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ABSTRACT

The fast and often chaotic urbanization of the developing world generates both economic opportunity and challenges, like contagious disease and congestion, because proximity increases both positive and negative externalities. In this paper, we review the expanding body of economic research on developing world cities. One strand of this literature emphasizes the economic benefits of urban connection, typically finding that agglomeration benefits are at least as high in poor countries as they are in rich countries. Yet there remains an ongoing debate about whether slums provide a path to prosperity or an economic dead end. A second strand analyzes the negative externalities associated with urban density, and the challenges of building and maintaining infrastructure to moderate those harms. Researchers are just beginning to understand the links between institutions (such as Public Private Partnerships), incentives (such as congestion pricing) and the effectiveness of urban infrastructure spending. A third line of research addresses the spatial structure of cities directly with formal, structural models. These structural models seem particularly valuable when analyzing land use and transportation systems in the far more fluid cities of the developing world.

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I. Introduction

The United Nations forecasts that "Africa's urban population is likely to nearly triple between 2018 and 2050." Together Africa and India account for almost two-thirds of the projected growth in the world's urban population from 4.2 billion in 2018 to 6.7 billion in 2050. The urbanization of our planet's poorer countries is one of the most important phenomena of the twenty-first century, yet our intellectual tools for dealing with the great challenges of developing world cities remain underdeveloped. In this paper, we survey the economics of developing world cities, and try to make the case that development economists should spend more of their time thinking about and working in cities, and that urban economists should spend more of their time thinking about and working in developing countries.

Throughout most of history, agricultural prosperity and transportation infrastructure generally preceded mass urbanization, because agricultural surpluses were needed to feed city dwellers. Today, much of the developing world is urbanizing at lower levels of income and with less developed governance than America enjoyed when it became a majority urban nation in 1920. Consequently, developing world cities must face the ubiquitous challenges of urban life with far fewer resources. The difficulties of developing world urbanization only increase when national leaders seek to stymie urbanization, perhaps out of a fear that cities will enable the mobilization of political opposition.

The study of developing world cities provides a window into topics at the heart of economics. Cities are home to externalities, both positive and negative. They present both the angels and demons of human behavior. The knowledge-based growth described by Paul Romer and Robert Lucas takes tangible form in urban areas. Pigouvian problems, such as traffic congestion and contagious disease, become hyper-charged in the extreme densities of poorer cities.

In this paper, we divide the field of urban development economics into three broad categories: agglomeration economies, density's downsides, and spatial models of transportation and housing. The central question of agglomeration economics is whether cities actually increase productivity, or whether the observed relationship between density and earnings represents the selection of more skilled people into cities or omitted variables that both attract people and make them wealthier. The growing urban development literature appears to confirm the positive effects

of urbanization on earnings that have been found in the wealthy world (Chauvin et al., 2017). Randomized control trials that induce migrants to come to cities have provided some of the most compelling evidence supporting the hypothesis that density increases earnings (Bryan, Chowdhury, and Mobarak, 2014).

Yet there is also evidence suggesting that slums contain millions of people who have been in cities for decades and remain poor (Marx, Stoker, and Suri, 2013). Resolving the question of whether developing world slums are dead ends or pathways to prosperity remains central to research on developing world agglomeration. There is also a need for research that uncovers means of improving the productivity of developing world cities, or that discovers how to spread the benefits of urban productivity more widely.

Urban proximity enables poorer workers to connect with employers, but it also enables the spread of disease and the perpetration of crimes. Western cities were known for epidemics until the early 20th century, and water-borne illnesses remain a serious challenge in the world's poorest cities. New York had high murder rates through the early 1990s, and homicide continues to bedevil many Latin American and African cities today. Demand for urban density can collide with limited supply of housing and make living space seem unaffordable. The challenges created by density create scope for research and public policy action that can potentially make developing world cities more livable.

Historically, the poorer urbanites of the west typically walked to work and that made the traffic congestion problem manageable. As the car came to places with limited public capacity, traffic congestion became particularly severe. Workers in highly congested cities, such as Jakarta and Sao Paulo, can often face commutes that exceed one hour.

