Urban accessibility: Balancing land use and transportation

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0. Executive Summary

In this paper, we examine the importance, theoretical understanding, and empirical measurement of urban accessibility. Drawing on examples from poor, rich, and intermediate-income cities, we argue that accessibility is the main urban quantity to consider from a resource allocation standpoint since it links land use and transportation, the two primary urban consumption goods. Despite the importance of accessibility, a sparsity of empirical knowledge about accessibility and a disconnect between policymaking and accessibility outcomes have led many researchers to retreat into narrow areas of expertise—such as land use, housing, or transportation treated in isolation—and many urban policymakers to ignore accessibility altogether. Even when data are good, the politics of land use and transportation decisions rarely favors accessibility as an important policy outcome. As a result, urban policies often fail to allocate land use or transportation either efficiently or equitably.

Throughout the paper, we make two basic calls. The first is to put accessibility more squarely at the center of the study of urban development. The second is to focus urban policymaking more directly on specific problems, such as congestion, pollution, and traffic fatalities. Despite the need for better knowledge and practice, we argue for a modest change of course, rather than a radical shift in how cities are studied and managed, however. The externalities associated with transportation and urban development are subtle and interact with each other through many feedback mechanisms. Doing nothing to improve urban accessibility is not a desirable option, but doing something is hard.

[1] We are grateful to Robin Lindsey for comments and his help with some of the references, to Tanner Regan for producing new figures for Nairobi, and to Jeff Guttman for some feedback on an earlier version.

Nevertheless, we are hopeful that a better balance for research and a better balance for policy practice will bring urban research and practice closer together. The remainder of this executive summary briefly touches on the key elements of each section of the paper.

Some facts about transportation and housing

Urban accessibility matters. In the United States, Latin America, Europe, urban residents dedicate nearly half of their spending on housing and transportation. They also dedicate a substantial proportion of their waking hours to travel, particularly in large cities like New York and Mexico City. While the general finding is that households spend a large portion of income on housing and transportation holds in most places, including many poor parts of the world, aggregate figures hide considerable heterogeneity and systematic differences in the amount of time spent traveling by age, gender, and city size. In poorer cities, for example, the poorest households sometimes spend substantially less on housing and transportation. However, this is often by consuming extremely little housing and living on lands with uncertain legal title that are also vulnerable to natural disasters like flooding or mudslides. These poor residents are willing to pay an extremely high non-monetary price for good accessibility.

Setting the scene: urban development and urban travel

The trade-off between housing and transportation costs is central to the earliest models of urban form in idealized cities and the most recent integrated transportation and land use models of actual cities. Although both types of models provide useful frameworks for understanding development patterns and the potential effects of land use and transportation policies, there are numerous challenges to incorporating real-world complexities into these modeling frameworks. In particular, it is difficult to model accurately the simultaneous location of firms and households, the relative importance of different types of land uses in firm and household decisions, the variety of transportation options, the heterogeneity in firm and household preferences, the role of land use regulation, the effect of new infrastructure, or the legacy of older infrastructure and building forms. There may also be differences between developed and developing cities that vary in nature and not only in degree. Each additional element of real-world complexity adds more nuance to the models but obscures the nature of the tradeoffs between transportation costs, housing, and other land uses.

Measuring Accessibility

Using this framework, measuring accessibility—which we define simply as the ease of reaching destinations—becomes conceptually, as well as empirically challenging. At its simplest, a labor market measure of accessibility might count the total number of jobs accessible to a place or person within a fixed time and by a fixed mode under typical travel conditions. More complicated measures weigh accessibility indices by job type, time of day, and distance. However, at its heart, accessibility is an individual concept. To take an extreme example, proximity to a butcher shop does factor into accessibility for vegetarian households. It is also a relative concept. People rarely go to the closest restaurant, attend the closest religious institution, or work at the closest job. While ad-hoc measures of accessibility such as walk scores are fast becoming more available and may be informative, they still constitute deeply unsatisfactory measures of accessibility. On the other hand, more theoretically and empirically robust measures that incorporate multiple trip purposes, travel modes, and user preferences are still out of reach and unlikely to be commonly used anytime soon. That accessibility is a hard concept that is often poorly understood and always poorly measured is an obvious obstacle to sound urban development policies. As a result, different people end up meaning different things when they talk about accessibility and end up talking past each other.

Policy challenges and implications

Partially as a result, accessibility plays little role in day-to-day investment or policy decisions. The complexity of defining and measuring accessibility make it a difficult metric for assessing policy and make it somewhat abstract and hardly pressing. Voters and policymakers have a much more personal connection to whether they have an easy time finding parking, whether housing is too expensive, and whether the trains come on time. Furthermore, different pieces of the accessibility puzzle resonate quite differently with different groups of people and individuals. While it is tempting to suggest that planning for accessibility requires a holistic approach, since accessibility is conceptually and empirically complex, this approach would like backfire since it is difficult, perhaps impossible to decide on an optimal accessibility level, let alone measure it. Instead we argue that policy makers consider whether policies, plans, investments, and regulations will tend to increase or decrease accessibility at the margin through the examples of providing appropriate space for transportation, investing in transit, evaluating the transportation impacts of new land uses, providing affordable housing, and dealing with congestion.

1. Introduction

We argue that accessibility is the main urban quantity to consider from a resource allocation standpoint since it links the two primary urban consumption goods: land use and transportation. As we document below, households in many countries devote about half of their spending to housing and transportation. Unfortunately, conceptualizing and measuring urban accessibility is difficult and depends on limited data. Even when data are good, the politics of land use and transportation decisions rarely favors accessibility as an important policy outcome. In particular, a limited understanding of the accessibility impacts of land use or transportation policy and a failure to acknowledge the importance of these impacts lead to poor urban policies that fail to allocate the two primary urban consumption goods either efficiently or equitably.

More specifically, urban transportation infrastructure is a congestible public good and commercial development, firm location, and household location decisions are also subject to externalities. A household's decision to move to a neighborhood directly affects the well-being of its neighbors through social interactions, peer effects, or investments that this household may or may not make in its house. Household location decisions have equally real but less direct implications on their neighbors through the schooling system or because of their influence on public services. The fiscal impacts of new construction depend on the cost of providing new services offset by new revenues. Whether the net fiscal impact is positive depends almost entirely on the presence of school-aged children, the assessed property value, and any fees that may be charged upfront for new developments.

While the fiscal impacts of new residents often lead to heated debates, they are only a part of the net economic impact. New residents also influence the character of a place. Households often select neighborhoods to be closer to like-minded people and may resent changes in the ethnic, racial, or political composition of where they live. At its worst, this leads to explicit, but more commonly implicit, regulations to keep out other types of people. Finally, location decisions also affect road congestion and, in some instances, the quality and quantity of public transport provision. These political forces and economic externalities lead to suboptimal and often inequitable outcomes, which in turn call for corrective policies that we refer to broadly as urban planning. As the situation of some developing cities show, the absence of urban planning can lead to disastrous outcomes.

While doing nothing is not a desirable option, doing something that is worthwhile is hard. The externalities associated with transportation and urban development are subtle and interact with each other through many feedback mechanisms. A new road will influence household and firm location decisions, which may, in turn, affect the demand for travel and further road investment decisions. Each urban policy will have multiple direct and indirect effects on accessibility. For instance, we expect that an increase in fuel taxes will decrease property values in the periphery, increase central density, decrease driving rates, and increase transit use. How much and precisely where these changes will happen and what secondary effects they will have—like pushing poorer and more transit-reliant households out of the center—are uncertain and difficult to quantify.

The sparsity of our empirical knowledge on many of these interactions has led many researchers, not to mention practitioners, to retreat into narrow areas of expertise. To caricature only slightly, land use specialists deal exclusively with land use, transportation planners focus only on transportation, and housing specialists only think about shelter. Without much integrated understanding and knowledge to rely on, urban planners also often make far-reaching decisions based on esthetic and ideological grounds rather than evidence. Empirically-based rules of thumb, where they exist, may give an air of credibility but often lack a serious empirical foundation or a clear understanding of the likely effects of the policy. For example, minimum parking requirements and front-yard setbacks have far-reaching impacts on transportation and land use, but are neither empirically justified nor well understood. The effects of esthetically-based rules, such as all houses should have front porches or back-entrance parking, are equally poorly understood. Knowledge about urban development is piecemeal and disjointed whereas the practice of urban planning is either overly precise—as with number of required parking spaces per chair in a barbershop vs. a beauty salon—or holistic and all-encompassing—as with movements like new urbanism, or, before that, modernism.

We would like to change this balance. In what follows, we make two calls. The first is to put accessibility at the center of our thinking about urban development. Because it links land use, housing, and transportation, a greater focus in urban research on accessibility will help avoid the balkanization of urban knowledge. Quite obviously, we do not negate the importance of specialist knowledge but researchers too often take the path of least resistance, which has led connected subfields of investigation to become disconnected. We do not propose that research on urban development should always consider land use, housing, and transportation, together. Instead, we would like the cursor to shift back towards a better middle where integrated and specialist knowledge would interact more fruitfully.[2]

Our second recommendation is to call for a more direct approach to urban policy-making that focuses on specific problems. For instance, we fully accept that transportation by private motorized vehicles generates large social costs in cities through congestion, pollution, and traffic fatalities. To curb these costs, the best solution is not to affect mobility indirectly through land use policies—whether minimum lot sizes or density bonuses—or transportation investments—whether in roads, transit or bike lanes—but directly by focusing more specifically on the harm caused. If the problem is congestion, congestion should be addressed directly as we discuss below.

Of course, it must be acknowledged that improvements along one dimension or geographic scale may cause harm along another. For example, traffic-calming will tend to improve traffic safety, but will likely increase congestion and probably also pollution, if slower speeds are not offset by shifts from cars to walking or biking. Minimum lot sizes and neighborhood cul-de-sacs may improve local congestion, air-quality, neighborhood safety, and property values, but almost certainly increase total driving and worsen metropolitan congestion, air-quality, safety, and housing affordability. We also recognize that the support and opposition for specific policies often come from a wide array of different types of people with a wide variety of interests and motivations. It is unrealistic to assume that metropolitan accessibility is ever going to matter more to local voters than local school quality.

Nevertheless, moves to focus planning solutions more directly on planning problems will tend to improve planning quality at the margin. Hence, we advocate an approach where urban planning should use direct instruments to focus on the main distortions in transportation and land use markets. We do not, however, defend or advocate a complete reversal of current, somewhat holistic, policy practices. Not only is this politically unrealistic, but the blind application of one instrument (like a tax for vehicle-kilometers travelled or land use deregulation) to solve one problem (like congestion or housing affordability) may worsen other problems. Again, we want to shift the cursor, not swing the pendulum to another undesirable extreme. A better balance for research and a better balance for policy practice will also bring the research and practice closer together and enable them to inform each other.

[2] We are doing our best here by having an economist and an urban planner joining force.

In the rest of this paper, we proceed as follows. We first provide some facts about housing, transportation, and accessibility to highlight that accessibility is an issue of first-order importance. We then highlight the basic urban tradeoff between proximity and housing prices and we show how adding further realism to our theoretical framework generates a lot of complexity. In section 4, we present the difficulties of making the notion of accessibility operational and the complications associated with empirically defining and measuring accessibility. In section 5, we show how policymakers often ignore, misuse, and misunderstand accessibility. The result is the inequitable and inefficient misallocation of the two most important urban consumption goods, housing and transportation.
accessibility.

