital platforms. Again, the presence of this bias would result in an unrepresentative sample but is also, unfortunately, unavoidable.

3.1.5 Reliability

According to Van Thiel, "the reliability of a study is a function of: 1 the accuracy, and 2 the consistency with which the variables are measured" (Van Thiel 14, p. 48). This research is reliable in both senses. It is accurate because it is measures what it aims to measure (i.e. appreciation for urban form features and modal choice preferences). This research is also consistent, or repeatable, in that any researcher with a similar variables and operationalization in the same sample would likely find similar results. A threat to reliability could be a lack of understanding by some participants of what certain indicators mean (although the survey provided definitions for each urban form factor mentioned, and these definitions can be found in a table below).

3.2 Operationalization

3.2.1 Variables and indicators

The table below states clearly how each concept is defined and measured. The first concept, urban form, which is the independent variable, is operationalized and measured by using appreciation of urban form features. Appreciation was defined in the survey as how much participants "notice, care about, or enjoy" certain features. This specific terminology was used for a number of reasons. Firstly, the independent variable needs to be inherently independent from the dependent variable (more linear regression conditions will be discussed in section 4.6 Methodological Assumptions for Multiple Linear Regression), so "use" or "consideration" of urban form features would be too closely related to use of modes of transportation (i.e., modal choice). Secondly, "appreciation" has an inherently positive connotation, which helps give the results direction (for example, "awareness" was considered as an option, but a person can be aware of something without liking it). This would have resulted in less clear results. Therefore, urban form is measured by self-reported appreciation of specific urban form features, specifically as they relate to the built form, human scale, and complexity.

The dependent variable, or modal choice, is also measured using self-reported data. Much research on modal choice uses publicly available transportation data, but in the case of this research it was necessary to have self-reports to collect individualized data (e.g. data on the independent and dependent variables from the same individuals) in order to make valid statistical tests. Therefore, participants were asked to self-report how often they use each mode of transport per week on average (frequency) and how far each trip is on average per mode of transport (distance). These figures were later multiplied to create a new variable called Weekly Kilometers Traveled (WKT) per mode of transport, which is the main measure used in the regression analysis.

Lastly the control variables, which consisted mostly of demographic information and other relevant modal choice indicators as discovered throughout the literature review (e.g. bike or car ownership), were self-reported as well.

3.2.2 Operationalization Table

Table 3: Operationalization Table

Concept	Variable	Indicator
Urban Form [Independent Variable]	1. Appreciation for Built Form	1.1 Self-reported appreciation for sidewalk width (scale 1-10)
		1.2 Self-reported appreciation for sidewalk continuity (scale 1-10)
		1.3 Self-reported appreciation for shared space (scale 1-10)
		1.4 Self-reported appreciation for bike lane network (scale 1-10)
		1.5 Self-reported appreciation for bike parking (scale 1-10)

		1.5 Self-reported appreciation for car parking (scale 1-10)
	2. Appreciation for Human Scale	2.1 Self-reported appreciation for trees (scale 1-10)
		2.2 Self-reported appreciation for planters (scale 1-10)
		2.3 Self-reported appreciation for street furniture (scale 1-10)
	3. Appreciation for Complexity	3.1 Self-reported appreciation for people (scale 1-10)
		3.2 Self-reported appreciation for cars (scale 1-10)
		3.3 Self-reported appreciation for street decoration (scale 1-10)
		3.4 Self-reported appreciation for outdoor recreational areas (e.g. plazas, courtyards, parks, playgrounds) (scale 1-10)
Modal Choice [Dependent Variable]	1. Non-Motorized Transport (NMT) (also called Active Transport)	1.1 Self-reported average weekly kilometers travelled (WKT) - walking
		1.2 Self-reported average weekly kilometers travelled (WKT) - bike
	2. Public transport	2.1 Self-reported average weekly kilometers travelled (WKT) - bus
		2.2 Self-reported average weekly kilometers travelled (WKT) - metro
		2.3 Self-reported average weekly kilometers travelled (WKT) - tram
	3. Shared Micro Mobility	3.1 Self-reported average weekly kilometers travelled (WKT) - scooter (e.g. moped)
		3.2 Self-reported average weekly kilometers travelled (WKT) - shared kick-scooter
		3.3 Self-reported average weekly kilometers travelled (WKT) - share bike and/or e-bike
	4. Private transport	4.1 Self-reported average weekly kilometers travelled (WKT) - private car
		4.2 Self-reported average weekly kilometers travelled (WKT) - private scooter/moped/motorcycle
		4.3 Self-reported average weekly kilometers travelled (WKT) - taxi or ridesharing service

Personal Characteristics [Control Variables]	1. Age	1.1 Self-reported age
	1. Gender	2.1 Self-reported gender
	2. Gross annual income	3.1 Self-reported approximate gross annual income in Euros
	3. Parental status	4.1 Self-reported number of children
	4. Household size	5.1 Self-reported household size
	5. Bike ownership	6.1 Self-reported number of bicycles in household
	6. Car ownership	7.1 Self-reported number of cars in household

3.2.3 Data Analysis Methods

In this research there is the independent variable, which is urban form, and the dependent variable, which is modal choice. Van Thiel (2014) states that "inferential statistical analysis aims to establish whether a certain (theoretically presupposed) relation between two variables is systematic" (page 128). Therefore, inferential statistical analysis will be performed to better understand whether there is a systematic relationship between urban form and modal choice. Specifically, the research aims to understand if urban form can predict modal choice. In order to understand this, regression analysis will be performed. Regression analysis "tests whether the relation between two variables (the dependent variable and the independent variable) is linear," where "a positive linear relation means to say that an increase in the independent variable… leads to an increase in the dependent variable" (Van Thiel 2014, page 130). In this case, the independent variable is measured by "appreciation for urban form features" on a scale of 1-10, meaning that it is a continuous variable, and the dependent variable is measured by "self-reported weekly kilometers travelled" per mode, which is also a continuous variable. Continuity of variables is an important requirement for performing linear regression analysis on continuous variables (more conditions are discussed in section 4.6 Methodological Assumptions for Multiple Linear Regression). Finally, because there is more than one independent variable, the inferential analysis method that will be used is *multiple linear regression* (Van Thiel, 2014).

From the regression outputs it will be clear which relationships are statistically significant according to their stated p-values. A sample result would be a 31.2 coefficient for "appreciation of sidewalk width" and "WKT walking" with a p-value of 0.001, which would imply that a one-unit increase in appreciation of sidewalk width is associated with a 31.2 increase in weekly kilometers travelled by foot.

This result would imply that people who appreciate (e.g. notice, care about, or enjoy) sidewalk width are more likely to choose walking as a modal choice, or that appreciating sidewalk width can predict higher weekly kilometers traveled by foot. The outputs from regression will show if and how strongly appreciation for urban form factors influences modal choice (holding all other variables constant). This will help answer the main research question, which is "To what extent does appreciation of superblock urban form factors relating to the built form, complexity, and human scale predict modal choice in Barcelona superblock residents?"

3.3 Expected challenges and limitations

In terms of expected challenges, the most threatening was a low survey response rate. Without sufficient support from contacts on the ground in Barcelona and from the residents themselves in snowballing the survey on to neighbors, there may not have been enough responses to draw statistically significant conclusions (and this would have threatened external validity). Fortunately, this did not turn out to be the case.

Limitations also included unclear terminology for what "commuting" means in the COVID-19 era. Due to COVID-19's disruption on working from offices, and thus commutes, the general consensus is that the 5-day a week office norm will no longer be relevant in a post-COVID world. So, although trip type is a critical determinant of modal choice, and "commuter" travel was used as a concept in this survey, this may have resulted in unclear results from respondents.

My research successfully addressed the four main ethical principles in research ethics according to Bryman (2012). There was no harm to participants of any kind (including physical, emotional, or psychological) in any direct or indirect way. Mobility choices are not a deeply personal or emotional topic, so barring extreme circumstances, participants would not have been triggered. There was an informed consent form at the beginning of the survey, so participants were aware of what the research was being used for, how their data would be processed, and were able to give consent accordingly. On the topic of data, all GDPR measures were taken to ensure that the research was GDPR-compliant in terms of data storage (e.g. using SURF drive). No names were taken in the survey, which ensured anonymization of the data, and efforts were made to collect as minimal personal data as possible while still gathering information on the control variables (e.g. income, age, etc.).

Chapter 4: Research Findings

4.1 Overview of Survey

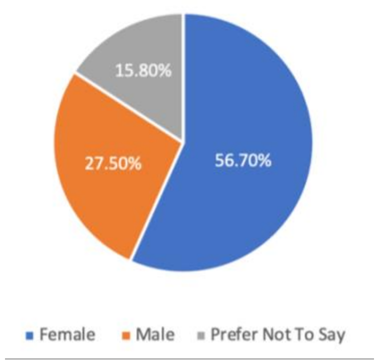
In total there were 16 questions, divided into three sections: Travel Preference Measurement, Urban Form Feature Appreciation Measurement, and Demographic Information. The Travel Preference section asked respondents to select which modes of transport they use most often, what their favorite modes of transport are (and why), and to fill in estimates of how many times per week on average they use each mode as well as how far on average they go on each trip per mode (in kilometers). Then respondents were also asked to select what they use each method of transportation for (commuter travel, utilitarian travel, or recreational travel).

The next section required respondents to answer how much they appreciate certain urban form features on a scale of 1-10, defining appreciate as how much they "notice care about, and/or enjoy them." For this section, each urban form feature was accompanied by a short description to improve clarity and ensure accuracy (descriptions can be found in Table 6 below). Then respondents were asked to answer to what extent they agree with a series of questions about living in Barcelona, sustainability, and mobility choices. These questions relate to mobility culture and subculture. They were included to better understand respondents' attitudes on these topics. Thus, for the purpose of this analysis they will be called the Attitudinal Questions. The final demographic section asked about their gender, age, gross annual income, family size, household size, and finally the number of cars or bicycles in their household, which are the control variables.

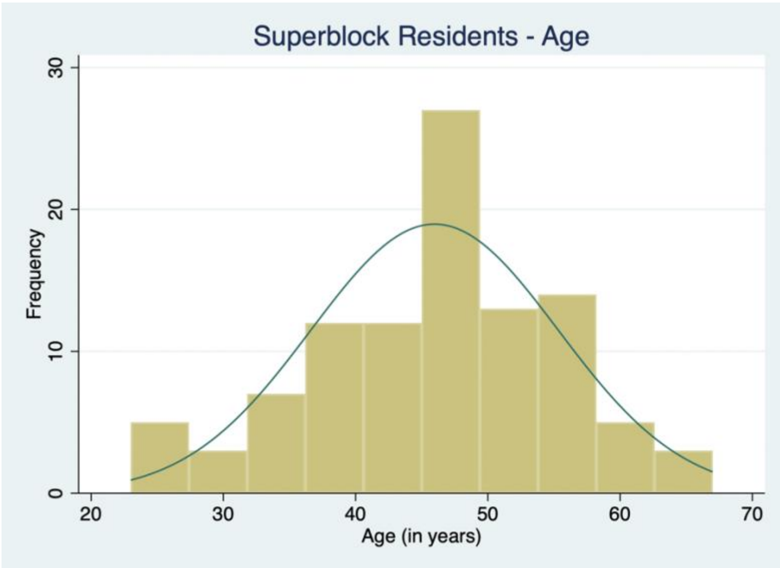
4.2 Descriptive Summary of Sample

Before diving into the analysis, it is important to understand who the respondents are and set the context for their answers. Therefore, a series of tests were performed to assess the homogeneity of the sample. As a safeguard against the potential limitation mentioned above of low response rate, the survey was widely distributed to Barcelona residents in addition to being targeted to superblock residents. In total there were 147 respondents. Of the total 147 respondents, 120 of them self-identified as living inside or near a superblock. As 120 responses is robust enough to perform regression analysis, only the "yes, inside" and "yes, near" responses were further used in the data analysis so as to more fully answer the research questions (which are specific to superblock residents). So, n=120 for this data analysis. Of those respondents, 68 (56.7%) were female, 33 (27.5%) were male, and 19 (15.8%) chose not to give their gender.