Economists are increasingly analyzing the roles that incentives, infrastructure, and institutions can play in moderating urban crime, traffic congestion, and disease in developing world cities. High levels of homicide in many poor world cities has been linked to extremely low probabilities of arrest and punishment. A large and growing literature is examining how institutions, such as Public Private Partnerships, impact road maintenance and demand management. One major finding of this literature is that weak public institutions do not imply better performance by

private institutions; such private providers of public services often have incentives to subvert the government that is allegedly overseeing them (Engel, Fischer, and Galetovic, 2014).

Analyzing the impact of land use in a city requires fully fledged spatial models that can assess the full equilibrium implications of building up one area of the city. Similarly, large scale changes in transportation infrastructure may have impacts that ripple throughout a metropolitan area. Section IV of this paper particularly focuses on the growing subfield of developing structural spatial models that can use empirically estimated parameters and forecast the city-wide impact of policy changes.

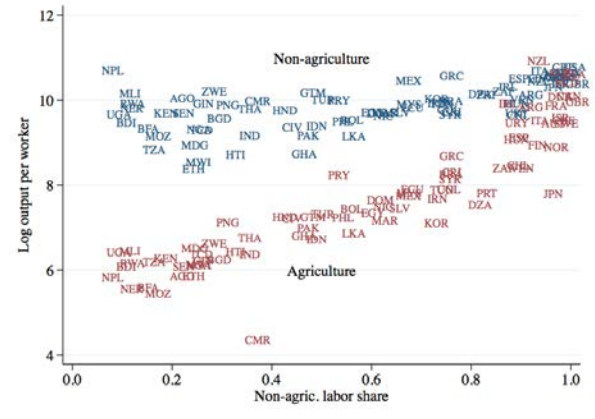
While many development economists have been appropriately excited about the scientific precision generated by randomized control trials, cities are complex systems and many urban problems cannot be addressed only with research interventions that can be randomized at the individual. The structural approach to urban economics typically embeds a series of optimization problems, including the locations and employment decisions of people and firms, and developers' decisions about construction. These models' parameters are then estimated directly from the data or by using other sources of information, including randomized control trials. Different policy choices can then be simulated using these parameter estimates. These models are just starting to be applied to contemporary policy challenges, but structural spatial models seem well-suited for land use and transportation decisions in developing world cities.

The future of the developing world is urban, and that generates both challenges and opportunities. The research that we now discuss represents the beginnings of a robust literature on developing world cities. There is every reason to believe that this literature will continue to grow and that it will provide fascinating policy-relevant results.

II. Agglomeration Economies in the Developing World

Should national governments promote or restrain the process of urbanization? The case for an active spatial policy depends on many factors, particularly whether cities actually enhance productivity or are more correlated with productivity. Empirical estimates of the true causal magnitude of agglomeration economies are therefore crucial elements in this most basic urban policy question.

Figure 1 documents two remarkable facts. The first panel plots, at the country level, the correlation between non-agricultural labor share, and the log of output per worker in agriculture and non-agriculture. The poorest countries in the world are predominantly rural and agricultural, implying that these countries lie in the left of the figure. Not only are developing countries relatively worse at agriculture, most of their workers labor on farms (Vollrath, 2014). The second panel shows the correlation between urbanization in 1960 and growth between 1960 and 2010 among a sample of poor countries in 1960.



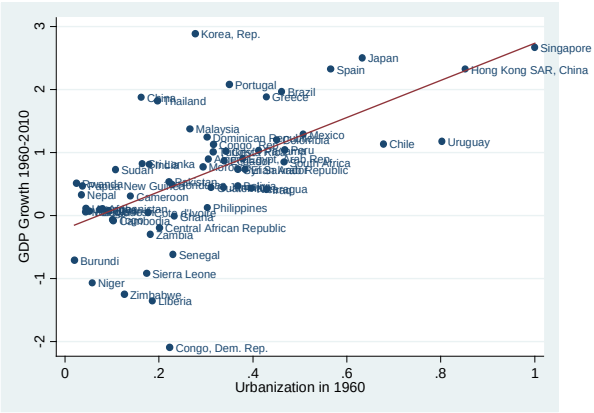


Figure 1a: Cross Country Productivity Gaps

Figure 1b: Urbanization and Growth

To paraphrase Lucas (1988), these figures suggest enormous *possibilities.* Is there something that Malawi could do, some action that its government could take, that would allow the 75% of its workers that work in rural areas in agriculture to access the productivity levels of its non-agricultural, more urban workers, increasing their productivity above that of agricultural workers in Great Britain? In this section we will try to understand whether these *possibilities* are real or