2. Some facts about transportation and housing

Although complicated to measure, accessibility matters. Urban households devote considerable time, money, and effort to housing and transportation. In the U.S., according to the U.S. Bureau of Transportation Statistics (2013), households devote 32.8% of their expenditure to housing and 17.5% to transportation.[3] American households are not unique in devoting so much of their resources to housing and transportation. Combes et al. (2016) report similar figures. French homeowners and renters devote 33.4% of their expenditure to housing and 13.5% to transportation. Similar magnitudes can be found for both housing and transportation in Colombian cities (Gallego and Ramírez, 2012) and in Mexico City (INEGI 2007). Many countries also appear to devote between a quarter and third of household expenditure to housing. Dasgupta et al. (2014) show that it is only in countries with GDP per capita below $3,000 that housing investment represents a significantly lower fraction of expenditure.

Households do not only use a considerable share of their earnings on transportation, they also spend a lot of time traveling. The average American spends about 80 minutes traveling per day (by our calculation using the 2001 and 2009 National Household Travel Surveys). Again, the U.S. is not unique. The 2011 Bogota transportation survey indicates that Bogotans spend about 100 minutes travelling every day (Akbar and Duranton, 2016, Bogota Department of Transportation, 2013). In Mexico's largest

[3] The U.S. Bureau of Labor Statistics (2014) reports that American households devote 27% of pre-tax income on housing and 14% on transportation. This is another way to present essentially the same data given that American households face an average tax rate of about 21%.

cities, roughly two-thirds of workers reported one-way commutes that were 30 minutes or less on the 2015 Intercensus—a figure that is not very far from what we observe in the U.S. In Mexico City, where commutes are most onerous, nearly a quarter of workers have one-way commutes that exceed an hour, not very different from New York City. More generally people tend to travel on average above an hour per day in the more developed and developing cities alike (Mokhtarian and Chen 2004; Schafer 1998).

While the general finding is that households spend a large portion of income on housing and transportation holds in most places, including many poor parts of the world, these aggregate figures for housing and travel hide considerable heterogeneity and interesting though systematic differences in the amount of time spent traveling by age, gender, and city size. There is first some evidence that richer households travel more. For instance, Duranton and Turner (2016) estimate that the elasticity of kilometers traveled by private vehicles with respect to household income is about 0.25. At the same poor households appear to devote greater financial and time resources to transportation and housing than richer households. Data from INEGI (2007) suggest that the poorest fifth of households spend almost a quarter of their income on transit alone in Mexico City. These figures are consistent with comparable calculations performed for Bogota by Gallego and Ramírez (2012)[4]. Poor commuters in developing cities, however, often travel less by choosing informal jobs that are closer to their homes than wealthier households (Suárez, Murata, and Delgado 2015). At the lowest income levels, households rely more on walking and biking to reduce expenditures further.

Similar results appear to hold for housing. In French urban areas, Combes et al. (2016) estimate an income elasticity of the demand for housing slightly below 0.80. Consistent with this, a 10% increase in income is associated with a 2 to 3 percentage point lower share for housing in household expenditure. Housing and transportation are thus essentially normal goods, except perhaps at very low levels of development.[5]

[4] Complicating matters, there is evidence that poorer households report fewer trips than wealthier households (relative to the number of trips that they actually undertake). In its 2012 household travel survey, the Delaware Valley Regional Planning Commission fitted a subset of respondents with GPS devices to check the quality of reporting. The agency provides a weighting factor that accounts for these differences for estimating Philadelphians' aggregate metropolitan travel behavior.

[5] Again, we seem to observe very low levels of housing consumption and travel at very low levels of development. A key question for both types of expenditure is how much of these very low consumptions is demand vs. supply. Housing may be a luxury good at extremely low levels of development (be it only because food is even more important). Alternatively, for housing, tenure uncertainty and the absence of financing mechanisms may play an important role on the supply side.

Looking across cities, we also find that the cost of both transportation and housing increase with city population.[6] So do expenditure shares. For housing in France, Combes et al. (2016) estimate that the share of housing in expenditure is about 22% for a city with 100,000 inhabitants and about 37% in a city with 12 million inhabitants like Paris. There are fewer available figures for transportation but they appear to point in the same direction.[7]

There is also substantial variation within cities. Unsurprisingly and consistent with the theoretical framework we highlight below, housing costs are lower in suburbs but households travel more.[8] There are crucial differences across countries in how much housing households consume in the center of cities relative to suburbs. Glaeser and Kahn (2004) report that housing units are about 25% larger in the suburbs of large American cities than at their center. This pattern is far from universal. Rather than moving to suburban locations to consume more housing, suburban households in Mexico generally live in dense informal or publicly-subsidized suburban settlements that are comprised of small houses, packed densely together on small lots (Guerra 2015; Monkkonen 2011). This allows access to homeownership, but neither reduces travel expenses nor likely increases land consumption. A similarly dense suburban fringe is the norm in cities as diverse as Dakar, Lima, Surakarta, Chennai, and Yerevan.

There are also large differences within and across countries in how people travel. In the U.S., most travel is by car (U.S. Bureau of Transportation Statistics, 2013). The car represents nearly 90% of commutes whereas transit is only about 6% and walking nearly 4%. Transit is used disproportionately by poorer households and in the largest city. Results from the 2009 National Household Transportation survey indicate that the share of transit in all trips in New York City is slightly below 50%. It then hovers around 20% for a number of large metropolitan areas, and is essentially less than 5% (and sometimes much less) nearly everywhere else. In large European cities, the car is far less dominant while transit, walking and, in some countries like the Netherlands or Denmark, cycling are much more important. In Mexico, using data from the 2015 Intercensus, we find that cars are used for between 20 and 30% of commutes in urban areas from central Mexico, including Mexico City, and the poorer southern regions. It is between

[6] See Glaeser and Kahn (2004) for the U.S. and Combes et al. (2016) for France.
[7] For transportation in Mexico, our computations using the 2015 Intercensus data are also supportive of longer commutes in larger cities. Gallego and Ramírez (2012) also find larger shares of transportation in expenditure across Colombian cities and a roughly constant share of expenditure for housing.
[8] For housing costs, see Glaeser and Kahn (2004) for the U.S. and Combes et al. (2016) for France. For vehicle-kilometer traveled in the U.S., see Duranton and Turner (2016).

40 and 50% in northern cities. In Bogota, the share of the car trips is less than 20%, including taxi rides for all types of journey. The share of transit (formal and informal) is about 30%. Walking represents 46% of all trips, including nearly 30% of trips longer than 15 minutes. Overall, the finding is that poor households economize on transportation costs by relying on transit and non-motorized modes. This substitution is perhaps less easy in the United States where trip distances are often long, transit service is sparse, and wide roadways with long signal times often discourage walking.

While we do not dwell on this for lack of easy comparisons, we note that there are sizeable differences in housing consumption. With an elasticity of housing prices with respect to city population of about 0.20 estimated by Combes et al. (2016) and a price elasticity of demand of about -0.75 implicitly estimated by the same authors, the elasticity of housing consumption with respect to city population in France is about -0.10. An income elasticity of demand of about 0.80 will also imply large differences in housing consumption between rich and poor households. Differences across countries are perhaps even larger. With a median occupied housing size of 150 square meters (American Housing Survey 2013) and an average household size of 2.5, American households appear to consume much larger housing quantities than in the rest of world.

There are also large variations in the speed of travel. First, the rich appear to travel faster than the poor nearly everywhere. Even for car travel, Couture et al. (2016) find that U.S. households with above median income travel by car about 10% faster than the poorest households. In the most recent National Household Travel Survey, the average transit commute lasted 59.0 minutes, compared to 22.9 minutes for the average car commute. Given that in the U.S. transit is disproportionately used by the poor, that will make their travel all the slower. The Bogota Department of Transportation (2013) reports that average trip duration for motorized trips is nearly 80 minutes for the poorest households and only about 40 minutes for the richest households. As we will argue below, these differences are caused by the use of different modes of transportation but also accessibility, in particular accessibility to jobs.

There are also differences across cities. Correcting for a number of measurement issues, Couture et al. (2016) find sizeable differences in travel speed across different U.S. metropolitan areas. The slowest U.S. metropolitan area is Miami-Fort Lauderdale (followed by Portland, Seattle, Los Angeles and New York), which is about 30% slower than the fastest Southern and Midwestern metropolitan areas: Kansas City, Greensboro, Louisville, and the aptly named, Grand Rapids. There are also differences within cities.

Duranton and Turner (2016) estimate an elasticity of travel speed with respect to the density of residents and jobs of about -0.10. Put differently, a 10% higher density is associated with a 1% lower speed of travel. Obviously, these differences only measure differences in mobility, not what residents can access. A 10% higher population density with a U.S. metropolitan area is also associated with 1.5% shorter trips (and an increase of 0.15% in the number of trips).

The cross-country differences are also striking. On average residents of large American metropolitan areas travel at about 40 kilometers per hour. Again, this is not true everywhere as travel is slower in the more central parts. Even in the largest U.S. metropolitan areas, however, travel speeds are well above 30 kilometers per hour. Akbar and Duranton (2016) estimate travel speeds by car at about 20 kilometers per hour in Bogota. Guerra (2014) estimates an average door-to-door travel time of 11.4 kilometers per hour in Mexico City by all motorized modes and 10.8 kilometers per hour by transit. Obviously, some caution is needed here when performing such a comparison. Even though households in Bogota, Mexico City, and the U.S. appear to devote the same share of resources to transportation, they travel substantially different amounts. Relative to Bogotan households, residents of large American metropolitan areas take about 50% more trips that are about twice as long[9]. Most of these trips are by car whereas a plurality of trips in Bogota involves walking (ahead of informal transit). Even car trips are much faster in the U.S. Understanding the welfare implications of these figures is not easy, as the rest of this paper will show.

Now that we have demonstrated the quantitative importance of housing and transportation, our next step is to provide a conceptualization of these issues and show that accessibility is the central concept that links them.

3. Setting the scene: urban development and urban travel

A simple framework (or perhaps already not so simple)

[9] Here, we add the important caveat that there is substantial variation in how many trips get reported based on the design of the travel survey. For example, after the U.S. household travel survey changed methodologies from 1990 to 1995, the change had such a profound impact on survey results—a 40% increase in total trips per capita—that the survey designers referred to their methodological understanding as naïve and applied a 1.33 adjustment factor to aggregated non-work travel reported from the 1990 survey (Hu and Reuscher 2004; Liss 1997).

Thinking about urban travel and accessibility presents considerable conceptual challenges. To appreciate the difficulty of these issues, let us start with the simple model of urban structure that is taught in introductory classes and has been used by economists for many years.[10] Despite its extreme stylization, this model is fairly subtle as this subsection will show. The following subsections will show that adding greater realism and relaxing some of its most extreme assumptions generates further complexity.

Let us assume that jobs are all located in the same place, the central business district, and residents need to commute to work daily, say at a constant cost per unit of distance. Residents choose where to live, how much land to consume, and how intensively to develop it for residential housing. Land is sold to the highest bidder and housing is competitively provided.

To minimize commuting costs, residents would ideally live as close as possible to the jobs. Of course, not everyone can be accommodated there. As a result, residential areas will develop around the job locations. Land closer to the center will fetch a higher price. Because of this, it will be advantageous to develop it more intensively. As we move away from the center, we thus expect land prices, house prices, and the intensity of housing development to decline. Because of cheaper prices, the consumption of housing will increase with distance to the center and population density will thus decline.

This simple model is highly stylized but it provides a reasonable description of many cities throughout the world with a concentration of jobs in the center and gradients of declining land and housing price, declining intensity of development, increasing parcel size as one moves away from the centre.[11]

While this framework is the simplest we can think of to link land use, housing, and transportation, it is already fairly involved and difficult. To appreciate this point, think about two households with identical preferences but different incomes. Which one will live closer to the center? As it turns out, the answer will depend on the magnitude of the income elasticity of the demand for land relative to the income elasticity of the cost of commuting. The intuition behind this result is that richer households will live

[10] It is usually referred to as the monocentric urban model. It was originally developed by Alonso (1964), Mills (1967), and Muth (1969) and led to the development of a large formal literature, culminating with Fujita's (1989) book. See Duranton and Puga (2015) for a recent review of this literature.