Table 4: Respondent Gender Breakdown

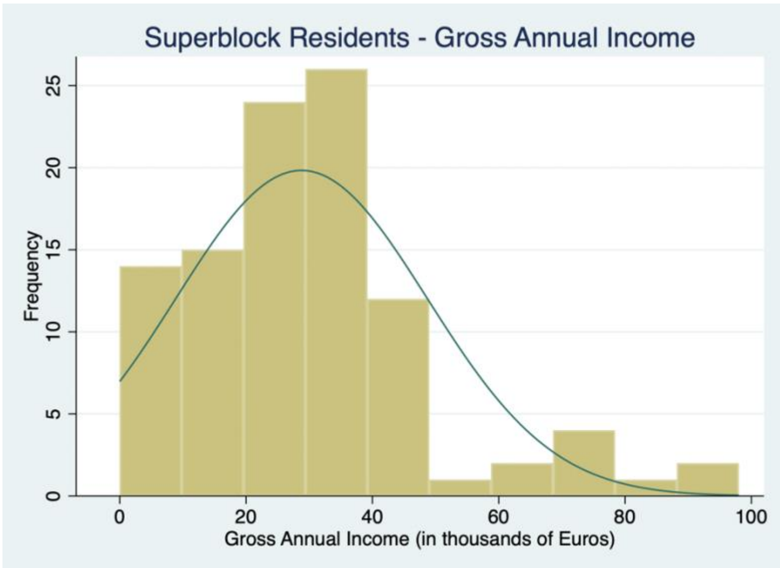


The variable "age" was mostly normally distributed, with a very high peak around 45 years old. As such, the mean respondent age was 45 years old, with a standard deviation of 9.3 years. The youngest respondent was 23 years old, with a small dip in respondents around 30 years old, and with the oldest respondent being 67 years old. There were no outliers reported.



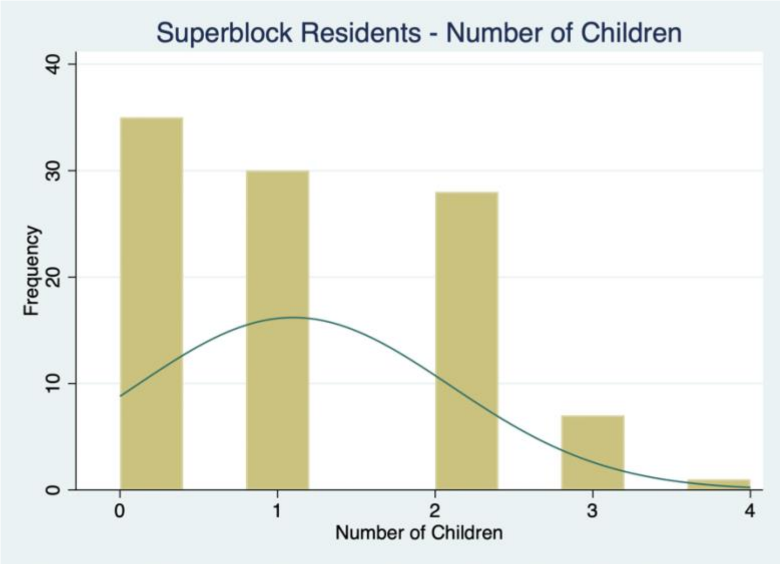
Graph 1: Age Histogram

The average gross annual income was €28,700 with a standard deviation of €19.9k. The minimum was €0 (presumably student respondents), and a maximum of €98,000. The gross annual income distribution is skewed to the right, indicating that most of the respondents are in the lower-earning category while a few had substantially higher incomes.



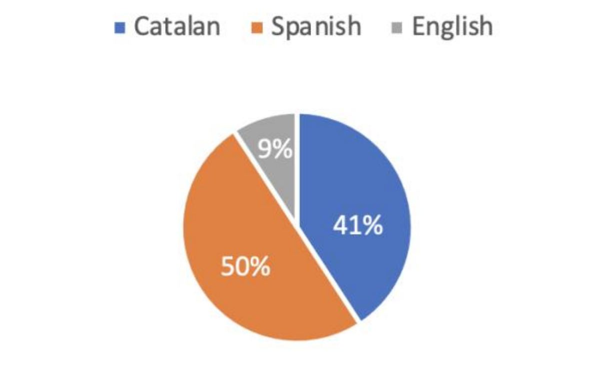
Graph 2: Gross Annual Income Histogram

The average number of children was 1, with 29% of respondents having no children, 22% of respondents having 1 child, 21% of respondents having 2 children, and only 5% having 3 or more children. This distribution is unsurprising since people in cities tend to have fewer children due to spatial and financial constraints. Having no children or few children impacts modal choice because it facilitates non-motorized transport / active transport, such as walking or biking, which turned out to be the top two most used *and* most enjoyed modes of transport for this respondent group.



Graph 3: Number of Children Histogram

Of the 120 responses, 49 (40.8%) took the survey in Catalan, 60 (50.0%) took it in Spanish, and 11 (9.2%) took it in English. This gives us clues as to the cultural background of the respondents, which is consistent with the diverse cultural makeup of the city.



Graph 4: Survey Language Chosen Pie Chart

4.3 Descriptive Summary of Attitudinal Questions

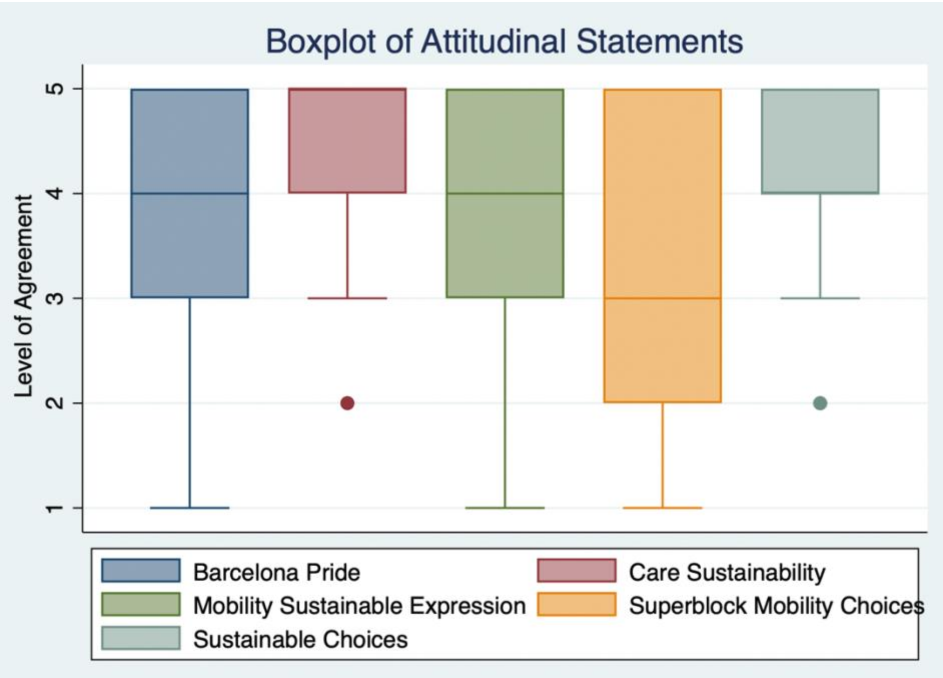
In terms of their attitudes about mobility and sustainability, the results tended towards high scores, which can be seen in the summary below. This table shows the variable names as they will appear in the box plot below, the associated statement that respondents were asked to evaluate a scale from 1-5, where 1=don't agree at all and 5 =agree strongly. The means, standard deviations, and minimum and maximums were as follows:

Table 5: Descriptive Statistics of Attitudinal Questions

Variable Name	Statement	Sample Mean (x-bar)	Standard Deviation	Min	Max
Barcelona Pride	"I feel proud to be a Barcelona Resident"	3.81	1.25	1	5

Care Sustainability	"I care about sustainability"	4.46	0.72	2	5
Sustainable Choices	"I make conscious efforts to make sustainable choices in my life"	4.25	0.83	2	5
Mobility Sustainable Expression	"I think my mobility choices are an expression of my beliefs about sustainability"	3.92	1.03	1	5
Superblock Mobility Choices	"I think living in or near a superblock impacts my mobility choices"	3.28	1.53	1	5

Below is a boxplot, which provides a more visual representation of the information above and is therefore useful for comparison and analysis.



Graph 5: Boxplot of Attitudinal Statements

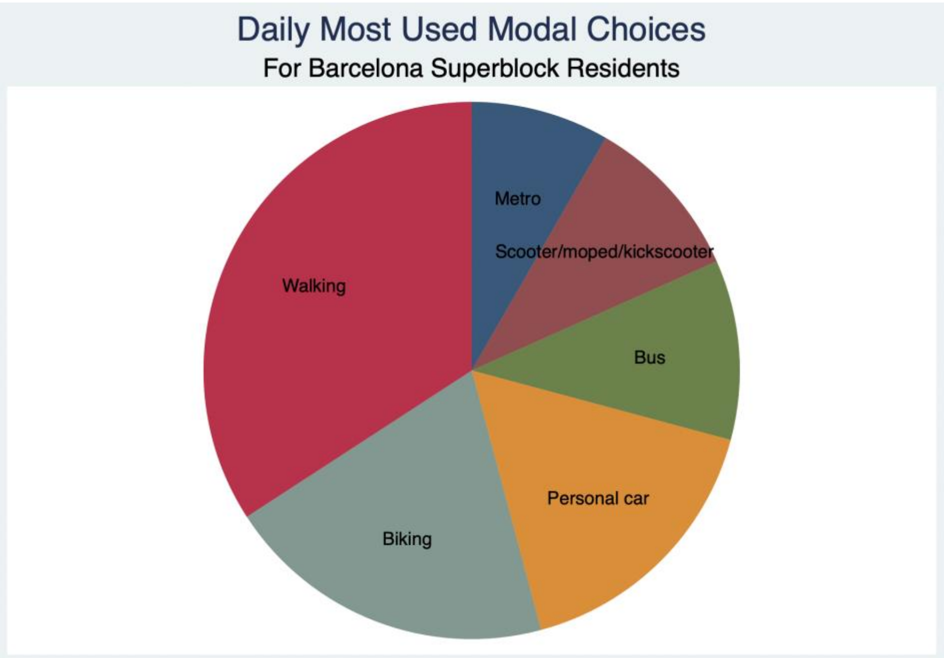
Interestingly there was much less spread in the questions specifically about sustainability. These statements, "I care about sustainability" (mean=4.46) and "I make conscious efforts to make sustainable choices in my life" (mean=4.25), both had 3 as their lowest scores (aside from outliers who ranked it at 2). The other three statements showed more even spread across the scale. This could be a case of response bias, where people tend to answer favorably towards themselves, since in today's political and social climate it would be very unpopular and unfashionable to say that you strongly disagree with caring about sustainability.

However, interestingly, there was a much lower percentage of people who agreed with the statement "I think my mobility choices are an expression of my beliefs about sustainability" [mean=3.92]. This discrepancy between caring about sustainability and making conscious efforts to make sustainable choices versus not making sustainable mobility choices is a point of contention in the superblock debate. There are many people who must commute far distances to work and who feel excluded by the implementation of superblocks. One respondent said, "Something that apparently, in Barcelona they do not understand, is that there is a large percentage of people who work 20, 30 or 50 km from Barcelona and we need a car to travel to our place of work, since, to do 20 km by public transport it can take up to 90 minutes depending on which part of Barcelona you live in and only 18 minutes by car. The superblocks just cause delays and nobody wants them, apart from those who don't work." This same participant further elaborated, pointing out that superblocks cause more traffic, extending his trip length by 3x, which also increases the amount he is polluting by car by 3x. These are some of the unintended domino effects of superblocks, which are certainly a barrier to expansion in Barcelona and to adoption in other cities.

The lowest scores were for the statement "I think living in or near a superblock impacts my mobility choices" with a mean score of 3, or "neutral". It's possible that the effects of superblocks on mobility choices are subconscious, a hypothesis which is supported by the lack of statistically significant relevant findings in the below analysis of the relationship between appreciation of urban form and modal choice.