whether higher urban productivity might just reflect the selection of more skilled people or better firms into cities.[2]

Is there economic opportunity in developing country cities?

Figure 1a invites the hope that if more people lived in cities in the developing world then productivity and wages would be higher. In this section we review three classes of theories, each consistent with the facts, but which have different implications for whether these opportunities are real or merely illusory.

The first model is that more able people choose to live in cities, which would occur if people who have an absolute ability advantage also enjoy a comparative advantage at producing in cities. [3] A second possibility is that the urban wage premium is real but that the amenity losses or high housing prices ensure that there is no welfare benefit from increasing urbanization.[4] That model still suggests an urban productivity premium (for why else would private sector employers be willing to pay higher wages in cities?) but not a welfare premium for rural to urban migrants.

A third model is that city size generates positive externalities that might be static or dynamic in nature. Static externalities might occur because a larger market size encourages the entry of new

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[2] Gollin, Lagakos, and Waugh (2014) investigate and reject the hypothesis that the urban productivity advantages suggested by Figure 1a are purely measurement error.

[3] Lagakos and Waugh (2013) note that if absolute and comparative advantage are independent, then a small wedge or friction can lead to large differences in productivity between rural and urban dwellers. Bryan and Morten (2019) use a structural model that assumes that absolute and comparative advantage are uncorrelated and Indonesian data to estimate the speed with which average wages drop with movement across space. They find that the elasticity of average wages with respect to the proportion of an original population moving is around -0.039. In their setting, this implies that despite large spatial wage differences there are only moderate gains to moving people across space.

[4] In the classic Harris and Todaro model, urban unemployment is higher than rural unemployment, but urban workers earn higher wages if they are lucky enough to be employed.

product varieties, as in Krugman (1991). Dynamic externalities might occur if cities spread ideas and speed up the right kind of technological progress, as suggested by Lucas (1988).

If the urban wage premium just represents omitted individual characteristics, then there is little reason to think that moving to cities will make people or the country as a whole more productive. If the urban wage premium represents place specific assets, then moving to that area will make people more productive, but it will not have any positive effect on overall regional welfare. If the urban wage premium represents local externalities, then relocating to the area may generate benefits for existing residents or for the country as a whole. These externalities typically represent market failures.

Empirical Estimates of Agglomeration Economies

Urban workers do typically earn more, but does this represent a true effect of place or merely selection of more able people into cities? The simplest and most common approach to measuring the economic benefits of agglomeration is to run an individual level regression, where earnings are regressed on individual characteristics, such as age and education, and local characteristics, such as area density or total population agglomeration. Within the U.S., such estimates typically yield a coefficient of .05 when the logarithm of wages are regressed on the logarithm of population (Ciccone and Hall, 1996, Glaeser and Gottlieb, 2008, Ahlfeldt and Pietrostefani, 2019) meaning that wages increase by about 5% when total population or density doubles.[5] Chauvin et al. (2017) perform three comparable exercises for Brazil, China, and India, finding much larger effects of density on earnings for India and China.

Young (2013) uses Demographic and Health Survey data to construct consumption equivalents of education, and uses his data to document large differences in consumption levels between rural and urban areas in a sample of 65 countries that includes many of the poorest in the world. His results show that the urban rural wage gap accounts for about 40% of within country

[5] Combes et al. (2010) is a particularly effective paper estimating agglomeration effects in France that controls for firm characteristics and usees soil characteristics as an exogenous source of variation for density.

inequality in his sample, but he also notes strong sorting on observable characteristics which suggests that sorting on unobservables may also be important. Gollin, Kirchberger, and Lagakos (2017) document large consumption differences across density levels in twenty African countries.