[11] These gradients, particularly the price and density gradients, have receive a lot of attention since Clark's (1951) pioneering work. See, again, Duranton and Puga (2015) for a recent assessment. The two known exceptions of positive density gradients are Russian and South African cities. Given the extremely particular institutional settings of these two countries during most the 20th century, these are arguably the exceptions that confirm the rule.

further away from the center where land and housing are cheaper, provided their desire to consume more land and housing is high enough relative to the higher commuting costs that they face to reach more remote locations.

It is also important to note that in this simple model, the simple process of bidding for land and developing it that we have assumed is efficient. More precisely, the socially efficient amount of land is used and each parcel is developed at its optimal intensity. Furthermore, transportation costs per distance of travel are uniform and the infrastructure is not explicitly modeled. In other words, there is no need for urban planning at this point. Order will emerge for the uncoordinated decisions of residents and no centralized intervention can improve upon the outcome.

Although we will soon show that introducing important features of cities, like congestion and firms, will change this conclusion, the basic framework is often unpopular with the planners and policy makers who deal daily with urban complexity. There is also something of a debate within the planning academy about how much current urban form is the result of market forces and how much the result of land use regulation and investment decisions[12]. Nevertheless, the monocentric model provides a useful framework for considering the implications of urban planning decisions in a systematic and rigorous way. It also remains the foundational basis of the most popular land use and integrated land use and transportation models.

Firms also decide where to locate

The next step to improving the monocentric model is to introduce a more realistic theory of firm location. The monocentric model—and similar models that introduce different job distributions, transportation costs, and geographic features—essentially presents a theory of residential location, given the location of employment. A better model would incorporate a theory of both residential and employment location.[13] Such a theory would be immensely more complicated since it would have

[12] For an overview of this longstanding debate, see Gordon and Richardson (1997) and response by Ewing (1997).
[13] In this respect, we note that the monocentric model is often dismissed as an intellectual curiosity with an extreme (and irrelevant) geography. This criticism is beside the point. It is easy to propose alternative distributions of jobs. Instead of assuming that all jobs are located at the center, we can impose any pattern of job location. Solving the model becomes messy but, conceptually, the same economic forces remain at play and they lead to the same tradeoff between job accessibility and housing prices. The real problem is that the distribution of jobs remains exogenously imposed.

residents competing for the best locations in terms of access to jobs and firms competing for the best locations in terms of access to employment and arguably access to each other. The best locations are no longer given since where firms choose to locate determines what the best locations are for residents and vice-versa. There is a broader lesson here. In the simplest theory with fixed job locations, accessibility is essentially given. With endogenously determined locations for jobs, accessibility emerges instead as an outcome of the choices made by everyone (firms and residents at this point of the argument). Unfortunately, after 40 years of research by economists and geographers, a workable theory of urban locations where both residents and firms would choose their locations remains elusive.[14]

An fundamental point here is a adding greater realism is not only about making the stark description provided by the basic model slightly more complicated slightly or less stark by adding a few frictions following the relaxation of some extreme assumptions. The addition considered here, like the ones that follow, potentially alters the nature of the model. To go back to the analogy proposed by Sutton (2002), some economic problems are akin to Newton's apple falling on the ground. Considering the frictions from the atmosphere will modify slightly the calculation without altering the main forces at play. Instead, dealing with urban accessibility is more like the complicated and messy prediction of tides for which the movement of the planets will interact in subtle ways with the local geography and weather conditions to determine the movements of the sea.

Another complication: Urban resident and firms are different

We can further appreciate the conceptual difficulties of accessibility by exploring further limitations of our baseline framework. First, the model so far assumes that residents are only interested in jobs and firms are only interested in workers. While the location of jobs clearly plays an important role in residential location choices, many other factors also matter, including the quality of local schools, noise, crime, pollution, the type of neighbors, and the ease of conducting other daily errands. In short, a myriad of accessibility-related factors drive households' location decisions.

[14] The first effort to model such situations dates back to Ogawa and Fujita (1980). Duranton and Puga (2015) review this class of models.

An appropriate model also needs to acknowledge the great variety of residents in cities and differences in their preferences. To understand where different socio-economic groups locate in the city, the simple framework outlined above highlights that—under certain conditions—richer households want to consume more housing and thus are willing to live further away from the center where land is less expensive but commuting costs are higher. Empirically, for richer people, their higher commuting costs, which pulls them to the center, nearly offsets their greater demand for land, which pushes them to the suburbs (Wheaton 1977). As a result, other forces may come to dominate this weak tradeoff and explain observed patterns of residential location by income. Brueckner, Thisse, and Zenou's (1999) argue that the location, distribution, and value of urban amenities and dis-amenities vary across cities, regions, and countries. European cities have arguably strong amenities at their center, which is not the case of many American cities. In turn, richer households may seek to live close to amenities. To paraphrase their title, this may be why central Paris is rich and downtown Detroit poor.[15] Obviously, income is not the only heterogeneous factor that matters, so do ethnicity, household size, preferences, and so on. The extremely high costs of travel in many developing cities may also explain why richer households are more centrally located in these cities.

We also need to acknowledge the prominence of firm heterogeneity. Some firms may be mostly interested in locating close to their workforce but others like retailers will want to locate close to their customers. Some firms, like large trucking companies, will need to be close to highways and distribution facilities. Others, like advertising agencies in Manhattan, will want to locate close to other firms in the same activity. This is a fundamental point. Accessibility is never absolute, always relative and conditional on one's needs and preferences. Consequently, any change in land use patterns or in the transportation infrastructure will be positive for some and negative for others. Accessibility is inherently a source of conflict.[16]

Adding realism: travel is not only to work

[15] Historical factors clearly also play an important role, and a historian would likely note the intentional removal of poor central Parisians under Baron von Haussmann and the many car-oriented planning decisions that helped hollow out the motor city's center.

[16] In the long-run, we expect households (and firms) to sort and choose their preferred location depending on their preferences and the constraints they face. Even though one's preferred location subject to constraints (including budget) may not be one's ideal location, being able to choose will attenuate the problem. In the short-run, however, residential mobility is extremely costly and it is difficult to imagine unanimity for most planning decisions.

Another limitation of our model of residential location choice is that every resident travels to work every morning and comes back every evening. There is some justification for this assumption (albeit not absolute) since it is true that many of us are actually required to go to work every week day and we (mostly) do not get to choose where work is taking place. This assumption is nonetheless extremely limiting since non-work trips account for three quarters of all travel in the United States (U.S. Department of Transportation 2013). The role of non-work accessibility in housing choice is thus almost certainly more than an academic curiosity.

More generally, the amount of travel is endogenous to accessibility and there may not be an obvious relationship between how much a household's members travel and how accessible their neighborhood is. Improving accessibility may reduce travel as each errand is now shorter.[17] But with better accessibility, more trips may be undertaken. Overall, the total amount of travel may go up or down with accessibility.[18] Adding a further complication, although most workers commute longer than they would like, few people want a commute shorter than 10 minutes (Redmond and Mokhtarian 2001).

Hence, thinking meaningfully about accessibility for households requires knowing about their travel decisions, the choice sets they face in terms of destinations, the prices of both travel and housing, and the preferences, size, income, wealth, and composition of the households in question. Even when we know all this, accessibility is hard to measure as households are expected to sort across locations depending on their travel preferences. We return to this point below.

Adding realism: the transportation system

There are two further important complications to consider about transportation. Travelers' decisions to travel also affect the cost of mobility of other travelers and governments provide two key inputs for transportation: the roadway and transit.

[17] Duranton and Turner (2016) find that a 10% increase in nearby density is associated with households driving about 1.3% fewer kilometers at a speed 1.1% lower for trips that are 1.5% shorter and 0.1% more numerous. Much of effect of local density on kilometers traveled appears to be causal. See below for further discussion of the empirical literature.

[18] The relationship may not be monotonic. The same person may undertake very little travel when located in rural Montana if there is no place to go to, many travel a lot in the exurbia of metropolitan area since the places to go to are far, and again travel little in mid-town Manhattan since everything is so close.

In our baseline model, we have considered that city residents could travel at a constant cost per unit of distance. While this simplification was useful to avoid overwhelming complexity right from the start, it is unwarranted. Understanding how travel costs are determined is actually key to understanding issues of surrounding accessibility and urban travel. The first issue is that, for a given road capacity, an increase in the number of travelers slows down travel. Travelers only pay the average cost of travel, not the marginal social cost, which includes the congestion costs they impose on others. This congestion externality and failure to pay the full social cost of travel results into too much traveling relative to what would be efficient.

As we argue below in our discussion of road provision, integrating roads and congestion explicitly into the stylized framework we have considered so far is extremely challenging. Obviously, one can always resort to numerical methods but they no longer allow for crisp and transparent results. One may also worry about the robustness of results obtained with numerical methods.

If we forego the analytical tractability of stylized models, an alternative is to model real cities instead of idealized cities. There is a long tradition of land use models for actual cities (see Lee, 1973 of an early perspective and Waddell, 2011, for a recent review). When it comes to transportation, the delay functions on individual roadways and intersections can be incorporated into the urban modeling framework. At this point, however, the model needs to be integrated into a transportation model and the complexity begins to increase exponentially. Even running on high-powered servers, integrated transportation and land use models based on individual and firm choices can take weeks to converge. Unlike stylized models, these more practical models rely on many shortcuts and ad-hoc assumptions.[19] While they may constitute useful tools for public decision makers, they present something of a black box due to their complexity, sometimes opaque assumptions, and repeated calibrations.[20]

[19] For instance, transportation models routinely implement for all roads the speed-density curves estimated on one particular road. Recent evidence by Akbar and Duranton (2016) suggests that the aggregation is not as straightforward. The speed-density curve for an entire city (or a part of it) looks nothing like the speed-density curve of individual road segments. See also Daganzo and Geroliminis (2008) and Geroliminis and Daganzo (2008) for more on "macroscopic" approaches to traffic congestion.

[20] Three land use and transportation integrated models (LUTI) derived from Anas (2013), De Palma and Marchal (2002), and Waddell (2002) were used for the ex ante evaluation of a large subway project in Paris. While the aggregate conclusions of these models were in the same ballpark, locally they could diverge. Understanding the sources of these differences is near impossible given the complexity of these models and their proprietary nature (Marc Gaudry, personal communication).

Adding to this complexity, road supply has substantial impacts on when and how people travel. The main issue is that an increase in roadway capacity will most certainly lower travel costs, all else equal. All else does not remain equal, however, and the lower travel costs of new road capacity elicits more travel. In the end, a roadway increase either through adding lanes or creating new roads appears to do very little to improve travel conditions (Duranton and Turner, 2011).

People also travel by a variety of different modes like transit, walking, and biking. Not only does the cost of travel vary based on the supply of roadway and the aggregate volume of travel on roadway segments by time of day, it also varies substantially by mode. Transit costs, in particular, can be complicated to model given the complexity of transit travel and the importance of transfers, wait time, and certainty to the costs that travelers perceive (for a review, see TCRP Report 95, 2004); perceptions which of course also vary by observable and unobservable heterogeneity in a given population. For example, it holds true on average that wealthier households prefer to drive, but there are plenty of wealthy individuals with a preference for transit.