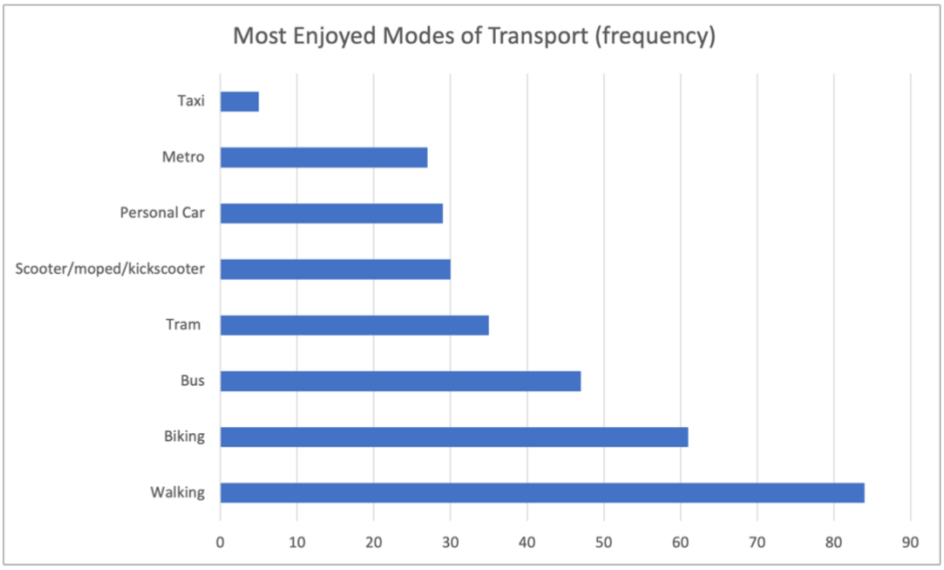
4.4 Descriptive Summary of Modal Choice Preferences

Respondents answered a series of questions on their modal choice, or the transportation choices they regularly make. The first question was about the mode of transport they use most often in their daily life, and the top three responses were walking (34%), biking (20%), and using a personal car (17%). Interestingly, nobody selected "tram" as their most used daily means of transport. The bus (11%), scooter/moped/kickscooter (10%), and metro (8%) were among the least used options, respectively. The relative breakdown was as follows:



Graph 6: Daily Most Used Modal Choices

When asked which modes of transport they enjoyed most, regardless of how often they use it, walking and biking were still the top choices (respondents were allowed to select more than one mode of transport, so the table below shows the frequency with which each mode was selected). However, interestingly, the next most reported modes of transport in terms of enjoyment were bus, tram, and scooter/moped/kickscooters (in that order, respectively). The personal car was ranked 6th. This marks a divergence from the personal car as the third most used daily mode of transport above, indicating that although people need to use their car to get around, they don't actually enjoy using it (or at least not as much as other modes of transport). This has big implications in terms of potential for changing daily behaviors to more sustainable modes of transport, because it suggests that people use their personal cars only out of *necessity* and not out of enjoyment. This makes it easier to change behaviors when practical and cost-feasible alternatives are presented.

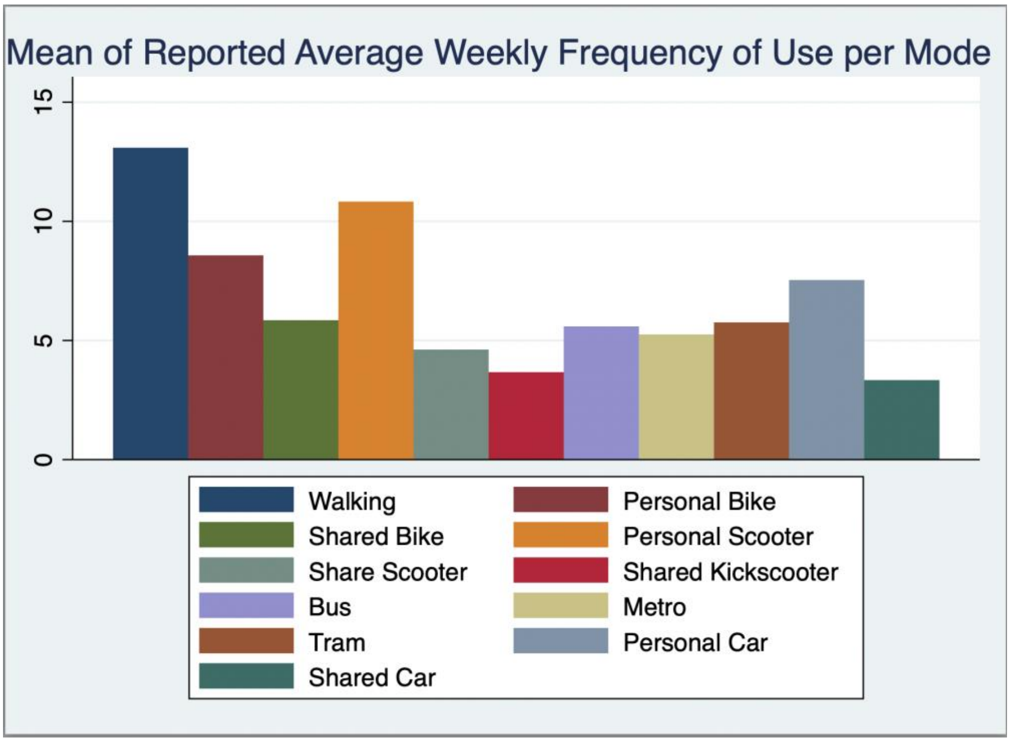


Graph 7: Most Enjoyed Modes of Transport

When asked *why* they prefer these modes of transport, there were a few common themes. For walking and biking, answers included freedom (also described as "liberty", or "autonomy"), health, sustainability, ease of use (e.g. no need to find parking) and connecting with their surroundings (or "enjoying the views"). The health and sustainability points of view were the most common. One respondent said, "I walk for health and use my private car out of necessity." Another respondent chose biking as their favorite mode of transport, then explained that it was because it's "easy to park and transport objects, and it allows me to reach greater distances than walking." One respondent said, "I like the metro for its comfort and speed, then walking for doing some exercise and to enjoy what I get to see along the street." Another specified that, "to move within the neighborhood I like to walk, then depending on how far I need to go I choose either the bike or the metro, and if I need to leave the city I prefer to go by car." These quotes highlight the different preferences at the individual level, which are mostly, but not fully, driven by practical needs.

Aside from these more practical considerations, many respondents also spoke to their emotional states as they relate to how they experience each mode of transport. One proponent of the bus said, "Barcelona is a relatively small city, and I enjoy observing it while I'm on the bus." Another respondent said, "I like being outdoors and being able to look at my surroundings," while another said, "It [the bus] is a means of relaxation." One respondent said that although they use their car most often, they enjoy walking, scootering, and using the bus because "at all times you see the street, it's fast (even when walking, you're cutting your way) and you don't feel caged." These sentiments show that, consciously or subconsciously, people are emotionally impacted by their surroundings and make transportation choices based on those feelings. This is at the root of how human scale and complexity impact modal choice.

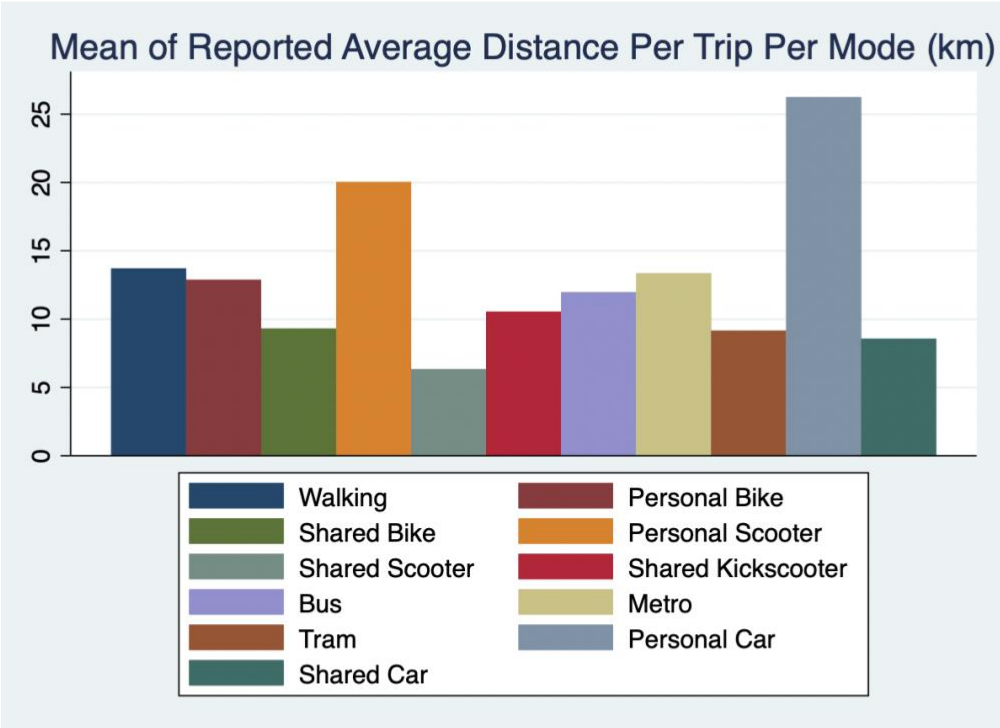
Then respondents were asked to share how many times a week they use each mode of transport per week on average, or their weekly frequency of use, per mode. The average results were as follows:



Graph 8: Mean of Reported Average Weekly Frequency of Use per mode

They self-reported walking, using a personal scooter/moped, and a personal bike the most often, respectively. It is interesting to compare the results of this question (average weekly frequency) with the results of the earlier question (most often used mode of transport in daily life), as there are some discrepancies. For example, the high frequency of personal scooter use in weekly frequency is surprising because this mode of transport was not mentioned or heavily discussed in the sections above. This indicates that superblock residents regularly use personal scooters but do not particularly enjoy them, as tram and bus ranked as more highly enjoyable than scooters. Again, this indicates a potential for changed behavior towards more sustainable means of transport, which could be either shared or personal electric scooters, or more active modes of transport such as walking or biking. Shared car (e.g. taxi) and shared kick scooters ranked among the lowest most frequently used. The shared e-kick scooter trend is still relatively new in most major cities, so this finding indicates an opportunity space for new offerings or policies that will promote higher adoption of this sustainable mode of transport.

Below are the results for the mean reported average distance per trip for each mode of transport. They show that the average trip distance for superblock residents is highest by personal car (27 kilometers per trip), then by personal scooter (20 kilometers per trip), with walking, biking, metro, bus, and shared kick scooters roughly clustered at about 12-14 kilometers per trip. It is logical that motorized transport means such as automobiles and scooters have the highest trip distance as compared to active modes of transport. However, walking still ranked as the mode of transport with the third longest average trip distance, suggesting that superblock residents enjoy taking trips by foot and are willing to go long distances by foot. This could have to do with the pleasant urban form features associated with superblocks, which will be further discussed in the regression analysis below.



Graph 9: Mean of Reported Average Distance Per Trip Per Mode

It's also important to understand what each mode of transport is being used for in order to contextualize the average distance for trip. The pie charts below in Graph 10 show what type of travel (recreational, utilitarian, or commuter) each mode of transportation is used for. Utilitarian travel was defined as going shopping, going to appointments, or traveling to social commitments. Recreational travel was defined as travel for leisure or for exercise. Finally, Commuter travel was defined as travel to get to work. Some respondents replied "Not Applicable" for the modes of transport that they do not use, which is why there are varying amounts of responses per mode type (denoted by "n" in the charts below). For simplicity, each respondent was asked to select only one type of travel per mode (phrased as "in general, what do you usually use each mode of transportation for?"), which could possibly have obscured some nuance in what each mode of transport is used for. Still, these results give us a good overall picture of how superblock residents use each mode of transport.