To address the problem of selection on unobservable attributes, researchers have increasingly relied on migration, natural experiments, and even randomized control trials to estimate the treatment effect of place on earnings. Glaeser and Mare (2001) began the literature that estimates the urban wage premium by looking at the wage gains experienced by urban-rural migrants. The key identifying assumption is that unmeasured worker ability doesn't change over time, or at least that changes in unobserved worker ability are not correlated with moving across space. Glaeser and Mare (2001) find that workers who come to cities experience faster wage growth in the years after they move to large urban areas, which is compatible with the view that cities enable human capital accumulation. De la Roca and Puga (2017) use administrative data that enables them to follow the wage patterns of almost all Spanish workers as they move across geographies. They also find that workers who come to large cities, like Barcelona and Madrid, experience wage gains over time.[6]

In the developing world, Hicks et al. (2017) use panel data from Kenya and Indonesia to present fixed effect estimates of the urban rural wage gap. Their fixed effect estimates show that urban workers in Indonesia earn 2.8% more per hour while urban Kenyans earn 26% more.

Limited by the lack of panel data sets, other researchers have produced work surveying rural-urban migrants who moved first to impoverished neighbourhoods. Perlman (2010) starts with an initial sample of favela-dwellers in Brazil in 1969 and looks at the outcomes for their children and grandchildren. She finds that while 72% of the grandparents' generation were illiterate and 94% worked in manual jobs, only 6% of their children in 2001 were illiterate and 63% held

[6] Chetty and Hendren (2018) use income tax data in the U.S. to look at families who move across areas and establish the impact of place on economic opportunity.

manual jobs. Sixty-one percent of the grandchildren's primary job is non-manual. Alesina et al. (2019) similarly find that intergenerational upward mobility is related to urbanization in Africa.

By contrast, Marx, Stoker, and Suri (2013) examine a cross-section of migrants in a number of slums today and focus on whether the migrants who came earlier now earn more. They find no relationship between time in the city and earnings in Kenya's Kibera and a negative relationship between tenure in the city and earnings in Bangladesh's Tongi. If successful people just leave the slum then these facts may reflect the selection of who remains in the slum over 40 years, not a broader lack of upward urban mobility. Yet it is undoubtedly true that many of those who come to the city remain quite poor for decades afterwards.

A second approach has been to seek cases in which people, typically immigrants, have been literally allocated by government programs across space. Edin et al. (2004) provide a classic example in which the Swedish government directed new immigrants to particular places across Sweden. However, administrators are rarely willing to completely ignore the idiosyncratic needs of individuals, and so unobserved immigrant characteristics may well have influenced the choice of location and biased the results.[7]

Sarvimaki et al. (2019) study Finnish farmers who were forced to move after World War II and given a similar farm in a different part of the country. Relative to a comparison group who were geographically nearby, the forced migrants were more likely to be urban in the long run and had substantially higher earnings. Nakamura, Sigurdsson, and Steinsson (2016) study individuals from a wealthy fishing village whose homes were destroyed by a volcano. Using a spatial discontinuity design, this study shows that 30 years later the displaced workers were more likely to be urban, had higher education, and had much higher earnings.

A third approach has seen researchers help design social programs that provide incentives for people to move across location. The Moving-to-Opportunity experiment required a randomized share of recipients of housing vouchers to move to lower poverty neighbors in order to receive

[7] The so-called Gautreaux experiment in the U.S. is an earlier experiment where apparent administrative randomness was used to estimate the effect of place.

the vouchers. Early estimates of the program found few impacts on the children who moved out of poverty (Katz, Kling, and Liebman, 2001), but more recent work has found quite sizable impacts on the adult earnings of children who moved out of poverty at an early age (Chetty et al., 2016).