The challenges run even deeper than this. Because the number of transit lines is limited, transit cities are expected to be more monocentric than car cities. Transit can reduce the cost of travel but it is inherently less flexible than the car. Transit technologies also change the balance of the inputs that enter into the production of travel. Because of economies of scale, transit can be cheaper in monetary terms but it is more intensive in time. Commuting by transit typically takes longer than commuting by car and the time costs of transit greatly increase with each connection (Glaeser and Kahn, 2004). A lower monetary cost and a higher time cost make transit more attractive to the poor. This may in turn explain why the poor disproportionately elect to live where transit is available (Glaeser et al., 2008). The dense cities where transit gets used most frequently are also the places where parking is most expensive and difficult to find—adding substantially to the time and monetary costs of driving.

Incorporating bicycling into the mix adds a further wrinkle, since perceptions of comfort and safety play a larger role in the costs of cycling than travel time or cost. Put simply, cycling is the fastest and least expensive (after walking) mode for door-to-door travel for many trips. Yet, without substantial traffic-separated cycling facilities, cycling mode share generally remains low.

We have so far described a setting in which households and firms make complex location decisions, which are interdependent and influenced by a range of factors. Beyond this, these location decisions and these interactions do not occur in a void. Land use in most places is, for better or worse, highly regulated. Within their urban fringe, cities are also mostly built up. Location choices are thus also constrained by structures that are extremely long-lived and sometimes developed many years ago. Let us discuss these two issues next.

Adding realism: land use is heavily regulated

Land use in American cities is highly regulated and land use regulations are ubiquitous.[21] Regulations like zoning designations, minimum and maximum floor-to-area ratios, required setbacks, minimum lot sizes, and other limitations on land use, all affect accessibility. Sometimes the explicit purpose of a regulation is to improve accessibility. The claim is often made regarding regulations that promote mixed land use for instance. For other regulations, this is often more of a side effect. Although unintentionally in most cases, strict `Euclidian zoning arguably increases travel needs for shopping purpose by preventing any form of commercial activity in residential areas.[22] Minimum lot sizes also increase travel by making development less dense than it would otherwise be. Minimum parking requirements constrain density and encourage firms and households to rely more on cars than they might otherwise.

One can think of five reasons why land use is regulated. First, land development is rife with market failures. A manufacturer may find it advantageous to open a polluting facility in the middle of a residential area. This would come at a high cost for local residents. Preventing non-conforming uses of that type has a strong rationale. Second, land use regulations might seek to address market failures elsewhere. For instance, California's Senate Bill 375 from 2006 asserts, "it will be necessary to achieve significant additional greenhouse gas reductions from changed land use patterns and improved transportation". Third, local residents may also restrict land use because they stand to profit from

[21] Although Houston, Texas, is famous for its lack of zoning ordinance, it still regulates land use heavily directly through minimum lot sizes, setbacks from the street, or buffer zones for development, among others. The city of Houston also regulates land use indirectly through private covenants, which are often more restrictive than what most local governments would impose in the U.S. (Festa, 2013).
[22] This naming for the strict separation of users refers back to the 1926 decision of the U.S. Supreme Court in the case Euclid vs. Ambler opposing the Euclid community in Ohio to a manufacturing developer, Ambler Realty (Fischel, 2004).

increased scarcity if their neighborhood is in high demand.[23] They mays also want to prevent the arrival of undesired or fiscally costly neighbors through exclusionary zoning.[24] One of the first instances of zoning was specifically designed to remove Chinese laundries in Modesto, CA, in the 1880s (Hall, 1988). Fourth, local residents may simply dislike change and prefer to keep their neighborhoods relatively static.

Finally, some zoning regulations may simply be misguided. As should be clear by now, land-use planners are confronted with complicated decisions. As a result, they may not always fully understand the implications of individual land use decisions. In his book the High Cost of Free Parking, Donald Shoup makes a convincing argument that minimum parking requirements stem from a misguided pseudo-scientific approach to measuring parking needs. These regulations have in turn generated a host of environmental, economic, and social problems that he characterizes as a great American planning disaster.

Urban structures last forever!

The last important modification to our initial framework regards the durability of housing, roadways, and other urban structures. The structure of current cities does not reflect current economic fundamentals, it reflects the economic fundamentals at the time they were developed and perhaps the expectations that people had then. While we expect developers of new building and urban planners of new infrastructure to be forward-looking, no one has perfect foresight.[25] For instance, urban investments fifty years ago in the city of Philadelphia were based on a projected long-term population of

[23] Unless locations are perfect substitutes, the demand curve for a particular location will be downward sloping and local suppliers (the landowners) will have incentives to restrict supply and behave as a monopoly. Within each community, there is then a tension between owners of less developed land who would like to develop it more and owners of developed land who would like to limit new developments. Restricting development also requires costly collective action, which may not be worthwhile when demand for a location is low. These two features explain, at least in part, why land use is not equally restricted everywhere.

[24] Primary and secondary education in the U.S. is largely funded through property taxation. Richer communities with well-funded schools often imposed binding minimum lot size requirements to prevent the arrival of poor households willing to consume only a tiny amount of land and contribute little to the funding of local schools while benefiting from them. It is hard to imagine how this situation might evolve as changing school funding formulas is often met with extremely strong resistance and moving from property taxation to a head taxation is simply not going to happen (notwithstanding the fact that it would create other issues).

[25] In a recent survey of the long range planners and planners, Guerra (2016) found that uncertainty about the timing and impacts of driverless cars (and a political disconnect between planning and investment decisions) prevented planners from considering driverless cars in long range transportation plans, despite believing that these impacts were likely to occur and likely to be significant within the planning horizon.

about 3 million, about twice the current size. The population of metropolitan Las Vegas was about 300,000 in 1970. Although some growth was expected, probably very few in Las Vegas in 1970 thought its population would be around 2.1 million today.

When cities grow in population, we expect them to become denser and grow in height. In our baseline model, growth in population, height, and footprint are all concomitant and happen continuously. In reality, changes in buildings happen, but only slowly. We know extremely little about the adjustment of the roadway and other infrastructure but it is likely to be slow as well.[26] Many of the subway tunnels that benefit present day residents of a city like New York are a century-old legacy. The basic layout of streets in a historic center may be as old as a city itself.

More generally, there is a lot of permanence in cities. For instance, the two main commercial arteries in Cologne, Germany, Hohe Strasse and Schildergasse can be traced back to the two main streets, the `cardo' and `decumanus', traced by their Roman founders in 50 AD. To take another example, Brooks and Lutz (2013) show that in Los Angeles, the influence of the streetcar on patterns of urban density within the city remains conspicuous to this day, even though the streetcar started its decline as the dominant mode of transit after 1910 and the last piece of streetcar track was dismantled in 1963. These two examples, while extreme, should not be dismissed as carefully chosen anecdotes. They are revealing of a broader trend. Examples of fast large-scale urban change are not that many. One can mention the great Boston fire of 1872 or the 1906 San Francisco earthquake (Hornbeck and Keniston, 2014, Siodla, 2015). It is often difficult to find much long-term implications of large shocks on the structure of cities. For instance, the 9/11 terrorist attack in New York did not appear to affect the city much beyond a slight acceleration of the decline of Lower Manhattan and the rise of Midtown (Bram, Haughwout, and Orr, 2009).

The durability of urban structure and the persistence of patterns with cities have a number of important implications for our theory of accessibility. First and fairly obviously, urban policies do not take place in a void and most of them will not have a major impact. We return to this issue below when we discuss

[26] For interstate highways in U.S. metropolitan areas, Duranton and Turner (2012) show that planned kilometers of highways in 1947 were roughly proportional to population at the time. The elasticity of actual kilometers of interstate highways today with respect to current population is much below one, at about 0.7. New highways appear to be provided to metropolitan areas when they do poorly, not to accompany their growth. This is either because land is cheap or as make-work.

transit policies. Slightly less obvious, the durability of urban structures implies that the decline of a city or neighborhood is very persistent (Glaeser and Gyourko, 2005). Consider for instance a new highway that cuts through a neighborhood and makes it less attractive. Residents will start leaving but the exodus will be limited in the short run as property prices decrease. Low prices will then induce some residents to remain, in particular the poorest ones and those least likely to leave due to discriminatory housing practices or other restrictions. Low prices will also tend to reduce and even eliminate investment in new construction. In the end, the adjustment will essentially take place through the slow decline of properties. Hence, a shock like the highway shock considered here can take many decades to be fully absorbed by a neighborhood and the decline in population will mirror that of residential structures.

Thinking about developing cities requires adding even more moving parts

In most of our exposition so far, we have implicitly (or explicitly with most of our examples) referred to cities in developed economies. We often think about developing cities like Ernest Hemingway's apocryphal answer to Scott Fitzgerald's assertion that the rich are different from the rest of: "yes, they have more money" quipped Hemingway. Here, we actually side with Fitzgerald. Developing cities have some features that make them different in nature and not only in degree. Importantly, these features do not come in replacement to what we have mentioned so far. They come in addition.

In our initial framework, cities are essentially labor markets. Although we subsequently enriched this framework to account for urban consumption and amenities, access to jobs remains fundamental. It may be uniquely important in poorer cities. These poor cities are also characterized by their dual labor market with a formal and an informal sector. While defining labor market informality and measuring it is challenging, labor market informality is important everywhere in the developing world (see for instance, Kanbur, 2014). It is useful to keep in mind that even in the cities of more advanced developing countries like Colombia the rate of informality is roughly 50%. In the cities of less advanced countries in Africa or in India, it is 80% or more.

Following Harris and Todaro (1970), urbanization was long viewed as somewhat perverse. The prospects of a few formal public sector jobs would attract rural dwellers to cities even though most of them would not succeed and end up worse off in the informal sector.[27] More modern approaches to urbanization take a less dim view of the informal sector and view it as a potential stepping-stone (Lucas, 2004). The duality of urban labor markets is also due to the outcome of the over-regulation of labor combined with weak enforcement. While we agree that dysfunctional labor market institutions play a large role to explain informality, we also conjecture that formal sector jobs require more travel on average than informal sector jobs. Poor urban transportation conditions in developing cities as documented above might play an important role as well.

The second defining feature of developing cities are high rates of housing informality, often referred to as informal settlements or, more crudely, slums. If duality is hard to measure in the labor market, it is even harder in the housing sector. Using satellite imagery and detailed local records, Henderson et al. (2016) find that informal housing occupies about 20% of the built area of Nairobi, Kenya. This represents about 50% of the extant floorspace and hosts a disproportionate share of the population. By some estimates, the residential density of Kibera, Nairobi's largest slum, may reach 2,000 residents per hectare.[28] This is in contrast with a population density of 150 across all residential areas of Nairobi (including Kagera and other slums).

Importantly, Henderson et al. (2016) document that about a third of buildings get redeveloped in the core of Nairobi over a 12-year period. There are also a lot of new in-fills in more central areas. At the same time, they observe only minimal slum redevelopment or conversions of slum areas into non-slums.

Just like labor market informality, housing informality is, to a large extent, the product of inappropriate land use regulations and weak enforcement. In Nairobi for instance, minimum lot size in most residential areas is 500 square meters.[29] Even if we generously assume households with four members and share of 30% of land for residential purpose, this type of regulation would limit population density to less than 25

[27] The prospects of urban living, furthermore, are (realistically) considered in relation to rural living. A worsening of rural outcomes will thus bring more residents to cities even though most of them will end up in the informal sector. This is often referred to as the "push" factor for urbanization.
[28] https://en.wikipedia.org/wiki/Kibera.
[29] Nairobi is not even a particularly pathological case. Minimum lot size in large sections of Dar Es Salaam in Tanzania is 1,000 square meters.

persons per hectare.[30] This is less than half the density of Philadelphia and even less dense than Los Angeles. Obviously, compliance is very low and most new developments are informal.