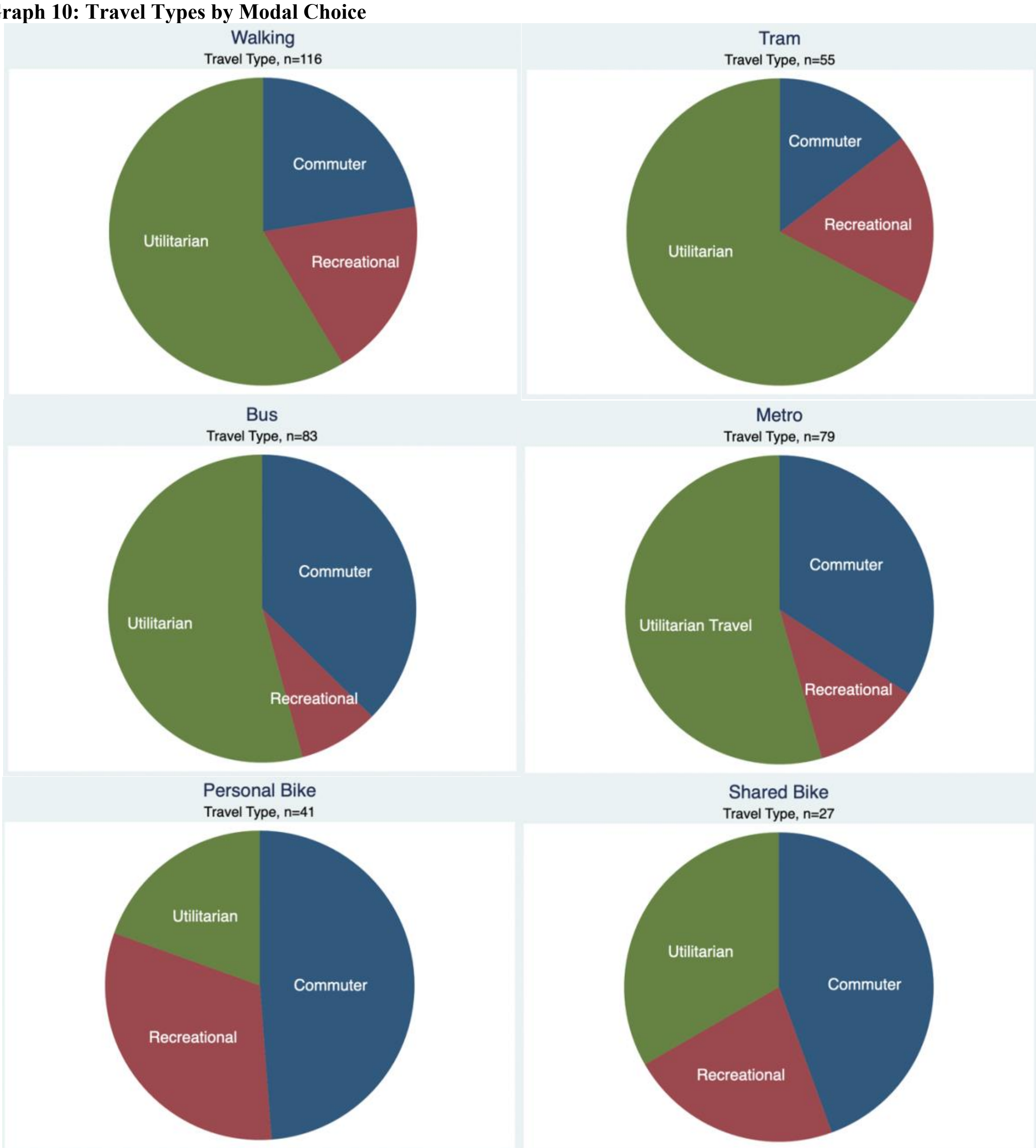
The results show that most respondents walk for utilitarian purposes, while the proportion of those who walk for recreation and commuting are more or less equal. This, along with the high number of respondents (n=116), is a positive finding in that it indicates that Barcelona is a "walkable" city, or that inhabitants can walk for practical purposes (e.g. can conveniently run errands by foot). Interestingly, utilitarian travel ranked as the least selected travel type for a personal car, which is often the use case that is cited in defense of private vehicles.

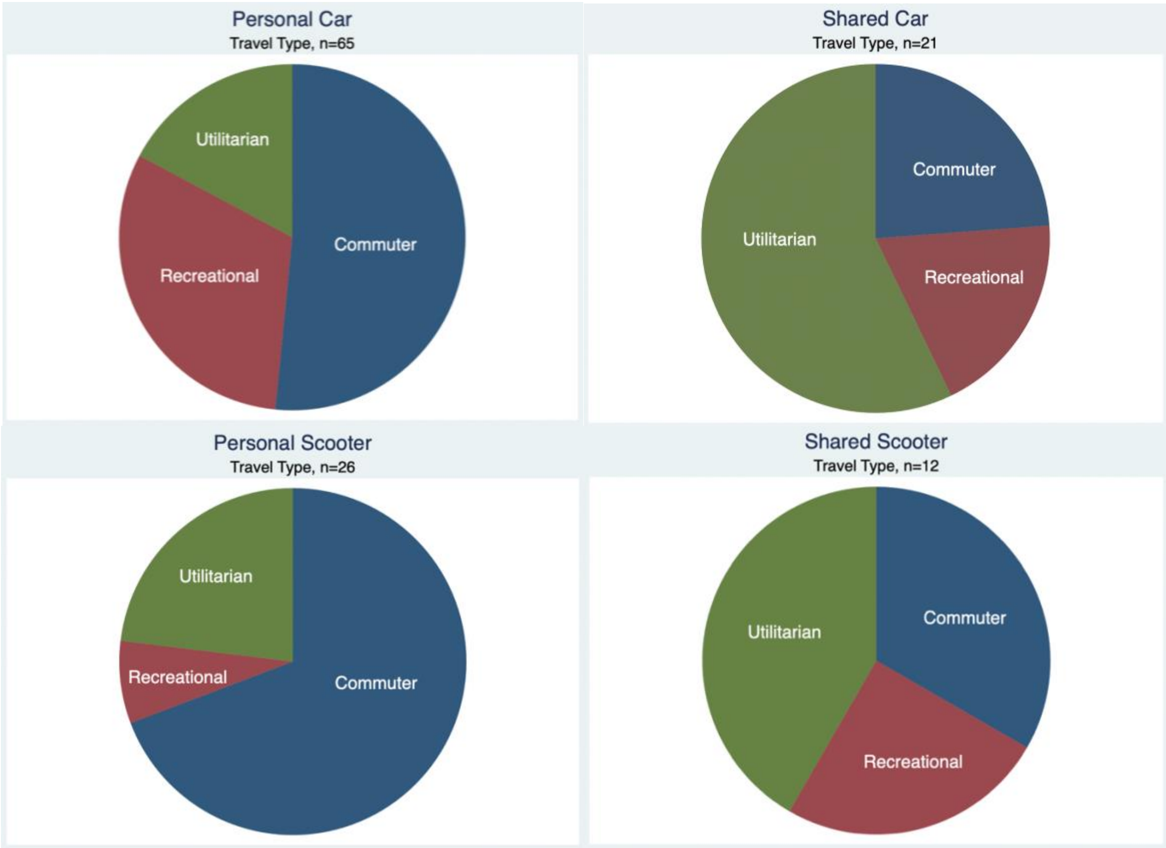
In terms of commuting, surprisingly few people use the tram to commute, while the bus and metro are slightly more popular commuting options. The most popular commuter option, however, is the personal scooter (although it should also be noted that the response pool was smaller for this question at n=26). This means that not many respondents have personal scooters, but most of those who do use it to commute to work. About half of those with a personal bike use it to commute, and, unsurprisingly, more than half of those with a personal car use it to commute. There were more respondents with a personal car (n=65) than with a personal bike (n=41), which implies an opportunity area for converting these drivers to bike, or e-bike, users.

Interestingly, recreational travel was most popular on personal bikes, personal cars, and shared scooters. The personal bike recreation is likely related to exercise and leisure, while the personal car option is likely related to transportation to exercise or leisure destinations (e.g. going on a weekend trip), and the shared scooter recreation is likely related to cruising, or enjoying a ride around town. According to this interpretation of the results, both the personal bike and scooter could be related to urban form features, a hypothesis which is explored in the regression section below.

Travel Type by Modal Choice

Graph 10: Travel Types by Modal Choice





These analyses serve to answer sub question #1, which is: "which modes of transport are most popular among superblock residents and why"? The main conclusions are that residents mostly use and enjoy walking and biking for the liberty that they feel from these modes of transport, which they mostly use for utilitarian or recreational purposes. However, the personal car is also a popular mode of transport, which is less enjoyed but more practical, and is mostly used for commuting. Bus, tram, and metro are used mostly for utilitarian purposes, but are also relatively well-liked for their flexibility (e.g. no need to find parking), availability, and ease of use (e.g. ride is enjoyable). There is a fair amount of shared transportation types, such as shared bikes, scooters, and cars, scooters/mopeds, which are more recent developments in most urban areas, Barcelona included, and which provide a promising outlook for sustainable transportation habits to come. The next section will integrate findings from the appreciation of urban form factors as they relate to the built form, human scale, and complexity into the findings from travel preferences and habits.

4.5 Descriptive Summary of Urban Form Appreciation

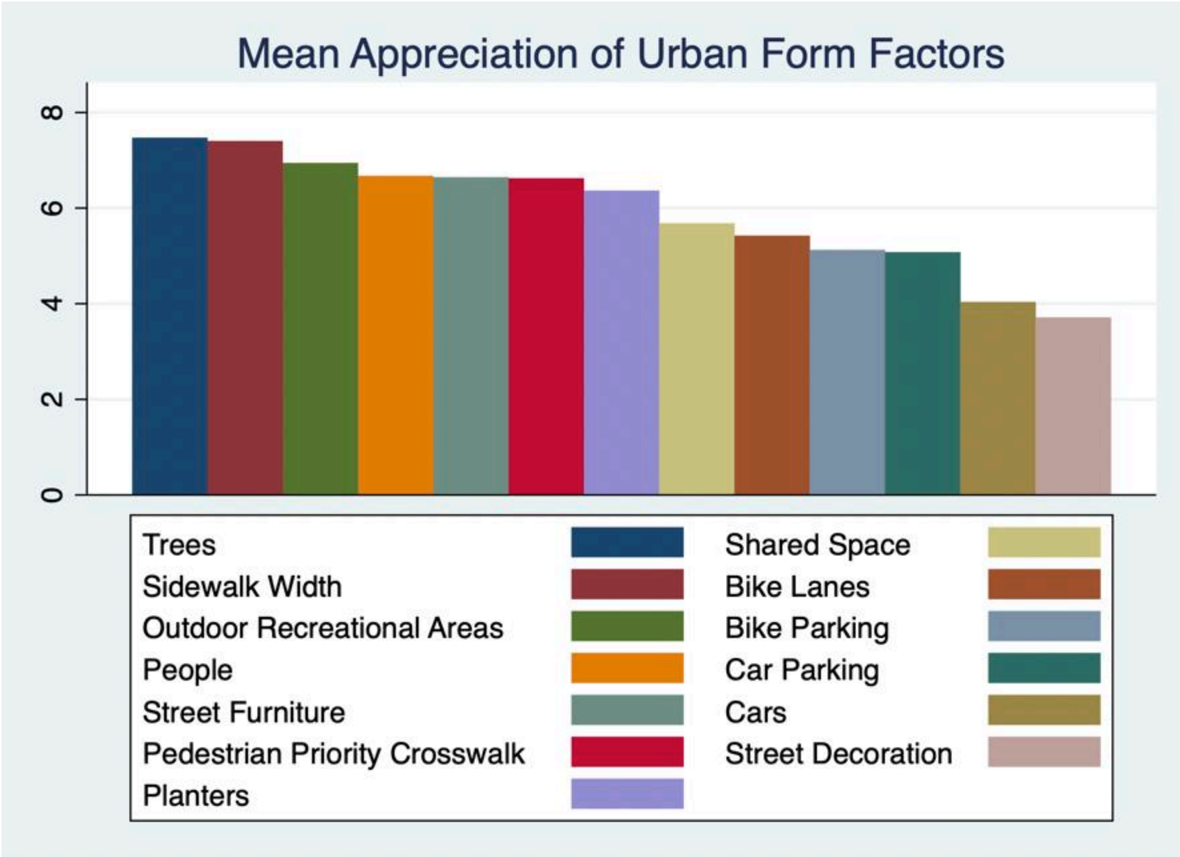
The second sub question is, "How much do residents appreciate (notice, care about, or enjoy) certain superblock urban form factors as they relate to the built form, complexity, and human scale?". To answer this question, superblock residents were asked to rank how much they appreciate each feature on a scale of 1-10. Each urban form feature was accompanied by the following descriptions or definitions. In the table below they are also categorized by independent variable category (e.g. built form, human scale, or complexity) and each form factor has a visual photographic reference from section *2.1.2.2 Superblocks in Barcelona* for ease of understanding.