Bryan et al. (2014) take a similar approach and provide small incentives (about the cost of bus fare) for rural Bangladeshi workers to move (at least temporarily) to a nearby city. A small incentive generated a 22 percentage point increase in the number of families reporting that at least one of their family members had sought work in the city, and a sizeable impact on average household expenditure which increased by about 33 percent. The study also showed that up to three years after the small incentive was paid, treatment households were about 10 percentage points more likely to have a migrant worker from their household. This work suggests real utility gains from moving to the city, because workers continued to come to cities when the incentive was no longer available, perhaps suggesting that initial migration was limited by credit constraints Small scale experiments, however, cannot estimate the general equilibrium effects of large scale migration to the city, and may also lack external validity.

While the latter studies seem to rule out the possibility that selection explains all of the agglomeration earnings effect, they use data on migrants themselves, and so cannot look at whether urban location generates positive or negative externalities. A final form of experiment shocks the place not the person, and then looks at the impact on people who were in the place originally. Greenstone, Hornbeck, and Moretti (2010) measured the differing fates of medium density communities that did and did not receive the investment generated by a “million dollar plant.” The results suggest a 12% increase in total factor productivity for incumbent plants, indicative of strong positive spillovers that are not internalized in plant opening decisions. This work requires the place-based shock to be independent of unobserved, time-changing attributes at the place level. While the “million-dollar plant” experiment comes close, few private or public investment are completely independent of local characteristics.

Greenstone et al.’s (2010) results on agglomeration economies open up the possibility that levels of agglomeration are not optimal, but it is not clear that they are directly relevant to developing countries, where movement costs may be higher even in dense areas, and technologies are

different. As Glaeser and Gottlieb (2009) emphasize, policy requires comparing the benefits that the winning place gains from having a new plant with the losses that the losing place faces. Relocation policies require us to know the full functional form of agglomeration economies.

Imbert et al. (2018) uses variation in international agricultural prices to generate plausibly exogenous variation in earnings across rural areas in China and thus plausibly exogenous variation in the number of migrants moving to nearby urban areas. In-migration leads to a reduction in wages and value added per worker along with a move to more labor-intensive production. These results seem to suggest a standard downward-sloping demand curve rather than positive externalities from the in-migration of low skill workers.

A firm-level literature links area-level characteristics and plant productivity (Henderson, 1999). In this case, the selection problem is that more productive plants may move into more productive places. A parallel "quantities" approach looks at the co-location of industries and tests whether firms locate near other firms that buy and sell it goods, near other firms that use that same type of workers, or near other firms that exchange ideas (Ellison, Glaeser, and Kerr, 2010). In the U.S., the co-agglomeration estimates point to the importance of transportation costs for goods and people, at least in manufacturing industries.

The literature linking urbanization with dynamic externalities and national growth is smaller and necessarily less compelling. Many classic theories could also rationalize a causal effect of urbanization on growth. If fixed cost technologies required large market sizes, as in Rosentein-Rodan (1943), then urbanization could provide the "big push" that leads to industrialization. Cities might enable poorer countries to trade with rich countries. The apparent ease of shopping in Dongguan and Shenzhen's famous electronics markets for all the parts required to create a state of the art smart phone illustrates this possibility nicely. A final hypothesis is that cities enable political change, and dictatorships certainly face more revolutions in more urbanized countries.

The scale of these theories makes them hard to test. Rauch's (1993) pioneering work estimating human capital spillovers in cities was directly motivated by Lucas's paper. Henderson (2000), for example, links country-level growth and the level of urban primacy and finds a non-

monotonic relationship. The endogeneity of urbanization levels and their correlations with other growth-enhancing factors makes causal inference from cross-national data difficult.

A more plausible research path may be to examine the links between cities and the ingredients of growth, such as new patent creation and patent citation (e.g. Jaffe, Trajtenberg, and Henderson, 1993), foreign direct investment (Guimaraes, Figueiredo, and Woodward, 2000), and education (Muralidharan and Sundararaman, 2015). Sub-national data makes identification more plausible and makes it easier to see the mechanisms, if any, through which cities are enabling national transitions from poverty to prosperity.

Can developing world cities become more productive?