How can we explain the presence of such regulation? Mistaken policy is arguably the first explanation here. Kenyan urban planning regulations are a legacy of Kenya's former colonial power, the United Kingdom, where such regulations have been used for many years. Large minimum lot sizes are viewed as part of the development process. This is of course a case of mistakenly putting the carriage before the horse. In addition, inefficient regulations may occur by design as an exclusionary device, just like they occur in U.S. suburbs. After pushing people into housing informality, the cities and their taxpayers no longer need to provide them with costly local public goods like water, sewers, and electricity. This reduces current expenses on local public goods as well as future expenses as low-quality informal housing will reduce incentives to move into the city.

While regulations, intentionally or not, push newcomers into informality, other forces keep them there. The persistence of informal housing occurs for two main interrelated reasons. Slums are often controlled by a small number of agents (often referred to as slumlords) who derive very large rents from their slums (Durand-Lasserve and Sélod, 2009). Slumlords either make slum dwellers pay them directly through a rent or fee or indirectly through some public services like a water truck that they provide at a high price. In many developing cities, property rights are also poorly defined and weakly enforced. A functioning land registry is lacking in most places. Establishing one is a real challenge because each piece of land is typically claimed by several "owners". Many countries, like India, also lack a clear-cut notion of ownership as tenants and even subtenants have strong customary rights. Though necessary, a functioning land registry will not serve much of a purpose if courts are unable to uphold property rights and protect owners from being evicted by powerful parties. In many countries, the causes of housing informality will not be going away any time soon.

[30] Using a 2010 land use map from the Center for Sustainable Development at Columbia University (http://nairobigismaps.wikischolars.columbia.edu/home), the share of land occupied by residential areas is 33%. From this, we would need to exclude roads and parks. A different source that relies on older data, Oyugi and K'Akumu (2007), attributes again slightly more than 30% of land in Nairobi to residential areas. Taking away the roadway and other non-directly residential uses will surely make the figure less than 30%. In the 2009 Kenyan Census, the average household size in the Nairobi administrative area is 3.17 (2.90 for slums and 3.37 in the formal sector). This is consistent with the Kenya Demographic and Health Survey (KDHS) for 2008-09, which reckons that average household size in Nairobi is just below three. We are extremely grateful to Tanner Regan for his help with this matter.

Housing informality has a number of negative implications. As already mentioned, slums dwellers are often denied basic public services. The implications are many and usually negative. Substitutes to water and police services are costly. The lack of sewers is unhealthy and has severe public health consequences, etc. Informality may also weaken incentives to invest in housing and reduces access to the formal banking system.[31] This results in construction that is substandard in quality and quantity (informal construction is rarely more than one to two stories). More generally with poorly defined property right, land is inefficiently used, and as already argued, does not adjust to changing economic conditions as it does in the formal sector. Poor regulations also have direct detrimental effects. For instance, large minimum lot sizes like in Nairobi lead the city to sprawl and increase transportation requirements. For Bengalore in India, Bertaud and Brueckner (2005) estimate that the cost of suboptimal population density resulting from restrictions that are arguably much less extreme than in Nairobi (if they were enforced) represents about 3% of household income.

The last feature we want to mention here is the duality of the transportation sector. A lot of work has been devoted to dual labor markets in developing countries, much less to dual housing markets, and even less to dual transportation markets (for a recent treatment, see Cervero, 2011 and Golub). This is not because this is a small part of the transportation sector. In Bogota, the richest city of a middle-income country, informal buses still represent about 43% of all motorized trips according to the 2011 Bogota Transportation Survey. Formal transit and taxis only account for 14 and 7% of all motorized trips, respectively. Informal transit is most likely even more prevalent in poorer cities. Across a score of large African cities, 36% to 100% of public transit travel is on informal paratransit. In two thirds of these cities, more than 80% of public transit is on informal paratransit (Behrens et al., 2016, p. 10).

Informal transportation has a number of virtues. It mainly provides transportation services and mobility to people that cannot afford a private vehicle and for whom formal transit may be inexistent or too expensive. But then, informal transit is far from an ideal solution to the urban transportation problems of poor cities. It plays a disproportionate role in terms of pollution and, most likely, traffic fatalities. Although it is sometimes more affordable than formal transit when it exists, its pricing is deeply inefficient. Because informal transit is highly fragmented, each leg of a journey must be paid separately and the cost increases linearly with the number of connections. A journey with two legs in Bogota,

[31] The conjecture is associated with de Soto (2000). Using large-scale legalization episodes, more systematic studies have failed to find much of an effect (Galiani and Schargrodsky, 2010).

Colombia costs nearly an hour of work at the basic salary (which is above what many informal sector jobs will pay). Going back and forth from work, may thus easily cost nearly a quarter of someone's wage. Not surprisingly, many slum dwellers will work within walking distance of where they live even though their jobs pay extremely little.

Finally, we want to highlight that there are also some important differences in urban spatial structure and the geography of wealth between developing cities and more mature cities of the developed world. Over the past half century, suburbanization, car-ownership rates, and G.D.P. per capita have increased rapidly in many developing cities. Given these trends and the early models of spatial structure presented above, it is easy to assume that the demand for suburban living is driving the developing world's rapid increase in car ownership rates. This is not always the case and the average suburban expansion in a developing city bears little physical or socioeconomic resemblance to a typical U.S. suburb. In Mexico City—which is wealthier, more suburbanized, and more reliant on private cars than most developing-world cities—neither aggregate car-ownership trends by geography nor a joint model of residential location and car ownership decisions suggest that car ownership and suburbanization are strongly related (Guerra 2015). Instead, wealthier households opt to own cars and live in central locations with good accessibility, while poorer households tend to live further from the urban center and rely more heavily on transit. According to the study, a doubling of household income corresponds with a 44% higher likelihood of getting an additional car and a 29% higher likelihood of living in the urban center.

4. Defining and measuring accessibility in an urban setting

Now that the notion of accessibility has been discussed and many of the subtleties associated with it have been highlighted, we turn to the empirical measurement of urban accessibility.

Defining accessibility

Defining and measuring accessibility has empirical as well as conceptual challenges. In the spirit of the theoretical framework described above, we define accessibility as the ease of reaching destinations. This is a conventional definition. Accessibility is high where households can reach a wide variety of destinations, which are physically close and for which the cost of travel per unit of distance is low.[32] A lack of accessibility is instead characterized by a paucity of destinations, long distances, and high transportation costs per unit of distance.

Three important comments about this definition are in order. First, although our definition of accessibility is extremely straightforward, it is not the only one. In many U.S. planning circles, accessibility has become shorthand for improvements to pedestrian, bicycle, and transit infrastructure. These two definitions are not consistent with each other. From a definitional standpoint, all things being equal, faster car speeds means greater, not lesser accessibility. A bike lane may be desirable for many reasons but it does not change the destinations that are available (at least in the short run), does not make destinations closer, and, in many cases, does not make travel any faster.

Second, the notion of accessibility that we define applies to a household that resides at a given location. Accessibility is often understood as a measure of the ease of accessing other places from a given location. Because households differ in their tastes and in their travel needs, however, accessibility is – to repeat – a relative concept, not an absolute one and, for the same location, will vary across households . To take an extreme example, proximity to a butcher shop does factor into accessibility for vegetarian households. Easy access to many destinations means a lot to households with a high propensity to travel. It means far less to households with a low propensity to travel. Accessibility thus means different things to different people with respect to both the type and number of destinations that can be reached and the number of trips to be taken.

Pushing this argument further, we then expect households to choose their place of residence depending, at least in part, on their travel needs (as described above in our theoretical framework). We observe that households in denser residential areas take shorter trips. Is it because greater density increases accessibility and reduces the need for travel or because household who dislike travelling long distances elect to live in denser neighborhoods where more destinations are available within a short distance? The answer is in principle ambiguous and much debated.

Third, the definition given above for accessibility implies that maximum accessibility occurs when maximizing the number of destinations, minimizing the distance to these destinations, and maximizing

[32] The literature usually speaks of mobility when the focus is solely on the ease of travel.

the speed of travel. In practice, a larger number of destinations within short distance is also associated with slower travel. More specifically, we expect urban density to increase the number of destinations, reduce their distances, and reduce travel speed. Whether greater residential density reduces or increases accessibility is unclear. Couture (2015) shows that for restaurants in the U.S., maximum accessibility to restaurants is in Manhattan where travel is extremely slow.

Measuring accessibility

There is a large literature that attempts to measure urban accessibility.[33] Much of it focuses on job accessibility. Although there is something uniquely important about being able to access jobs and commute to work, recall that commutes represent less than a quarter of all trips in large U.S. metropolitan areas. The simplest labor market measures of accessibility count the total number of jobs accessible to a place or person within a fixed time and by a fixed mode under typical travel conditions. More complicated measures weigh accessibility indices by job type, time of day, and distance.

Alternative measures of accessibility consider a number of errands and estimate the travel time needed to run these errands from a given place of residence. More sophisticated measures provide weights for these trips and allow for imperfect substitutability between them.

While these measures are informative and can be readily computed with modern mapping technology, they remain unsatisfactory in light of how we defined accessibility above. To see why, consider an index that would measure travel time to a number of different locations from a given place of residence including for instance the nearest supermarket, doctor, school, and church. This index is essentially a price index: We consider the time cost of a bundle of trips rather than the monetary cost of a bundle of goods. Thinking of accessibility as price index is consistent with our definition above, which relies on the ease of reaching destinations. However, summing across destinations like this does not make for a good price index, even if we allow for some substitutions across trips and weigh them. As argued below, different households value destinations differently. Hence, the accessibility price index should ideally be specific to each household. The second weakness of simple indices is that we often elect not to go to the closest possible destination. Churches differ and worshipers will typically not go to the closest one if it belongs to another denomination. Couture (2015) shows that restaurant-goers in the U.S. barely ever go

[33] See Handy and Niemeier (1997), Anas et al. (1998), or Venter (2016) for more complete reviews.

to the restaurant closest to their house and typically pass many eating places before reaching their destination for a meal. Hence, a good measure of accessibility should not only measure the cost to reach broad categories of destinations but also consider the variety of possible destinations within each category.

In turn, to consider the variety of destinations and provide a valuation for them requires knowing about households' travel patterns. These patterns can then reveal households' travel preferences. Making some assumptions about traveler preferences, we can then recover a "true" measure of accessibility and provide an implicit valuation for it. As already stated, knowing only about possible destinations is not enough but knowing only about travel behavior is not enough either. The amount of travel that a household undertakes tells us nothing about accessibility. From ad-hoc measures of accessibility, it is tempting to conclude that greater accessibility should lead to less travel. This need not be so, as cheaper travel should lead to a greater expenditure on travel. The quantity of travel will depend on both its price and its demand elasticity. Simply put, a household may choose to travel more when accessibility is high and less when accessibility is low.

Aside from the ad hoc accessibility indices just discussed, there is a more promising tradition that defines accessibility consistently in models of travel demand. As noted Ben-Akiva and Lerman (1985), we can measure the accessibility of a resident by taking the estimated value of each destination obtained from estimation of travel demand, discounting by its distance to this resident, and summing across all destinations.[34] This approach was first implemented by Niemeier (1997) in a model of mode choice and commutes to different types of jobs.

While this is theoretically and empirically robust, measuring accessibility along these dimensions is an extremely difficult endeavor since it requires information about all locations and the choices made by lots of travelers in an area. Couture (2015) develops this approach further by reducing information requirements to only the location of destinations and the choice made by travelers. His index is also directly interpretable in monetary terms. He focuses exclusively on restaurants. Though travel to restaurants represents a small fraction of travel, the results are nonetheless extremely interesting. He

[34]Using an activity-based travel model within a random utility framework, a given person's potential utility—which may include both observed and unobserved preferences—is a measure of the highest value of the suite of activities and travel alternatives from which the person chooses. See Handy and Niemeier (1997) for a more precise description of how to use this type of framework to derive an accessibility index.

finds that in an U.S. metropolitan area, the accessibility price index of restaurants fall by about 20% between the outskirts of the metropolitan area and its center.[35] For an average households that represents about 600 $ per year. Importantly, more than half of these gains are about the availability of a greater variety of restaurants. Albeit taken at a lower speed, shorter trips represent the remainder of this accessibility gain.[36] These findings raise a number of interesting questions, including the possibility that faster mobility may actually correlate negatively with accessibility.