Table 6: Urban Form Features Definitions and References

Urban Form Feature	Given Definition	Category	Visual Reference
Sidewalk width	How wide the sidewalk is	Built form	Photograph 1
Sidewalk continuity	Pedestrian priority crosswalks, when you don't have to wait for a cross signal to cross the street	Built form	Photograph 6
Shared space	Public space on the street that is meant for everybody – older people, younger people, pedestrians, skateboarders, cyclists, etc.	Built form	Photographs 2, 3, 4, and 5
Bike lanes	The presence of bike lanes	Built form	Photograph 7
Bike parking	Having places to comfortably and safely park your bike	Built form	Photographs 8 and 9
Car parking	Having car parking easily available	Built form	Photographs 7 and 8
Trees	Trees along the street	Human scale	Photographs 3, 4, 5, and 7
Planters	Structures that are added to the street that have plants or trees in them	Human scale	Photograph 4
Street furniture	Benches, stools	Human scale	Photographs 2, 3, 4, 5, 7 and 8
Street decoration	Painting on the pavement	Complexity	Photographs 1 and 2
People	Seeing people on the street	Complexity	Photographs 2, 3, 4, 7 and 8
Cars	Seeing cars on the roads	Complexity	Photographs 7 and 8
Outdoor recreational areas	Playgrounds, courtyards, plazas, parks, outdoor dining	Complexity	Photographs 1, 2, and 3

The bar chart below shows a comparison of the resulting mean appreciation scores for each urban form feature. The most appreciated features of the street or urban form features are trees, with a mean appreciation score of 7.47, sidewalk width (mean = 7.41), outdoor recreational areas (mean = 6.94), while the least appreciated features are car parking (mean = 5.08), cars (mean = 4.04), and street decoration, which is defined as painting on the pavement, with the lowest mean score of 3.71.

The fact that cars and car parking are among the least appreciated features is not surprising, as they are polluting, dangerous, loud, and take up a disproportionate amount of space. It's more interesting that people seem to dislike the street decoration, which was defined as painting on the street, so much. It's possible that this comes down to aesthetic preferences, as the street painting are notably different from the historical visual identity of the city. These visual changes can be quite jarring and sometimes it takes a while for people to become accustomed to such changes in their neighborhoods. It's also possible that street paint is too inherently interconnected with other variables such as outdoor recreational areas, as playgrounds and running tracks seen in Photographs 1 and 2 use street paint to delineate their purposes. Therefore, appreciation for street paint alone may have been too narrow a definition for the variable.

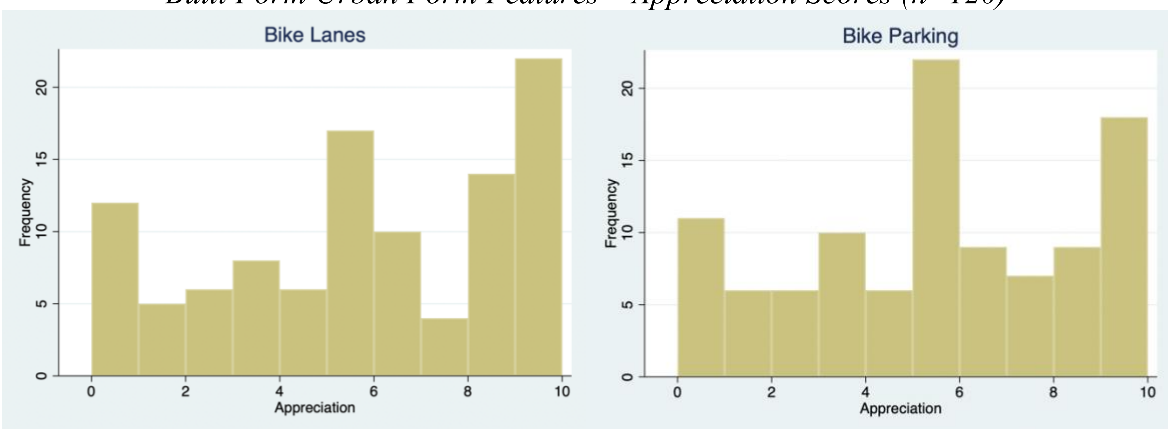


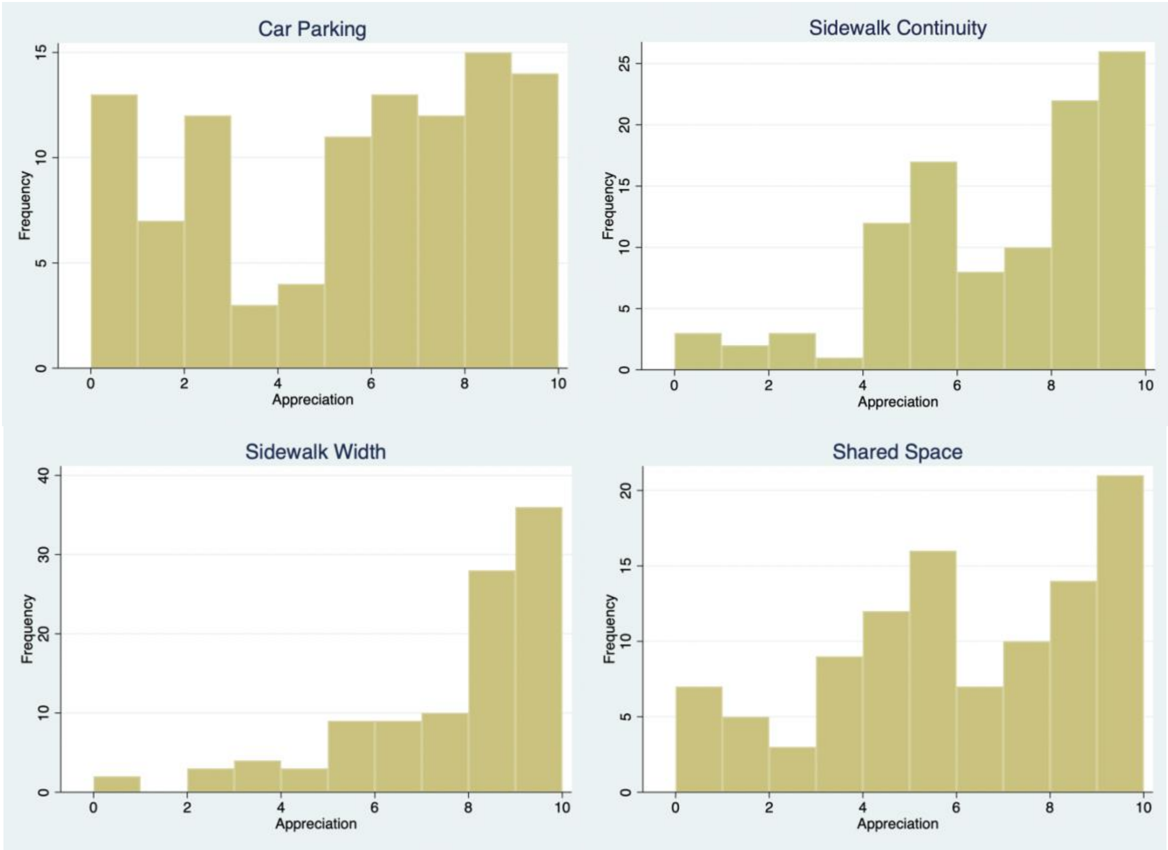
Graph 11: Mean Appreciation of Urban Form Features

Interestingly, the mean appreciation scores are more or less consistently linear, meaning that there are no drastic outliers and that the difference between means is not so high, with a range of 3.76. This shows that superblock residents are generally not extreme in their appreciation of any of the above urban form factors. Therefore, the more interesting analysis is to see the variation and spread per each form factor. Below are histograms of each urban form feature appreciation, divided by urban form category (e.g. built form, complexity, and human scale).

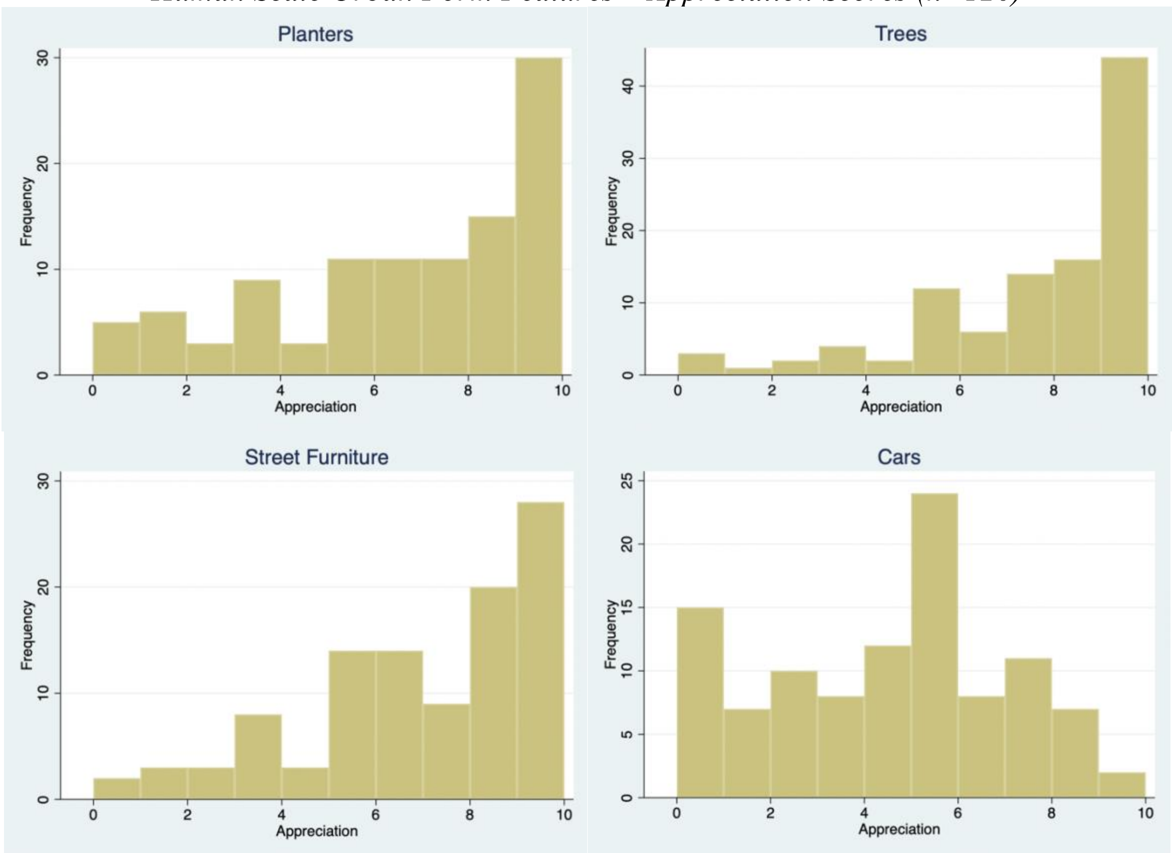
Graph 12: Appreciation Score Histograms

Built Form Urban Form Features – Appreciation Scores (n=120)

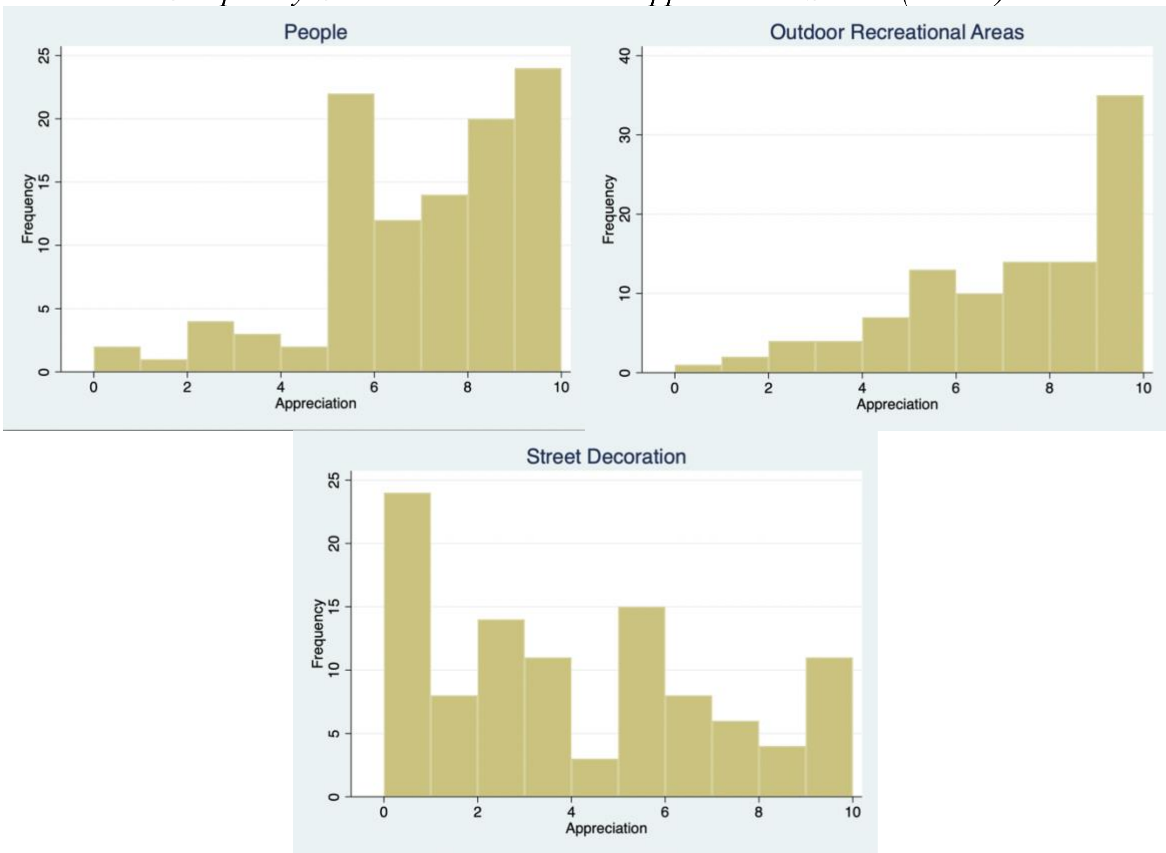




Human Scale Urban Form Features – Appreciation Scores (n=120)