The simple cross-national growth correlation shown in Figure 1b warns that restricting urbanization may have adverse consequences. Yet for most developing world cities, the pressing policy questions are smaller. City governments need to know whether investment in road quality or reforming the permitting process will enhance urban productivity.

Transportation infrastructure is one obvious place to look for productivity gains. Firms operate in particular locations and they need a supply of physical space, access to workers, customers, and suppliers. Government involvement in transport infrastructure is ubiquitous because transport infrastructure has some of the characteristics of a natural monopoly (limited non-rivalry) and usually requires large-scale coordination. As the relationship between transportation, building supply, and firm productivity cannot be studied in simple partial equilibrium models, we devote Section IV to this topic.

Productivity may also benefit from improvement in the legal infrastructure that governs firm behavior. The dense urban environment - and the negative externalities it gives rise to - intensifies the need for government rules that create both the rights and obligations of firms. These rules, if too onerous, can reduce productivity (Djankov et al., 2003), but some regulations seem likely to be beneficial. Designing the optimal set of rights and obligations is difficult enough under ideal circumstances, but developing countries often have small budgets and a dearth of effective legal infrastructure (Besley and Burgess, 2000, World Justice Project, 2019).

A system that provides the ability to determine property rights also gives rise to the potential to abuse that power (Goldstein and Udry, 2008), red tape that appears inefficient and the cause of corruption may be functioning as a second best means to fund public goods in the presence of tight government budgets (Banerjee, 1997, Banerjee, Hanna, and Mullainathan, 2013) and, more generally, the enforcement of any rights or obligations needs some kind of solution to the guardians problem (Hurwicz, 2008, Björkman, and Svensson, 2009).

Research on institutional improvements requires viable actual or natural experiments and a small but growing literature now attempts to understand solutions to these problems. Khan, Khwaja, and Olken (2015) work with government in Punjab, Pakistan to randomize an incentive pay scheme that rewarded property tax collectors for the revenue they raise. They find a large increase in government revenues at little cost in terms of tax payer satisfaction or assessment accuracy. In Kyrgyz Republic, Amodio et al. (2018) provide incentives to reduce bribe-taking among business tax inspectors and found that this reduction in bribes was passed through to consumers in the form of lower prices. The work of Banerjee et al. (2014) with the Rajashthan police provides a more nuanced view. The negative results from several seemingly sensible strategies serves to remind us of the difficulty of reforming complicated institutions.

The permitting and regulatory environment will be particularly important if local entrepreneurship is a significant determinant of local success, as appears to be true in the U.S. (Glaeser, Kerr, and Kerr, 2015). Yet it is unclear if poor countries need more local entrepreneurship or more foreign direct investment. If developing world cities today will be built by new versions of Soichiro Honda, who began with a small repair shop, then improving the permitting and regulatory process for small businesses is crucial. If foreign inputs are critical, then that leads to an emphasis on making the urban environment more attractive for outside talent.

How can the economic benefits of cities be more widely shared?

Even the most productive cities often have islands of poverty amidst seas of plenty. Policy-makers often want to improve the welfare of their least fortunate citizens. For many urban leaders, the most pressing policy question is how the prosperity of a few can be expanded into the prosperity of the many.

Plato's Republic famously noted that "any city, however small, is in fact divided into two, one the city of the poor, the other of the rich; these are at war with one another." As successful cities attract both rich and poor people, the existence of urban poverty or inequality is not a sign of urban failure. The important question is whether cities are turning poor people into middle-class people or whether the poor are remaining trapped in perpetual pockets of deprivation.

The opportunity atlas of Chetty et al. (2018) documents the low levels of upward mobility for poorer children growing up in America's cities. While urban America may be productive, it does not seem to be providing much opportunity for many of its poorer residents. In China, Combes et al. (2019) find that better educated rural-urban migrants seem to experience much larger wage gains than less educated workers who come to cities, which is echoed in the U.S. by Autor (2019).