While this type of approach represents in our opinion a big step forward, it is still very partial. Restaurants are only a small part of household travel. Other errands like shopping could be added using a similar methodology. Commutes are arguably more complicated because we do not patronize jobs like we patronize restaurants. Instead, households often choose their place of residence depending on their job. Then, about 7% of trips in large U.S. metropolitan areas are visits to friends and relatives. This will be even more difficult to handle.[37] We also note that this type of approach does not explicitly deal with heterogeneous preferences by households and their potential sorting across space depending on their preferences and the destinations available around them.

We draw a number of lessons from these considerations. While ad-hoc measures of accessibility such as walk scores are fast becoming more available and may be informative, they still constitute deeply unsatisfactory measures of accessibility. On the other hand, more theoretically and empirically robust measures that incorporate multiple trip purposes, travel modes, and user preferences are still out of reach and unlikely to be commonly used anytime soon. That accessibility is a hard concept that is often poorly understood and always poorly measured is an obvious obstacle to sound urban development policies. As a result, different people end up meaning different things when they talk about accessibility

[35] Those estimates rely on a utility function that exhibits a constant elasticity of substitution (which is closely connected to the logit framework as noted many years by Anderson et al., 1992). Couture (2015) provides corroborating evidence to that effect.

[36] Trips to restaurants are shorter and slower in denser areas. However, the first effect dominates so that the time cost of going to the closest or the n-th closest restaurant is less. In denser areas, restaurant goers also pass more restaurants before reaching their preferred one. However, the total duration of trip remains equal or slightly less than in less dense areas. This finding is consistent with an observation by Metz (2008) that commutes get longer in areas with a greater density of jobs. This type of feature needs to be related with the old observation that workers commute much more than they would if they were to occupy the job closest to their home (Hamilton, 1982). This is often referred to as “wasteful commuting” (inappropriately in our opinion). This literature is surveyed by Ma and Banister (2006)

[37] With current mapping technology, it is easy to know about the number of restaurants or supermarkets close to a location. It is much harder to know about the number of potential friends (for now at least, data from social networks will likely alleviate this constraint in the future).

and end up talking past each other. There may be something to the anecdote about transportation engineers, who by accessibility understand the maximization of vehicles throughput at intersections, while many urban planners equate accessibility with pedestrianization, the exact opposite of what the transportation engineer had in mind.

In many cities of the developing world, the challenges of measuring accessibility is even more daunting because many of the costs paid by residents are extremely hard to measure. In Mumbai, for example, hundreds of thousands of pavement dwellers sleep outside in central districts. This allows them to minimize transportation costs and take advantage of informal jobs opportunities, while also circumventing central Mumbai's astronomical central real estate prices. Sleeping on the streets, of course, has other associated costs in terms of health, comfort, safety, and sense of belonging. While the example of pavement dwellers in Mumbai is extreme, poor households and small landlords often construct housing in central locations that are otherwise undesirable to formal real estate markets due to high slopes, proximity to hazards like trash dumps, and vulnerability to floods, mudslides, or other hazards. These precarious land conditions—as well as the uncertainty of land titles—facilitate a minimization of housing and transportation costs, but often at a high cost of physical and legal uncertainty. This type of result is suggestive that if we do not observe nearly as much travel in developing cities, especially among their poorest residents, this is not for a lack of demand. These poor residents are willing to pay an extremely high price for good accessibility.

Accessibility and measures of accessibility also feature prominently in number of bodies of academic work. We emphasize three of these below. Our intent is neither to offer a comprehensive list of all the bodies of literature related to accessibility, nor to cover anything close to the full range of work on any of the topics. Instead, we wish to demonstrate how fundamental accessibility is to our empirical understanding of how cities work. For each area, we mention key ideas and results, but refer the reader to additional full-length literature reviews where appropriate.

Accessibility, travel behavior, and urban form

Accessibility features heavily in the large and growing body of literature on how urban form influences mode choice, vehicle kilometers traveled, and other travel outcomes. A key problem in that literature is to what to what extent residential self-selection biases empirical estimates as residents sort into neighborhoods that favor their travel behavior (Levine 1999, Handy, Cao, and Mokhtarian 2006; Cao, Mokhtarian, and Handy 2009) and to what extent unobserved local attributes may explain both urban form and travel outcomes.

The main point of agreement is that population density has a small but statistically significant relationship with how and how much people travel (Ewing and Cervero 2010; Boarnet 2011; Brownstone and Golob 2009). Recent work by Duranton and Turner (2016) which tackles both the possibility of unobserved individual characteristics and unobserved local characteristics that are correlated with urban form and travel behavior estimate an elasticity kilometers traveled with respect to density of about -0.07—right in the range of Ewing and Cervero's (2010) meta-analysis . As described above, greater density is also associated with modestly more frequent travel, shorter trips, and slower speeds.

To assess what changes in urban forms would do to kilometers traveled in the U.S., Duranton and Turner (2016) conduct a series of quantitative thought experiments. Concentrating the 10% of Americans that live at the lowest densities and occupy 83% of the territory into an area of about 1,500 square kilometers taking them to the 90th decile of residential density in the U.S. would reduce aggregate driving by about 5%. A slightly less drastic experiment relocating half of the population from the bottom two density deciles would achieve much smaller results because those that are left in low(er) density areas would have to drive more, offsetting most of the gains. It is only by bringing people to Manhattan levels of density and closing down the rural parts of the country that significant gains in terms of driving reductions can be achieved. This does not appear politically feasible.

There are two points of contention. Much of the literature, following Cervero and Kockelman (1997), argues that urban form cannot be easily characterized and a range of dimensions matter, density of course, but also diversity (through for instance mixed land use), and design. In a horse race between these variables, Duranton and Turner (2016) fail to find evidence for anything but population and employment densities as robust predictor of vehicle kilometers travelled. A caveat here is that they miss measures of the quality of the pedestrian environment.

Finally much of the literature argues that measures of metropolitan accessibility have a much stronger relationship with travel behavior than local measures like neighborhood density, generally measured at the Census Tract level (Ewing and Cervero 2010; Bento et al. 2005). Duranton and Turner (2016) only find robust evidence for the number of jobs and residents located in a 5 to 10 kilometer radius, a scale in-between the purely local and the metropolitan which coincides with the typical distances that urban residents travel. Once the effects of the "local" environment within this 5 to 10 kilometer radius have been conditioned out, they fail to find robust evidence of any effect of other metropolitan characteristics.

Transportation supply and accessibility

One of the primary hopes of transportation investments is that they will substantially influence accessibility. There is evidence that the accessibility benefits of rail stations often get capitalized into land and increase property values (Baum Snow and Kahn, 2000; Gibbons and Machin 2005; Hess and Almeida 2007; Chalermpong 2007; Rodríguez and Targa 2004; Cervero and Landis 1997). Similarly, new freeways and interchanges often increase land values and spark new highway-oriented commercial development.[38] However, the accessibility impacts of a new roadway or rail depend not only on the quality of the investment, but also on the relative importance of the new investment and the existing network. For example, the first north-south freeway in Austin, Texas, substantially shaped the future of urban development, while the latest's impacts on urban form will barely register since it adds so little to metropolitan accessibility. The first light rail lines in the United States sparked a suburban real estate boom, since the lines opened up previously unavailable land and housing types during a time when the slow speeds and relative discomfort of horse-drawn trolleys limited urban expansion. Early operators made money, not by selling fares, but by selling properties around them. Even today, the few profitable subway companies balance their books by owning the valuable property around rail stations (Kanemoto 1984; Cervero and Murakami 2009). Similarly, the construction of the U.S. interstate highways network was a major factor in the suburbanization of cities (Baum-Snow, 2007). New fast radial connections allowed workers to move to suburban settings leading the central part of American cities to hollow out. The physical destruction of hundreds of thousands of homes to make way for highways and urban renewal also contributed.

[38] Because land use is heavily regulated, the occurrence of these developments is often conditional on changes in land use regulations allowing for such developments. In some situations, local governments may create some uncertainty on this subject, which may discourage development. See for instance Bula (2016) regarding the recent anticipated subway line along the Broadway corridor in Vancouver and previous transit developments that did not lead to higher densities despite very large capitalization effects into local property values.

The relative attractiveness of travel alternatives also influences the accessibility impacts of specific investments. For example, in a sprawling city where bus ridership is low, a new investment in light rail that doubles transit speeds along a specific corridor will be unlikely to attract many new riders or increase surrounding property values substantially. Relative to the bus, the new light rail line is a boon to accessibility, but relative to car on most point-to-point trips, transit will remain uncompetitive. Similarly, a new elevated freeway in Mumbai, where most people walk or take the regional rail, will only have a small impact on aggregate accessibility.

Whether any new improvements in accessibility results in changes in form is another question. For this to happen, the marginal benefits of the added accessibility need to be higher than the marginal costs of redeveloping a parcel or constructing a new building. As a result, changes in land use around new transportation investments—even when they do produce substantial accessibility benefits—can be slow to materialize as already discussed.

Finally, it is worth noting that transportation investments may increase accessibility without influencing either travel times or congestion. In fact, congestion in particular is rather stubborn in responding to changes in transportation supply (Cervero and Hansen 2002; Duranton and Turner 2011). There is considerable latent demand for travel. Not only do people adjust when, where, a how they travel—what Downs (2004) refers to as triple convergence—but firms and households move to new locations to take advantage of marginally changed accessibility levels, while tending to maintain fairly constant rates of daily travel. Duranton and Turner (2011) decompose the proportional increase in vehicle-kilometers traveled associated with increases in roadway capacity. About half of it is either completely new traffic or traffic shifting to newly expanded highways and major roads from local streets. The reminder of the increase in traffic is due to changes in commercial traffic, which is extremely reactive to travel conditions and newcomers moving to places with more roadway. Based on this type of observation, Metz (2008) argues that using travel time savings as the basic measure of consumer surplus for transportation investments is fundamentally flawed.

To sum-up our discussion in this section, accessibility is a difficult theoretical concept and it does not come as a surprise that defining it empirically and measuring it raises considerable challenges.

Unfortunately, these difficulties are not only weaknesses in the academic literature, they have direct ramifications for policy-making as we show next.

5. Some policy challenges and implications

For all the emphasis on the importance of accessibility in planning and economics, accessibility plays little role in day-to-day investment or policy decisions. There are several reasons this happens. First, as already emphasized, accessibility is conceptually and empirically complicated. As a result, advocates and policy makers rarely promote new investments based on accessibility. Instead, projects are pitched based on their purported—and generally misstated—ability to reduce congestion, shorten travel times, or meet projected increases in vehicle travel. The most common measure of the road transportation system, Level of Service (LOS), is often used to the detriment of accessibility. LOS ranges from A to F based on the volume and spacing of vehicles on a freeway or the amount of delay at a local intersection. New development projects are frequently blocked, delayed, or altered because of potential impacts of the LOS scale. Land use and human activities are treated as impediments, rather than key elements of the accessibility equation. Worse, the scores do not even relate to any sort of efficient use of space, since LOS D—a failing grade—is actually the point of maximum throughput on a freeway.