Complexity Urban Form Features – Appreciation Scores (n=120)



Above it can be seen that the majority of these histograms are skewed left, meaning that most superblock residents rank their appreciation for these urban form factors quite highly. Bike Lanes, Bike Parking, and Car Parking don't fall into the same pattern, however, and show more polarized answers without a clear skew. These differences could be explained by bike or car ownership; a respondent's utility for these features is directly dependent on whether or not they own a car or bike, which in turn impacts (and polarizes) their appreciation for them. The scores for seeing People on the street has perhaps the most dramatic drop off, with 75% of respondents ranking it above a 5, although it only ranks 4th in terms of mean appreciation scores. So, in taking a closer look at the mean appreciation scores and their individual distributions, it becomes clear that trees, sidewalk width, outdoor recreational areas, people, street furniture, and sidewalk continuity (e.g. pedestrian-priority crosswalk) are the most appreciated urban form features with a leftwards skew, while certain other features such as bike lanes, car parking, and bike parking are less appreciated (and their appreciation is more irregularly distributed). This analysis answers the second sub-question "how much do residents appreciate (notice, care about, or enjoy) certain superblock urban form factors as they relate to the built form, complexity, and human scale?"

The third sub question is "How well does appreciation of these urban form factors (specifically built form, complexity, and human scale factors) predict modal choice?" Answering this question requires regression analysis, which is discussed below. First, regression analysis assumptions and conditions will be discussed to cover the methodology used, and later regression analysis results will be discussed.

4.6 Methodological Assumptions for Multiple Linear Regression

There are 8 key assumptions that must be met in order to successfully perform multiple linear regression. The first and second conditions are that the dependent variable and the independent variables must be measured on a continuous scale; these conditions are met in this research. There must also be independence of observations, or in other words the independent and dependent variables must be inherently independent from each other, which is also true of this research (and a primary reason why “appreciation” rather than “use” of urban form features was used). There must also be no significant outliers within the data; this condition is met.

Another condition is that there needs to be a linear relationship between the dependent variable and each of the independent variables as well as the dependent variable and the independent variables collectively. This was difficult to measure in this case because there was not a single dependent variable, but rather WKT by each modal choice as the dependent variable. This is a design flaw of the research and may have potentially impacted results. The data must also show homoscedasticity, or constant standard deviations around the line of best fit. This was another measure which is hard to visualize, and therefore assess, with so many measures for the dependent variable, showing another potential flaw in the research design. There are also conditions involving normality and multicollinearity, which will be discussed in further detail below.

A key condition for multiple linear regression is normality, or that the variables are normally distributed. So, the first step of data analysis is to check the variables for normality using a Shapiro-Wilk normality test on STATA. The results for appreciation of urban form features, or the independent variable, are shown below where Prob > 0.05 indicates a normally distributed variable:

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
app_sidewa~h	104	0.90448	8.150	4.664	0.00000
app_pedest~k	104	0.96339	3.123	2.532	0.00567
app_shared~e	104	0.98706	1.104	0.221	0.41264
app_bikela~s	104	0.98841	0.989	-0.025	0.50984
app_bikepa~g	104	0.99471	0.451	-1.769	0.96152
app_carpar~g	104	0.96894	2.650	2.166	0.01515
app_trees	104	0.91351	7.379	4.443	0.00000
app_planters	104	0.97173	2.411	1.957	0.02518
app_street~e	104	0.96327	3.133	2.539	0.00556
app_street~n	104	0.96908	2.638	2.156	0.01553
app_people	104	0.95923	3.478	2.771	0.00279
app_cars	104	0.97301	2.302	1.854	0.03187
app_outdoo~s	104	0.96205	3.238	2.612	0.00450

Figure 10: Shapiro-Wilk Test for Normality

This means that appreciation for Shared Space, Bike Lanes, and Bike Parking are normally distributed. The least normally distributed variables are appreciation for Sidewalk Width and appreciation for Trees, which are both skewed heavily to the left, implying that the large majority of people report appreciating them highly (as discussed above).

In terms of how to best use the information collected during the survey, the two dependent variable measures discussed above (frequency and distance) were combined to make analysis simpler. A new variable was created for each transportation mode called weekly kilometers travelled, or WKT_mode (e.g. WKT_Bus, WKT_Walking), by multiplying the self-reported average weekly trip frequency and self-reported average distance travelled per trip for each mode. However, when a Shapiro-Wilks normality test was done, none of the modes of transportation were normally distributed, an outcome which will be discussed in further detail below. The normality tests for the dependent variable, WKT, are even less normally distributed. The results are shown below:

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
WKT_bus	77	0.60337	26.385	7.156	0.00000
WKT_metro	69	0.63520	22.194	6.735	0.00000
WKT_PersBike	40	0.73987	10.282	4.904	0.00000
WKT_PersCar	60	0.82778	9.362	4.821	0.00000
WKT_PersSc~r	25	0.92950	1.959	1.375	0.08464
WKT_Shared~e	25	0.73687	7.311	4.067	0.00002
WKT_Share~ar	18	0.36676	13.919	5.271	0.00000
WKT~kScooter	2	.	.	.	.
WKT~dScooter	8	0.77166	3.181	2.194	0.01413
WKT_Tram	50	0.61440	18.135	6.180	0.00000
WKT_Walking	112	0.83650	14.844	6.021	0.00000

Figure 11: Shapiro-Wilk Test for Normality, WKT

In fact, every transportation mode was skewed heavily right, meaning that most of the respondents report traveling a low number of kilometers on average per week. The personal scooter variable provided the most interesting histogram, with an "inverse" normal distribution, where, although still skewed right, responses are clustered on either extreme (as shown below). This data suggests that of those that use a personal scooter, they either use them for very short or very long trips (the weekly kilometers travelled for Shared Scooters followed a similar pattern – either very low or very high, although with fewer observations).

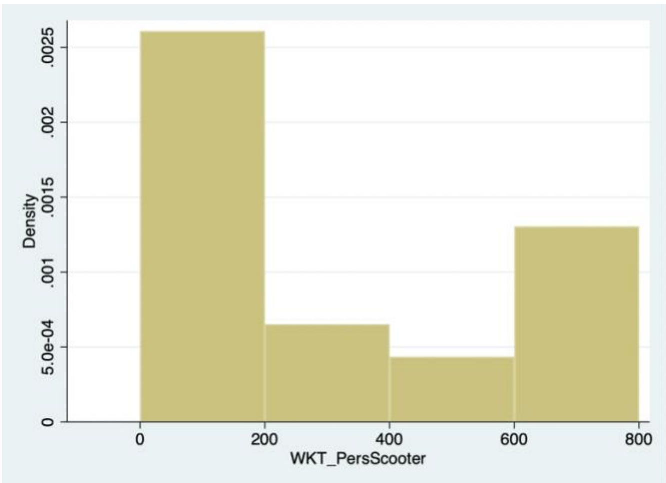


Figure 12: WKT Personal Scooter Histogram

Despite the lack of normality in the aforementioned variables, valid hypothesis testing using regressions can still be done, which will be discussed in more detail in the Conclusions on

Methodological Assumptions section below. The second assumption is a linear relationship between the independent and dependent variables (without outliers), which can be tested using scatterplots. This is also a way of testing for heteroskedasticity, or non-constant standard deviations. As discussed above, it was challenging to create scatterplots that encompassed each of the dependent and independent sub variables.

The third assumption is no multicollinearity, or high correlations between independent variables in a multiple regression model. The rule of thumb is an absolute correlation coefficient of 0.7; meaning any correlation equal to or greater than r=0.7 implies the presence of multicollinearity. A correlation table of the appreciation scores (the independent variables) below shows two instances of multicollinearity, delineated in red. The two cases are between appreciation for bike parking and bike lanes, which are logically highly positively correlated (r=0.77), and appreciation for trees and planters, which are also logically positively correlated (r-0.74). Therefore, these two sets of independent variables will not be included in the multiple regression analyses.

	app_si~h	app_pe~k	app_sh~e	app_bi~s	app_bi~g	app_ca~g	app_tr~s	app_pl~s	app_st~e	app_st~n	app_pe~e	app_cars	app_ou~s
app_sidewa~h	1.0000												
app_pedest~k	0.5294	1.0000											
app_shared~e	0.4843	0.5226	1.0000										
app_bikela~s	0.4586	0.4673	0.4272	1.0000									
app_bikepa~g	0.4370	0.4124	0.3565	0.7689	1.0000								
app_carpar~g	0.0214	-0.0561	0.0630	-0.1243	-0.0766	1.0000							
app_trees	0.3361	0.2823	0.3179	0.3299	0.2837	0.0672	1.0000						
app_planters	0.4478	0.3632	0.3685	0.3908	0.3635	0.0799	0.7422	1.0000					
app_street~e	0.3649	0.1959	0.3372	0.2959	0.3862	0.2199	0.5832	0.6947	1.0000				
app_street~n	0.3279	0.3398	0.4507	0.3952	0.4116	0.1516	0.3568	0.4412	0.4572	1.0000			
app_people	0.2251	0.2054	0.3905	0.3567	0.2343	-0.0431	0.3906	0.3896	0.3094	0.3995	1.0000		
app_cars	-0.2320	-0.1384	-0.1292	-0.2475	-0.1775	0.2918	-0.1358	-0.1411	-0.0623	-0.0456	0.0998	1.0000	
app_outdoo~s	0.5291	0.4894	0.5939	0.4499	0.4392	0.0384	0.4544	0.5012	0.4987	0.4954	0.4361	-0.1728	1.0000

Figure 13: Correlation Table for All Urban Form Factor Appreciation Scores

4.7 Conclusions on Methodological Assumptions for MLR

This section will provide evidence for the validity of doing regression analysis on non-normal variables. In the case of this research, answers are continuous, rather than interval. However, this continuous data was measured in the same way as Likert scale data (e.g. on a slider), which can never be normal. There has been some debate in the scientific community as to whether ordinal data can be treated as interval data when it is converted to numbers (Sullivan & Artino, 2013). Dr. Geoff Norman, who is a world leader in research methodology, has studied this question at length. He concludes that parametric tests (tests that make assumptions about the parameters of the population distribution from which the sample is drawn) can be used with ordinal data (such as Likert data), and furthermore that they are more robust than nonparametric tests (Sullivan & Artino, 2013). His work builds on an earlier review on the "laws" of statistics by Geoff Norman (2010), which found that "parametric tests tend to give 'the right answer' even when statistical assumptions—such as a normal distribution of data—are violated, even to an extreme degree. Thus, parametric tests are sufficiently robust to yield largely unbiased answers that are acceptably close to "the truth" when analyzing Likert scale responses" (Sullivan & Artino, 2013). Therefore, despite the lack of normality in some of the variables in this research, there is sufficient evidence that valid regression analysis can still be run with non-normal variables. As such, regression analysis can still be performed on this data set. The chosen methods of analysis are ANOVA (analysis of variance) and multiple linear regression.