As these studies suggest, individual education is strongly linked with upward mobility in cities (Psacharopoulos and Patrinos, 2018). Schools teach children skills that facilitate communication, such as reading, writing, and grammar, and those skills then enable urban interactions. The overall level of education in a city is also strongly linked to its success, as measured both by earnings (Rauch, 1993, Moretti, 2004, Chauvin et al., 2017) and by population growth (Glaeser, Scheinkman, and Shleifer, 1995). Urban density and education appear to be complements (Glaeser and Resseger, 2010), which suggests that better education may enable poorer children to take advantage of urban opportunities.

Next Steps and Research Priorities

Policy makers in developing world cities need evidence on the strength and nature of agglomeration, and the constraints that restrain their productivity potential. First, new work should measure the size and nature of the returns to concentration across formal and informal activity. Do cities facilitate matching between firms and workers and encourage the exchange of goods and services, or are they escalators that facilitate rapid learning of new skills and techniques? For residents, how do neighborhoods and slums help or hinder access to economic opportunity and mobility across social and vulnerable classes? Second, there is a need to understand the forces that reduce these potential agglomeration benefits. Which constraints on firms —such as a lack of skills, access to input and output markets, burdensome regulations or

limited energy access—constrain labor demand and support such high unemployment amongst the young and vulnerable population? What limits workers' abilities to acquire skills and learn from employers and co-workers as they have in the developed world? And how do the specific features of developing country cities—unplanned spatial expansion, the persistence of informality across land and labor markets—drag down economic performance? Evidence on the size and nature of these forces will require a range of empirical work from RCTs and historical policy quasi-experiments to structural modeling, but the answers will help policy makers identify policies with the greatest potential to raise urban productivity.

III. Infrastructure, Institutions, Incentives and Density's Downsides

Urban proximity enables the spread of ideas and the sale of services, but it also leads to the movement of bacteria and congestion of city roads. In the developing world, urbanization has proceeded far more quickly than institutional development. Consequently, massive developing world cities must address the downsides of density, such as contagious disease, crime, and traffic congestion, with limited wealth and scarce public capacity. In this section, we focus on three central downsides of density: pollution, congestion, and crime.

We begin by discussing the costs of different urban harms and then explore several central themes that cut through the policy responses to most urban disamenties, such as behavioral responses to policy changes, social returns to infrastructure and public capacity. We then apply these more general ideas to the topics of housing, planning, municipal finance and water and waste management. We end with a brief discussion of climate change and sustainability.

What are the social costs of urban contagion, congestion, and crime?

The first and most basic task is to estimate the size of the costs created by urban disamenities. This question is particularly crucial for policy-makers with limited time and resources, who are trying to focus on the urban problems that do the most harm. If air pollution does little damage, but bad water causes enormous illness, then policy-makers may want to invest more in water systems. Conversely, if air pollution is more harmful, then policy-makers may want to turn their regulatory energy towards the factors and vehicles that belch smoke into the air.

The economics literature on the impact of urban air pollution is large and compelling. The air pollution literature has focused on the adverse health consequences of bad air quality. Currie, Neidell, and Schmeider (2009) examine air quality monitor data in New Jersey and find that infant health suffers as air quality deteriorates. One challenge with this work is that poorer people, who are sicker for many reasons, live in places with worse air. The authors address this issue by looking at air quality changes over time for a panel of families. Alexander and Schwandt (2019) look at air quality deterioration that is associated with cheating on automobile inspections and find that bad air increases asthma and decreases birth weight.

While these papers focus on the U.S., there is also a literature, surveyed by Currie and Vogl (2013), that looks at developing world cities as well. Arceo-Gomez, Hanna, and Oliva (2016) find that bad air quality has more serious effects in Mexico City than in the U.S. Cesur, Tekin, and Ulker (2017, 2018) show that switching from coal to natural gas led to air quality improvements in Turkey, which in turn improved health outcomes for children and adults.[8] A smaller literature links air pollution to economic outcomes, such as labor supply, and also finds negative effects of air pollution (Hanna and Oliva, 2015, Fan and Grainger, 2019).[9] At the city level, air pollution can also harm the local economy by repelling skilled high-productivity individuals (Kahn, 1999).