Rail transit investments offer a notable exception to the difficulty of measuring and promoting accessibility as a policy outcome. Supporters often tout transit's ability to capitalize increased accessibility into higher property values and new development around transit stations. [39] Since higher property values mean higher rents, however, even this indirect measure of accessibility is not without conflict. Many advocates and policy makers worry about housing affordability and gentrification—particularly when a new line opens in a poorer neighborhood.

Second, compared to other competing land use and transportation objectives, accessibility is abstract and hardly pressing. People have a much more personal connection to whether they have an easy time finding parking, whether housing is too expensive, whether a new housing development will strain local school finances, or whether the trains come on time. Hence, the focus will be on the fiscal aspects and

[39] The total increase in land values associated with a new infrastructure project will indicate the economic surplus created by this project only under some assumptions that will not always be met in practice (Kanemoto, 1988).

some components of accessibility while other such as the closeness and diversity of destinations are less salient. Voters and policymakers unsurprisingly are likely to gravitate to policies, programs, and investments that touch on these more concrete and visceral outcomes.

Third, different pieces of the accessibility puzzle resonate quite differently with different groups of people. As a result, a person may favor policies that increase accessibility by increasing regional rail investments, but strongly oppose relaxed land use regulation that would allow marginally denser housing development in suburban areas—including those near regional rail. Job boosters rarely focus on whether a new firm is best located in terms of accessibility to workforce. Instead, they emphasize the number of jobs attracted and the impacts on the local tax base. While some affordable housing advocates prefer to locate new housing developments in places that have good access to transit systems and jobs opportunities, others emphasize building developments in wealthier neighborhoods with better access to schools and harder to quantify economic opportunities.[40]

Given these challenges, it is hardly surprising that planners and policy makers tend to interact with the component pieces of accessibility separately and in often-contradictory fashion. Yet there is a need to implement better policies, particularly in fast-growing developing cities where poor accessibility may hinder economic growth. The United Nations predicts that the number of people living in cities in low income countries (e.g., Afghanistan, Nepal, and Senegal) with populations over 5 million will more than triple from 34 million in 2015 to 109 million by 2030 (United Nations Population Division 2014). The number in lower-middle income countries (e.g., Honduras, India, and Vietnam) and upper-middle income countries (e.g., Brazil, China, and Mexico) will increase from 517 to 798 million.

It is tempting to argue that planning for accessibility requires a holistic approach, since accessibility is conceptually and empirically complex. However, this approach—were it ever to gain traction—would likely backfire. Specifically, it is difficult, perhaps impossible to decide on an optimal accessibility level, let alone measure it. As a result, policy makers would tend to set arbitrary accessibility goals that are somewhat ill defined and perhaps even poorly related to land use and transportation accessibility. Recall

[40] We note here that the economic and sociological literature that studied the effect of the Moving To Opportunity experiment in Boston found very little positive effects for most movers to better neighborhoods (Katz et al., 2001). Recent evidence from Chetty etal. (2016) points out to positive long-term effects for young children. To make relocation policies cost effective, they would need to be narrowly targeted. We also note that vouchers for rents would be enough as the social benefits from homeownership are still subject to considerable debate.

that, in some planning circles, accessibility has become shorthand for transit, pedestrian, and bicycle planning—the opposite of mobility planning, which focuses on highways. We argue instead that policy makers consider whether policies, plans, investments, and regulations will tend to increase or decrease accessibility at the margin. To elaborate on this recommendation, we consider its relationship to several urban public policy topics and related questions.

Providing appropriate space for transportation

Given its importance to transportation planning, it is somewhat surprising how little research or public policy considers whether cities have too much or too little roadway at the margin.[41] Theoretically, this is an extremely challenging problem that economists essentially gave up on after early attempts by Solow and Vickrey (1971) and Solow (1972). One of the greatest minds and mathematically gifted members of the economics profession, Solow (1972) actually writes in the opening paragraph: "This enquiry began as an attempt to work out a fairly general (though abstract) theory of land use. I was soon driven by the complexity of the theoretical problem, to a series of drastic simplifying assumptions. In the end, I am left with the analysis of a single austere example, based on assumptions chosen mainly to avoid complications."

Empirically, and although it is relatively simple to get kilometers or even lane-kilometers of roadway by road type in many parts of the world, researchers and policymakers tend not to know how much urban land is dedicated to transportation within or across metropolitan areas. Shoup (1997) traces the origins of a claim that cars consume half of urban space in most cities and as much as two thirds in Los Angeles back through several cited publications to an uncited and unsupported statement that the car consumes a precise 62% of urban space in Los Angeles. A widely cited World Bank transport paper by Gwilliam (2002) reports that with 10% to 12% of land devoted to transportation, Asian cities have far less than the 20% to 30% in U.S. cities. Again, the report provides no citations or methodologies.[42]

In more advanced countries, transportation authorities keep a precise record of all road segments. But, they usually count lane-kilometers of roadway, not the paved area. Lane width in the U.S. typically

[41] As we argue below, there is an important issue of data availability behind the paucity of research.
[42] The report argues that this contributes to a problem later identified as premature congestion—a state of low motorization rates together with high congestion levels. This is perhaps true but no more than a conjecture.

varies between 2.7 to 4.6 meters. Even for interstate highways, there is significant variation, depending on the exact highway.

Given the uncertainty and, seemingly, the wide variation in the amount of urban space dedicated to roadway both within and across cities and the somewhat arbitrary way that road investment occurs, it is extremely unlikely that most or even many urban areas allocate space to urban transportation efficiently. Instead, most cities probably have too much or too little roadway. If there is too much space dedicated to roads, then a policy to reduce road widths and give over more space to other urban land uses would tend to increase accessibility. If not, road widenings and new investments would likely improve accessibility. While precisely how much roadway is too much or too little is likely not answerable, whether there is too much or too little along specified dimensions (like economic output per worker, equitable distribution of income, average travel times, or traffic fatalities) is at least researchable. Instead, in practice, road widening and contraction investments happen with almost no consideration whether a city or neighborhood has too much or too little road capacity.[43]

Investing in transit

Another way to increase travel capacity is to increase the provision of transit. Again, more capacity is desirable in some cases even if it does little to reduce congestion and travel costs. Transit is nonetheless more than just a capacity issue. It is a set of technologies (trains, subways, light rail, bus-rapid transit, and regular buses) that differs from individual motorized transportations in several dimensions. Transit technologies exhibit increasing returns to scale because of their high fixed costs and low marginal costs. Hence, because of increasing returns, transit technologies only become advantageous at a high enough population density (Meyer, Kain, and Wohl 1965; Pushkarev, Zupan, and Cumella 1982; Newman and Kenworthy 2006; Guerra and Cervero 2011). Unsurprisingly, transit represents a larger share of travel in larger cities (Glaeser and Kahn, 2004). Among transit technologies, the higher fixed costs of subways relative to buses make subways attractive only for the densest parts of the largest cities.

[43] We also note that, following the work of Herbert Mohring (Mohring, 1961, Mohring and Harwitz, 1962), a number of important results were derived regarding the desirability of self-financing roads (see Small and Verhoef, 2007, for an overview). These results, although neglected in practice, should be more than theoretical curiosities and be investigated further. Similarly, there are solid theoretical "golden rules" for the provision of local public goods. They find their origin in the work of social reformer Henry George (1884). See Behrens et al. (2015) for recent developments and references.

Following Bertaud (2002), it is possible to imagine two different urban equilibria: An "Atlanta" type of equilibrium with low density and a preponderance of car-based travel vs. a "Barcelona" equilibrium with a much denser city with a high share of transit in travel. With about the same population as Barcelona in 1990, the built-up area of Atlanta was more than 25 times that of Barcelona. These are very different cities, indeed.

Whether one is more efficient than the other from an accessibility perspective remains an open question. Atlanta's equilibrium favors easy parking, long trips, fast travel in cars, and more dispersed development. Barcelona's favors transit, congested sidewalks, and more concentrated development. While, the Atlanta model consumes substantially more land and produces substantially more pollution than the Barcelona model, new investments will not turn Atlanta into Barcelona or Barcelona into Atlanta. Recall however that cities are extremely durable, and where they are built up, they change very slowly. When a new urban infrastructure requires a large change in local density to make economic sense or destroys substantial parts of the urban fabric, skepticism is in order. Transportation policies must adapt to their cities and not the other way round.

Measuring the transportation impacts of new development

One of the primary ways that local municipalities determine whether a developer should pay a development fee or whether a project should be blocked or hindered is through a traffic impact analysis. These analyses typically estimate the number of trips that a development is likely to generate by car, the time of day of the trip, and the direction of the trip. As an example, a suburban single-family home in a simplified monocentric model of the city would generate one-to-two morning-peak trips in the direction of the central business district and one-to-two afternoon-peak trips in the direction from the central business district. The predicted new trips are then added to a queuing model of the local transportation network to see if the additional trips will increase delays. If a project increases delay in such a way as to change the level of service, from say LOS B to LOS C, then the developer may be asked to improve the affected intersection or even halt the project.[44] Until recently, California state environmental review process required this type of analysis for all projects using public funding or requiring discretionary

[44] On local roads, the amount of delay at an intersection is used to determine level of service. For example, LOS B means that there is 10-20 seconds of delay with occasional full use of a traffic light cycle. LOS C means that there is 20-35 seconds of delay with regular use of the full cycle. Drivers rarely wait a light cycle in either condition.

approval from a public agency. (The process now seeks to mitigate increases in net vehicle travel, based on the environmental impacts of that travel.)

The focus of the local traffic analysis is entirely on road delay and ignores whether a development increases accessibility, by bringing more jobs, households, or activities in closer proximity with other jobs, households, or activities. In aggregate, the policy tends to discourage denser urban projects, where accessibility and delay are likely highest. A much better approach would consider land use accessibility as well as this delay. If a project increases accessibility, it should be greenlit. If it decreases accessibility, then perhaps there is a case to discourage it.

Spatial mismatch / jobs-housing imbalance

In the 1960's, riots in predominantly black neighborhoods in United States cities prompted State and Federal governments to commission a series of studies into the causes of the riots. Along with other explanations, John Kain's (1968) spatial mismatch hypothesis—that the suburbanization of jobs, low access to private cars, and discriminatory housing markets had created and perpetuated high levels of unemployment—played a prominent role in explaining the riots. Although the nature of the problem has changed substantially—most black households in America have cars for example—discrimination in housing markets continues to play a substantial role in reducing the accessibility in American cities. As the suburbanization of jobs has continued since the 1960s, many suburban cities have developed a large mismatch between the number of jobs and the number of workers, particularly low-income ones. The jobs-housing imbalance increases the amount and percentage of travel by car and puts a particular burden on lower income households (Cervero 1989; Levine 1998; Cervero and Duncan 2006).

As already highlighted, from Palo Alto to Nairobi minimum lot sizes and restrictive zoning drive up housing prices, reduce density, and force many households to live further from work than they would prefer and could otherwise afford. Similarly, this type of restriction severely hinders households' ability to restrict access to high quality public schools. Kleinbard (2014, 293) reports that the United States is one of the few OECD countries (the others are Israel, Slovenia, and Turkey) to spend more public money on wealthy students than poor. From an accessibility perspective, reducing restrictive zoning requirements would substantially improve metropolitan accessibility by making it easier for firms and households to locate near each other. As previously discussed, however, reducing restrictive requirements even at the margin is often an uphill battle.

As a result, urban policy often tackles those issues indirectly either through a range of housing policies, often referred to as “fair housing” policies, or to a lesser extent, transportation policies. Unfortunately, housing policies that attempt to deal with accessibility and spatial mismatch do not pay attention to transportation and vice-versa. As a result, these policies often do not no more than scratching the surface.