4.8 Testing for Gender Differences using ANOVA

ANOVA testing was used to determine whether there were statistically significant differences between the means of two groups. In ANOVA testing, the dependent variable is continuous, the independent variable needs to be categorical. Gender is a categorical variable, so gender differences were tested using one-way ANOVA's for the urban form appreciation scores, WKT (weekly kilometers travelled) per each mode, and the sustainability and mobility attitudinal questions. None were statistically significant except appreciation for shared space, where p=0.038 and the mean male appreciation score was 6.6, while the mean female score with 5.3. It is interesting that the male mean is higher than the female mean, as women and children tend to be the intended users, or beneficiaries, of shared space. This is based off the historical assumption that women are caretakers and spend more time at home and in public while men are at work. However, this result further adds credence to the fact that inclusive urban design is appreciated, and used, by everybody.

4.9 Urban Form and WKT Hypothesis Testing using MLR Analysis

Regression analysis allows us to understand what the relationship is between two variables, to see whether or not it is significant, and if so, to estimate the strength of the independent variable's effect on the dependent variable. This can be done with continuous variables, which in this case are appreciation for urban form feature scores and weekly kilometers travelled (WKT) per mode. In this case multiple regression analysis will be performed, which sets out to uncover the relationship between a dependent variable and *multiple* independent variables. The below regression tables show multiple regressions for each modal choice (as the dependent variable) against each urban form factor appreciation variable (excluding bike parking and planters, as those two variables presented collinearity problems with bike lanes and trees, respectively). Age and income were included as controls. The results are as follows:

<u>WKT - Personal Car</u>

Hypothesis*:* *Appreciating urban form features related to superblocks will predict a decrease in WKT by personal car.*
Results*:*

WKT_PersCar	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
app_sidewalk_width	16.26458	18.05083	0.90	0.373	-20.27742	52.80659
app_pedestrianprioritycrosswalk	-9.061174	13.29149	-0.68	0.500	-35.96839	17.84605
app_sharedspace	27.54315	12.94721	2.13	0.040	1.332898	53.7534
app_bikelanes	-16.29868	12.33772	-1.32	0.194	-41.27509	8.677728
app_carparking	24.4919	11.52167	2.13	0.040	1.167504	47.8163
app_trees	8.898471	15.24594	0.58	0.563	-21.96533	39.76227
app_streetfurniture	13.14599	18.00215	0.73	0.470	-23.29747	49.58945
app_streetdecoration	-11.69081	10.71637	-1.09	0.282	-33.38497	10.00335
app_people	-19.73243	16.43541	-1.20	0.237	-53.00418	13.53931
app_cars	13.54455	14.73627	0.92	0.364	-16.28747	43.37657
app_outdoorrecreationareas	1.373844	18.67215	0.07	0.942	-36.42595	39.17364
age	-2.194941	3.455268	-0.64	0.529	-9.189766	4.799884
gross_annual_income	.0103586	1.560406	0.01	0.995	-3.148519	3.169236
_cons	-22.29324	191.4989	-0.12	0.908	-409.9625	365.376

Significant Result #1: Shared Space
P-Value: 0.040
Significance level: 5%
Interpretation: A one-unit increase in appreciation scores for shared space is associated to a 27.54-kilometer increase in weekly kilometers traveled by personal car (all else held constant).
Analysis: This finding is surprising and may indicate that drivers enjoy feeling like they're driving through a neighborhood that is visually complex and accessible for everyone, rather than one that is strictly car-dominated.

Significant Result #2: Car Parking
P-Value: 0.040
Significant level: 5%
Interpretation: A one-unit increase in appreciation scores for car parking is associated to a 24.49-kilometer increase in weekly kilometers traveled by personal car (all else held constant).
Analysis: This finding is logical and to be expected given the need for car parking for use of personal cars.

WKT – Personal Bike

Hypothesis*:* *Appreciating urban form features related to superblocks will predict an increase in WKT by personal bike.*
Results*:*

WKT_PersBike	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
app_sidewalk_width	34.20943	28.38184	1.21	0.241	-24.65091	93.06978
app_pedestrianprioritycrosswalk	3.910687	23.36347	0.17	0.869	-44.54218	52.36356
app_sharedspace	12.19535	17.36962	0.70	0.490	-23.82703	48.21773
app_bikelanes	-81.86764	24.00569	-3.41	0.003	-131.6524	-32.08288
app_carparking	-43.60956	17.54131	-2.49	0.021	-79.98801	-7.231107
app_trees	39.53555	26.05822	1.52	0.143	-14.50588	93.57699
app_streetfurniture	3.239962	28.63794	0.11	0.911	-56.1515	62.63142
app_streetdecoration	6.783785	14.3274	0.47	0.641	-22.92943	36.497
app_people	19.42476	21.2285	0.92	0.370	-24.60047	63.44998
app_cars	14.58446	13.44384	1.08	0.290	-13.29637	42.46528
app_outdoorrecreationareas	-28.75062	19.56243	-1.47	0.156	-69.32063	11.81938
age	-4.702424	4.605497	-1.02	0.318	-14.25364	4.848793
gross_annual_income	-1.469708	1.804127	-0.81	0.424	-5.211238	2.271822
_cons	523.1256	252.8131	2.07	0.050	-1.176756	1047.428

Significant Result #1: Bike Lanes
P-Value: 0.003
Significance level: 1%
Interpretation: A one-unit increase in appreciation scores for bike lanes is associated to a 81.87-kilometer decrease in weekly kilometers traveled by personal bike (all else held constant).
Analysis: ****Nonsensical – no relevant analysis****

Significant Result #2: Car Parking
P-Value: 0.021

Significance level: 5%
Interpretation: A one-unit increase in appreciation scores for car parking is associated to a 43.61-kilometer decrease in weekly kilometers traveled by personal bike (all else held constant).
Analysis: **Nonsensical – no relevant analysis**

WKT – Personal Scooter

Hypothesis*: Appreciating urban form features related to superblocks will predict a decrease in WKT by personal scooter.*
Outcome: No significant results.

WKT – Shared Bike

Hypothesis*: Appreciating urban form factors related to superblocks will predict an increase in WKT by shared bike.*
Outcome: No significant results.

WKT – Shared Car

Hypothesis*: Appreciating urban form factors related to superblocks will predict a decrease in WKT by shared car.*
Outcome: No significant results.

WKT – Tram

Hypothesis*: Appreciating urban form factors related to superblocks will predict an increase in WKT by tram.*
Results*:*

WKT_Tram	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
app_sidewalk_width	1.56002	8.341553	0.19	0.853	-15.50037	18.62041
app_pedestrianprioritycrosswalk	4.099272	5.742564	0.71	0.481	-7.64559	15.84413
app_sharedspace	-8.089934	6.423438	-1.26	0.218	-21.22734	5.047472
app_bikelanes	13.75917	5.899599	2.33	0.027	1.693133	25.8252
app_carparking	4.953774	4.778868	1.04	0.308	-4.820109	14.72766
app_trees	5.89858	6.379475	0.92	0.363	-7.14891	18.94607
app_streetfurniture	-2.474566	6.883047	-0.36	0.722	-16.55198	11.60285
app_streetdecoration	-6.019619	4.853931	-1.24	0.225	-15.94702	3.907784
app_people	6.782658	6.372109	1.06	0.296	-6.249767	19.81508
app_cars	1.066216	6.022337	0.18	0.861	-11.25085	13.38328
app_outdoorrecreationareas	-15.43072	7.410481	-2.08	0.046	-30.58686	-.2745871
age	2.826512	1.249133	2.26	0.031	.2717491	5.381275
gross_annual_income	-1.037539	.5939769	-1.75	0.091	-2.252358	.1772806
_cons	-88.44728	76.07263	-1.16	0.254	-244.0333	67.13872

Significant Result #1: Bike Lanes
P-Value: 0.027
Significance level: 5%

Interpretation: A one-unit increase in appreciation scores for bike lanes is associated to a 13.76-kilometer increase in weekly kilometers traveled by tram (all else held constant).
Analysis: This finding could suggest that people who appreciate bike lanes enjoy seeing bikers on the street and the visual complexity that bike lanes bring, so they take the tram to be able to enjoy these urban scenes.

Significant Result #2: Outdoor recreational areas
P-Value: 0.046
Significance level: 5%
Interpretation: A one-unit increase in appreciation scores for outdoor recreational areas is associated to a 24.46-kilometer decrease in weekly kilometers traveled by tram (all else held constant).
Analysis: This finding perhaps suggests that the more superblock residents appreciate street decoration, the more they want to be on the street enjoying the visual complexity and therefore take the tram, which travels through the street in a more environmentally friendly way than cars.

<u>WKT - Walking</u>

Hypothesis*:* *Appreciating urban form factors related to superblocks will predict an increase in WKT by foot.*
Outcome: No significant results.

<u>WKT – Bus</u>

Hypothesis*:* *Appreciating urban form factors related to superblocks will predict an increase in WKT by bus.*
Outcome: No significant results.

<u>WKT – Metro</u>

Hypothesis*:* *Appreciating urban form factors related to superblocks will predict an increase in WKT by metro.*
Results*:*

WKT_metro	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
app_sidewalk_width	-9.337669	13.43144	-0.70	0.490	-36.35825	17.68291
app_pedestrianprioritycrosswalk	7.683726	9.9607	0.77	0.444	-12.35462	27.72207
app_sharedspace	11.37454	11.29786	1.01	0.319	-11.35382	34.1029
app_bikelanes	-7.74266	9.021872	-0.86	0.395	-25.89233	10.40701
app_carparking	-5.137824	8.790316	-0.58	0.562	-22.82166	12.54601
app_trees	-9.976811	11.97005	-0.83	0.409	-34.05745	14.10383
app_streetfurniture	21.42236	11.97542	1.79	0.080	-2.66908	45.5138
app_streetdecoration	-5.013344	9.124881	-0.55	0.585	-23.37024	13.34355
app_people	26.80464	11.92105	2.25	0.029	2.822588	50.7867
app_cars	-3.142558	11.09639	-0.28	0.778	-25.46561	19.18049
app_outdoorrecreationareas	-28.06486	12.87122	-2.18	0.034	-53.95842	-2.171306
age	1.5941	2.463363	0.65	0.521	-3.361547	6.549746
gross_annual_income	-.994961	1.086609	-0.92	0.365	-3.180937	1.191015
_cons	69.12019	139.7751	0.49	0.623	-212.0711	350.3115

Significant Result #1: People
P-Value: 0.029
Significance level: 5%
Interpretation: A one-unit increase in appreciation scores for seeing people on the street is associated to a 26.8-kilometer increase in weekly kilometers traveled by metro (all else held constant).
Analysis: This could perhaps mean that people-watching is a driver of metro usage, as people enjoy the visual complexity of observing and watching others on their way to (and perhaps also on) the metro.

Significant Result #2: Outdoor Recreational Areas
P-Value: 0.034
Significance level: 5%
Interpretation: A one-unit increase in appreciation scores for outdoor recreational areas is associated to a 28.1-kilometer decrease in weekly kilometers traveled by metro (all else held constant).
Analysis: This could be because superblock residents who appreciate outdoor recreational areas prefer instead to take above-ground forms of transport so that they can enjoy the visual complexity of these areas rather than being underground on the metro.

Regressions were also run to see if household size, number of children, number of household bikes, number of household cars, size of household and the sustainability and mobility attitudinal questions had significant effects on modal choice, but no significant results emerged.

Chapter 5: Conclusions and discussion

To recap, this study set out to examine whether urban form features can predict modal choice in superblock residents. More specifically, it was aiming to uncover whether appreciation of superblock urban form factors as they relate to the built form, complexity, and human scale can predict modal choice in superblock residents within the context of Barcelona. There were three sub questions that were designed to help answer the above question, which were 1) which modes of transport are most popular among superblock residents and why?; 2) how much do residents appreciate (notice, care about, or enjoy) certain superblock urban form features as they relate to the built form, complexity, and human scale?; and 3) how well does appreciation of these urban form features (specifically built form, complexity, and human scale factors) predict modal choice?

The hypotheses underlying this research were that appreciating certain superblock urban form factors, such as wide sidewalks or being able to watch people on the street, would be associated with, or predict, higher weekly kilometers traveled on active modes of transport such as walking or biking. The idea that implementing superblocks could change modal choice patterns and encourage sustainable mobility in the future was the grounding idea behind this research. It would have been interesting to study the superblock as an intervention in modal choice (e.g. ask residents if the implementation of the superblock impacted a change in their transportation habits), but this type of information is extremely difficult to gather. It would require finding people who have lived in the same area during for a long time and who could objectively remember their exact travel habits from years ago to appropriately gather "before' and "after" data. As such, this route for investigation was discarded in favor of the urban form feature appreciation route.