For example, affordable housing policies frequently encourage the creation of subsidized housing in suburban as well downtown neighborhoods. Affordable housing initiatives are often implemented as inclusive zoning policies that reserve a fraction of new developments to lower income families. In many areas where the demand for housing is strong and its supply restricted, these policies are clearly far from optimal. We can identify a range of drawbacks. First, new housing construction is expensive and building subsidized low-density housing is unlikely to produce enough units to offset jobs-housing mismatch. Because these subsidies are paid for the “full-price” buyers and the developers, they slow down development even further. In some circumstances affordable housing units may also depreciate the value of the market-rate units. Finally, providing access to the subsidized units by lottery and based on income means that those who most value the accessibility benefits are similarly likely to get a unit as those who are indifferent to the accessibility benefits. In any case, in more expensive areas, it is highly unlikely that lottery winners come anywhere close to valuing the housing subsidy that they receive to how much they cost.

More concretely, in areas where demand is strong and new constructions are limited to, say, six stories, the efficient solution would be to allow for more and taller buildings. The issue is that building more or higher is often politically unfeasible. Tinkering with height exemptions that allow for two more stories when providing affordable housing units is a suboptimal way to increase supply. However, these policies are often politically more broadly acceptable. This may be better than no new construction at all. In many wealthy suburban communities, furthermore, construction is limited to such a point that only the wealthiest households can afford to live in them. This creates an accessibility problem, particularly when these same communities are major employment centers. It also creates social problems by reducing poor and middle-income households’ ability to choose their optimal housing and transportation bundles. Resigning from her position from the Palo Alto Planning and Transportation Commission, Kate Downing recently wrote that, despite two professional salaries, her family could not afford to live there and that the local government had repeatedly rejected even modest proposals to reduce land use regulations and increase housing supply.[45]

In this situation and many others where regulation reduces supply, increased affordable units—particularly when coupled with density bonuses that would not otherwise be permitted—almost certainly improve metropolitan accessibility. Whether and to what extent affordable housing policy increases or decreases accessibility are empirical, rather than theoretical, questions and depend substantially not only on the specific policy, existing urban form, and regulations, but also on the next best politically acceptable policy counterfactual.

The record of reverse-commuting programs to increase accessibility to suburban jobs for low-income jobs—programs given particular attention during reforms to US welfare system in the 1990's—have not been much more successful. On the one hand, better reverse commuting programs--particularly subsidized car loans—have likely helped Welfare-to-Work program participants to maintain employment at the margin. On the other hand, the programs are costly per worker served (Cervero and Tsai, 2003) and insufficient to the larger task of reducing poverty or improving metropolitan accessibility (Wachs and Taylor, 1998).

Dealing with congestion: the ideal and the feasible

Given our call to focus on transportation and land use policies that improve accessibility at the margin, reducing congestion likely sounds like a good idea. Congestion, however, is somewhat tricky. Not only will a layman, an economist, and engineer's definition differ, but the spatial and temporal nature of congestion make it fairly resistant to blunt policies to alleviate it by increasing supply or decreasing demand. Perhaps the simplest way to discuss congestion is to first acknowledge that not all of it is bad. Congestion is a sign of economic and social vitality. It reflects a high demand for travel. No one wants to go to the empty restaurants. A city with no congestion is more likely a sign of a poor economy than good traffic management. Congestion is part and parcel of what allows people to be in the same place at the

[45] The full letter is available at https://shift.newco.co/letter-of-resignation-from-the-palo-alto-planning-and-transportation-commission-f7b6facd94f5#.4u6td4x8w

same time and participate in the activities that are the outcome of good accessibility. The most accessible places in the world are almost always among the most congested.

There is, of course, the bad part of congestion. Sitting in traffic is not fun. Unpredictable travel times—whether delayed on the freeway or waiting for a bus—are generally considered more onerous than predictable travel times of the same duration. Even if predictable, a thirty-minute drive on a congested freeway is probably less pleasant than a thirty-minute drive on an uncongested one. Furthermore, in many cities the economic costs of congestion outweigh the other external costs of driving (Parry and Small 2009). This cost, however, differs substantially from popular estimates of the costs of congestion. For example, the Texas A&M Transportation Institute's annual congestion report looks at difference between free-flow and peak travel times and calculates the lost time and fuel. This conflates all congestion as bad congestion.[46] The top five metropolitan areas with most wasteful congestion—Washington, DC, Los Angeles, San Francisco, New York, and San Jose—consistently rank well as attractive places to live and in terms of economic productivity. Stated perhaps most simply, economically harmful congestion occurs when the delay that an additional driver imposes on all other drivers outweighs the benefits that the driver gets from making the trip in the first place. This harmful congestion is endemic. Addressing it, however, has proven to be quite challenging. For all of the popular discontent about congestion, drivers in most metropolitan areas would rather sit in congestion than pay a toll to avoid it.

Since at least Pigou (1920), economists have advocated the use of a congestion tax. If the `price' of travel set by the market is not right, a tax or subsidy can be used to make it right. This is of course, easier said than done. Making users pay for roads that have been so far free is politically challenging. The seemingly successful introduction of congestion taxes in Singapore, London, and Stockholm, has not been broadly imitated. As the London experience teaches us, there are also technological challenges, which turn out costly to resolve (Leape, 2006). Taxing traffic is easy in theory but complicated and often costly in practice. If a congestion tax is not available, recent research (see for instance Inci, 2015)

[46] More specifically, they compute the "cost of congestion" in American cities by valuing the time gain associated with being able to conduct all existing trips at "free-flow speed". This obviously neglects the fact that free flow travel would elicit a very large demand response. Beyond this, it also ignores that free-flow travel at 8 am or 5 pm in large American cities would mean that something would have gone terribly wrong regarding the demand for travel or that travellers have been inefficiently priced out of the road. There are too many cars on the roads of San Francisco and New York City at peak hours but optimal conditions would still entail a lot of traffic to accommodate demand. This is what we mean by "good congestion".

suggests that an appropriate pricing policy for downtown parking might achieve some desirable results. Unfortunately, this alternative is not popular either and the full force of this idea has yet to penetrate the mind of decision makers on these issues.[47]

Instead of dealing with excessive travel directly by taxing congestion, cities all over the world have experimented with a variety of alternatives, including quantitative restrictions that bar access to certain areas to vehicles based on plate numbers, traffic-calming, or increases in roadway or transit capacity. While the jury is yet to reach a final verdict on quantitative restrictions, the effects are somewhat mixed.[48] Attempting to curb congestion by discouraging traffic is self-defeating in our opinion as congestion is replaced by some other costs that are perhaps worse (Prud'homme and Kopp, 2008).[49] [50]

6. Closing remarks

Cities are about interactions between a variety of people. These interactions bring benefits that economists refer to as agglomeration economies.[51] This is why our world is fast becoming urban and cities have been dubbed our greatest invention (Glaeser, 2011).

Cities are also physical environments where people live and must travel to interact with others. Unfortunately understanding the physical environment of cities is nearly as difficult as understanding the human interactions taking place in cities. There are many components to this physical environment

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[47] Good ideas do not immediately strike most decisions makers as being good ideas. The slow diffusion of one-way vs. two-way tolls for bridges in the U.S. may be a case in point. When there is no easy substitute for a bridge, a one-way toll is an obvious proposition as it reduces waiting times and collection costs relative to two-way tolls. One-way tolls started in the late 1960s in California. New Yorkers had to wait until 2012 before the one-way tolling was systematically implemented there (Spock 1998, http://en.wikipedia.org/wiki/Verrazano%E2%80%93Narrows_Bridge). Of course, electronic tolling collection now makes two-way tolls attractive again.

[48] See Carillo et al., 2016, for a recent assessment for Quito in Ecuador and a discussion of past literature.

[49] Of course, curbing congestion is just one objective of the transportation system. For example, traffic-calming measures often discourage traffic but are, first and foremost, intended to reduce traffic speeds and improve safety and pedestrian comfort. Reducing speeds may also improve the number and quality of social interactions in neighborhoods and encourage local retail.

[50] Transit is often viewed as a response to road congestion. While it is true that, when provided efficiently, transit can carry more travelers than cars, we must keep in mind that transit may also create congestion and be itself subject to congestion. See de Palma et al. (2016) for a derivation of an optimal investment rule and fare system when transit creates congestion.

[51] See Combes and Gobillon (2015) for a thorough review of the evidence.

and they interact in a complex manner. We have tried to provide a sketch of these components and their main interactions. This was intended as both a roadmap and an illustration of the conceptual difficulties when we try to think about the physical environment of cities. As result of this complexity, we identified a number of problems. The first is the tendency of urban specialists to retreat into their area of specialism and treat it in isolation. This implies that the central issue of accessibility, which is about how the main activities we choose to undertake in different locations can be conducted at the lowest possible cost to us and to society, is often neglected. Land use, residential and commercial development, and transportation are all intimately connected. Another tendency is to rely on holistic solutions. These holistic solutions are often hollow, if not harmful, and one fad replaces another. The emphasis of planning cities around the car has led to some disastrous outcomes. Replacing it by an anti-mobility outlook and viewing travel as a nuisance unless it takes place on a bicycle or in a tramway is no better.

We believe that accessibility planning should focus on key urban problems, the supply of housing, congestion, and amenity provision. As suggested above, dealing with urban congestion seriously may require a focus on the pricing and management of parking as well. Instead, extant parking policies are often a compromise between residents who want to pay little and park easily and the mayor who wants to raise revenues.

There are unfortunately a number of inevitable conflicts between the stakeholders of the physical environment of cities. Related to this, we fully recognize that there is no single optimal way to organize a city. Cities have different geographic and historical circumstances, as well as different populations with varying preferences. Furthermore, some types of city structures or investments will tend to improve accessibility by one mode, such as transit, while disadvantaging another.

There are also important tradeoffs between land use, transportation and other public amenities like open space or the quality and character of a place. We understand that one city’s residents may favor economic development when another’s favor historical character and amenities. A wide variety of types of cities and the possibility for people to move between them is likely positive. We also recognize that technocratic approaches to planning and urban management created or exacerbated many of today’s challenges. As stated in the previous section, we generally recommend an approach that focuses on improving policy at the margin rather than determining an ideal and setting policies to resolve it.

There is also need for research that informs how policies affect metropolitan accessibility at the margin. For example, whether, where, and to what extent new roadway will tend to increase accessibility are open questions. As is the question of what kind of transit investment is most likely to improve access. There is also a need for better understanding and measurement of accessibility in general. New data and better computing power may help but, as we emphasize in the introduction, policymakers cannot afford to wait.

Nevertheless, tThere are also several examples where there are clear benefits to substantial changes in urban public policy. For example, we lament the ubiquitous persistence of urban travel congestion when the solutions are known and the likely benefits to deploying them are large. Perhaps most importantly restricting housing development far below what the market would otherwise supply produces substantially suboptimal economic, social, and environmental outcomes.[52]

Creative ideas will be needed. To our knowledge, Ahmedabad in India is the only case we know of a city that has managed to escape restrictive land use regulations through transferable development rights and a range of other policies (Annez et al. 2014). While the process is still on-going, it has increased the built-up density of the central part of the city from a floor to area ratio slightly above one to eventually more than five while also allowing for more roadway and more public spaces. Although the example of Ahmedabad is rather unlikely to sway an angry homeowner in Palo Alto, we nevertheless choose to conclude on a positive note. The current land use regime is so inefficient in places like the San Francisco Bay Area, Mumbai, Nairobi, and New York City, that (1) small policy changes could have large economic and social benefits and (2) there reducing restrictions there will produce more than enough surplus to compensate losers.

[52] Given congestion and agglomeration effects, we may actually expect the market to provide too much density and cities that are too large (Duranton and Puage, 2015). While this may need to be curbed, in many places extant policies arguably lead to outcomes that are socially much less desirable.

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