Fortunately, the survey was able to gather much data on the first two sub questions. In reviewing the analysis above, it can be concluded that superblock residents are already quite active, opting for walking and biking as their most-used daily modes of transport. This implies that Barcelona's efforts to make it a walkable city have indeed paid off. There are also other factors such as generally good weather and flat terrain which make walking and biking attractive choices. However, the third most used daily mode of transport is the personal car, which presents a big opportunity area for Barcelona to address through the continued implementation of superblocks, improvement of alternative public transport choices, and relevant policy changes. Examples could include subsidizing on-demand first-and-last-mile bus and van solutions. Given respondents' enjoyment rankings, this solution seems plausible. They ranked the bus as the third *most* enjoyable form of transport, and the personal car as the third *least* enjoyable mode of transport, indicating that they would be willing to change travel behavior patterns in this direction if it didn't mean sacrificing flexibility and time. Shifting their commute from sitting in a car alone to being able to relax on a metro then bus would also increase the amount of productive time they have in their day. These solutions should be considered by the municipality of Barcelona.

In terms of conclusions that we can draw about which superblock urban form features are most appreciated by superblock residents, trees and sidewalk width are the winners (although there were other features that were ranked very highly as well). Trees being the top choice is not surprising – humans are biophilic by nature and gain numerous benefits to proximity to greenery, as discussed in the literature review. They also help with heat, pollution, and noise (also discussed above), and are thus a multi-faceted solution for many urban ills. Sidewalk width as the second choice speaks to the very core of what superblocks are, namely reducing street space for cars and giving that space back to people for a variety of purposes. These results could help shape future superblocks, 504 of which are planned to be implemented in Barcelona, by helping prioritize the features which are most appreciated by residents and de-prioritize those which are less useful for them.

Unfortunately, however, the regression analysis which was designed to answer the third sub question delivered results which were largely inconclusive and, in some cases, counterintuitive. Therefore, convincing conclusions cannot be drawn from this data set about whether or not superblock urban form factors influence, or predict, modal choice in people who live in or near superblocks. This is partially due to the design of the research and the fact that there was not a single dependent variable, but rather a set of dependent variables of WKT per modal choice. This complicated the analysis and made it difficult to verify the necessary conditions for multiple regression analysis. Also, some of the control variables were categorical rather than continuous which also further complicated the regression analysis, and some that were continuous (such as number of cars, bikes, and people per household) were not accepted in the regression because of their low variability.

It would have been interesting to have significant results by gender, age, income, parental status, household size, and number of cars and/or bikes in the household, as this would have given clues about how people experience certain superblock features and thus how their modal choices are influenced by them. This knowledge would be incredibly useful to help design superblocks of the future in Barcelona and beyond, as well as to help garner support for them in political and social spheres.

Similarly, it would have been interesting to have statistically significant differences between attitudinal statements to understand whether or not people who report caring about sustainability and sustainable mobility are more likely to actually show this in their modal usage, or to report higher weekly kilometers travelled on active or public modes of transport. This knowledge would have been useful to help understand how society and culture impact modal choice and would have provided clues on how to best approach changing behaviors towards more sustainable mobility patterns.

In conclusion, there needs to be further research on the question of to what extent perceptual qualities such as those outlined by Ewing & Handy (2009) impact modal choice. Although the limitations on the gathering the ideal types of data for this research which were discussed above still stand, further research should find innovative ways of measuring the impact of urban form on modal choice. Perhaps a group of people who live in an area with a planned urban design intervention can be followed and periodically surveyed on their transportation choices for months leading up to the intervention, and then months (or years) after the intervention. This would help isolate the effect of the urban design intervention and would help uncover useful information on how urban form features impact modal choice, keeping all else constant. In the absence of such a scenario, important questions to be asked are: are there better, more efficient ways of measuring appreciation for urban form? How can researchers effectively gather this type of information, which is often sub-consciously processed?

Furthermore, there needs to be more research that can integrate the three approaches to studying modal choice as outlined by Hollevoet et al. (2011). The three approaches are the rationalist, socio-graphical, and psychological approaches. To recap, the rational approach is the "mainstream" approach and assumes that travelers make decisions based on maximizing their utility by minimizing travel time and costs. It is a microeconomic approach that assumes perfectly rational behavior and does not leave much space for subjective factors. The socio-geographical approach explicitly includes spatial components into modal choice and views this choice from the perspective of derived demand for travel as it relates to the social activities they must pursue that are distributed in time and space. The present research used Quian et al. (2018)'s travel purpose typology, namely "commuter (go to work)" travel, "utilitarian (go-to-store)" travel, and "recreational (strolling)" travel, to classify the socio-geographical component of this research. Lastly, the psychological approach explains modal choice through individual attitudes as well as concepts such as intentions and habits (Hollevoet et al. 2011). The present research used self-reported appreciation as well as a series of attitudinal questions to address the psychological element of modal research.

This research falls somewhere in between the socio-geographical and psychological approaches, but would have benefitted from rationalist inputs. Perhaps such inputs would have made the analysis stronger and helped produce more concrete findings and conclusions. Although designing research that encompasses variables from all three of these approaches would be a massive undertaking, it would also provide a holistic view on all the elements that influence modal choice. Findings from this type of research would have practical relevance in a variety of settings, but especially in the further implementation of superblocks.

Regardless of the fact that the results were not conclusive, the small sample size and non-normality of variables suggest that the findings would not have been generalizable anyway. However, this study is still useful in terms of better understanding which modes of transport are most popular among superblock residents, which ones are most enjoyable according to superblock residents, and how often and how far they travel on each mode of transport. There is also qualitative insights about *why* they like each mode of transport, which helps support the numerical findings.

These findings can help point further studies in the right direction. Practical suggestions and recommendations for further research include surveying superblock daily car users on how to best address their needs and provide attractive alternatives. Making these residents feel heard and helping solve their pain points would help move forward the superblock vision, as the biggest blockers to adoption for this low-cost, tactical urbanism intervention are those that protest the implementation of superblocks because of increased traffic and inconveniences to their daily routines. Addressing the needs of all different mobility subtypes as identified by Stojanovski (2019), but in this case especially the car-enthusiasts and car-dependent Superblock protestors, is an important piece of the puzzle to solve to continue on the quest for sustainable, happy, healthy urban development through the implementation of superblocks in Barcelona and beyond.

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Annex 1

A. Perceptual Qualities (Ewing & Handy, 2009)

The 51 listed urban design perceptual qualities that impact walkability:

Table 1. Perceptual qualities

adaptability	distinctiveness	intricacy	richness
ambiguity	diversity	legibility	sensuousness
centrality	dominance	linkage	singularity
Clarity	enclosure	meaning	spaciousness
coherence	expectancy	mystery	territoriality
compatibility	focality.	naturalness	texture
comfort	formality	novelty	transparency
complementarity	human scale	openness	unity
complexity	identifiability	ornateness	upkeep
continuity	imageability	prospect	variety
contrast	intelligibility	refuge	visibility
deflection	interest	regularity	vividness
Depth	intimacy	rhythm	

B. Survey [English Version]

Hello and thank you for opening this survey. **It will take you between 3-5 minutes** to complete**.** It is available in Spanish, Catalan, and English. You may choose your language in the top right corner of this page.

This survey is being used to collect data for my Master's thesis at the Institute of Housing and Urban Development Studies of Erasmus University in Rotterdam. My research is about superblocks and mobility in Barcelona. If you have any questions, please contact me (Megan Jasson) at 590200mj@eur.nl.

Please share this survey with fellow neighbors and friends who also live in superblocks using the link in your browser! The more responses it gets, the more reliable the data will be.

Responses are completely anonymous and the data collected will be used in compliance with GDPR regulations.

Thank you for your time!

Do you live inside or near a Superblock? (https://ajuntament.barcelona.cat/superilles/en/)

○ Yes, inside

○ Yes, near

○ No, but I live in Barcelona

---

2. Please select the mode of transport you use most often in your daily life (for any purpose).

○ Walking

○ Biking

○ Scooter/moped/kickscooter

○ Bus

○ Metro

○ Tram

○ Personal car

○ Taxi

3. Please select the modes of transport you most enjoy, regardless of how often you use them. You may select more than one.

- [ ] Walking
- [ ] Biking
- [ ] Scooter/moped/kickscooter
- [ ] Bus
- [ ] Metro
- [ ] Tram
- [ ] Personal car
- [ ] Taxi

---

4. Please explain what you like about the mode (or modes) of transport that you chose above.

____

---

5. Please fill in an estimate of how many times per week (on average) you use each mode of transport. If you don't use a certain mode of transport, you may click "Not Applicable".

	Not Applicable 0 5 10 15 20
Walking	
Biking (personal bike)	
Biking (shared, e.g. Bicing)	
Scooter (moped, personal)	
Scooter (moped, shared e.g. Yego, Muving)	
Kick scooter (shared, e.g. Reby)	
Bus	
Metro	
Tram	
Car (personal)	
Car (taxi, ride-hailing, or ride-sharing e.g. Cabify)	

6. Now please estimate how many kilometers you travel on average per trip for each mode of transport. If you do not use a certain mode of transport, you may click "Not Applicable".

	Not Applicable 0 4 8 12 16 20 24 28 32 36 40
Walking	
Biking (personal bike)	
Biking (shared, e.g. Bicing)	
Scooter (moped, personal)	
Scooter (moped, shared e.g. Yego, Muving)	
Kick scooter (shared, e.g. Reby)	
Bus	
Metro	
Tram	
Car (personal)	
Car (taxi, ride-hailing, or ride-sharing e.g. Cabify)	

7. In general, what do you usually use each mode of transportation for?

	Commuter Travel (going to work)	Utilitarian Travel (shopping, appointments, social)	Recreational Travel (leisure, exercise)	Not Applicable
Walking	○	○	○	○
Biking (personal bike)	○	○	○	○
Biking (shared, e.g. Bicing)	○	○	○	○
Scooter (moped, personal)	○	○	○	○
Scooter (moped, shared e.g. Yego, Muving)	○	○	○	○
Kick scooter (shared, e.g. Reby)	○	○	○	○
Bus	○	○	○	○
Metro	○	○	○	○
Tram	○	○	○	○
Car (personal)	○	○	○	○
Car (taxi, ride-hailing, or ride-sharing e.g. Cabify)	○	○	○	○

Section 2/3. These questions are about living in your neighborhood.

8. On a scale of 0 (least) to 10 (most), please rank how much you appreciate the following features of the street. By "appreciate" I mean how much you notice, care about, and/or enjoy them.

	0 1 2 3 4 5 6 7 8 9 10
Sidewalk width (how wide the sidewalk is)	
Pedestrian-priority crosswalks (when you don't have to wait for a cross signal to cross the street)	
Shared Space (public space on the street that is meant for everybody – older people, younger people, pedestrians, skateboarders, cyclists, etc.)	
Bike lanes (the presence of bike lanes)	
Bike parking (having places to comfortably and safely park your bike)	
Car parking (having car parking easily available)	
Trees (along the street)	
Planters (structures that are added to the street that have plants or trees in them)	
Street furniture (benches, stools)	
Street decoration (painting on the pavement)	
People (seeing people on the street)	
Cars (seeing cars on the roads)	
Outdoor recreational areas (playgrounds, courtyards, plazas, parks, outdoor dining)	

9. To what extent do you agree with the following statements? (1=not at all, 3=neutral, 5=agree strongly)

	1	2	3	4	5
I feel proud to be a Barcelona resident					
I care about sustainability					
I make conscious efforts to make sustainable choices in my life					
I think my mobility choices are an expression of my beliefs about sustainability					
I think living in or near a Superblock impacts my mobility choices					

End of Block: Living in your Neighborhood

Start of Block: General Information

Section 3/3. This is the last section, which will ask you for general demographic information.

10. What is your gender?

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer not to say

11. How old are you?

____

12. Please give an approximation of your gross annual income (in thousands)

	0	10	20	30	40	50	60	70	80	90	100
Euros/year (0k-100k)											

13. How many children do you have? If none, please enter "0".

____

14. How many people live in your household? If you live alone, please enter "1".

____

15. How many bicycles does your household have? If you don't have any bicycles, please enter "0".

____

16. How many cars does your household have? If you don't have any cars, please enter "0".

____

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