Among economists, Cutler and Miller (2005) and the work of Werner Troesken (e.g. Troesken, 2008) has been particularly important in establishing the historic link between water infrastructure and public health. More recently, there has been a dramatic increase in the work of economists on water in the developing world. Gamper-Rabindran, Khan, and Timmins (2010) found that piped water decreased infant mortality in Brazil. Devoto et al. (2012) found that piped

[8] Quah and Boon (2003) place a dollar value on health outcomes with tools like multiplying mortality estimates by the value of a statistical life.

[9] Heath, Mansuri and Rijkers (2018) find that high frequency health shocks significantly reduce female labor supply.

water in urban Morocco increased happiness, but not health, presumably because families already had access to high quality non-piped water. Buchmann et al. (2019) find the particularly striking result that a health campaign to reduce exposure to arsenic-contaminated water increased infant mortality by inducing households in Bangladesh to switch to water sources with higher fecal contamination.[10]

As traffic congestion is defined by excessive time spent in travel relative to driving on an uncrowded road, economists have valued this lost time by multiplying minutes lost by the after tax wage (Alonso, 1964). More sophisticated papers have used survey instruments and found that the cost of time spent in traffic is lower than lost wages (Calfee and Winston, 1998).[11] Investment in transportation infrastructure may lead towards urban growth (Duranton and Turner, 2012) or suburbanization (Baum-Snow, 2007). While reduced form methods can estimate these impacts, interpreting those estimates requires the structural models that we will discuss in Section IV.

Most urban leaders accept on faith that reducing crime, and particularly violent crime, to wealthy country norms is desirable. Government have, after all, long sought a monopoly on violence. Consequently, the economics of crime and punishment has rarely focused on the costs of crime, but has instead tried to estimate the impact on crime of different policies, such capital punishment (Ehrlich, 1975), more policing (Levitt, 1997) and lengthier prison sentences (Kessler and Levitt, 1999).

The most standard approach to estimating the costs of crime is to estimate the loss to the victims of crimes that do occur (Chalfin, 2015), so that murders cost millions and robberies cost

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[10] The economics literature on solid waste management remains as limited as the literature on water before 2000. There is however a sizable epidemiological literature that finds robust correlations between disease and proximity to a wide range of solid waste (Giusti, 2009).

[11] While U.S. studies typically assume that traffic speeds in the absence of the congestion would have been the speed limit, the poor quality of roads in the developing can reduce travel speeds considerably even in the middle of night (Kreindler, 2018).

hundreds. These costs may overestimate the true social cost of crime because they omit the benefits of crime to the criminal, but it seems far more likely that they underestimate the costs of crime because they neglect fear and avoidance behavior.[12] Ludwig and Cook (2001) use a contingent valuation survey to estimate the willingness to pay to live in communities without fear of crime. Hedonic price models can also use the difference in housing prices between safe and unsafe areas to estimate the social losses due to fear of crime (Thaler and Rosen, 1976). Most estimates find that urban crime, unsurprisingly, generates significant costs, including spurring out-migration (Cullen and Levitt, 1999) and reducing tourism (Biagi and Detotto, 2014).

Incentives and Behavioral Change

Much urban infrastructure, such as subways and aqueducts, can be interpreted as adding effective space to a city where space is scarce. Yet adding infrastructure may not be as cost effective as reducing the behavior, especially when added infrastructure induces more socially harmful behavior. Duranton and Turner (2011) empirically document the "Fundamental Law of Highway Traffic," which is that vehicular miles travelled increase roughly one-for-one with highway miles built. If this law holds, then building more roads does little to solve traffic problems, because new drivers will congest the new roads. Consequently, the problems associated with density often need some combination of infrastructure and incentives.

The crime and economics literature has long asked whether incentives can reduce harmful behavior (e.g. Ehrlich, 1975, Levitt, 1998, Nagin, 2013), but much of this U.S. based literature may not translate easily to developing world cities. While over 50% of murders typically lead to an indictment in the U.S., under 15% of murders in Brazil are solved (Misse and Vargas, 2007). Corruption, malfeasance, and gang power may be worse in developing world cities.

[12] When person A steals person B's bicycle, then presumably this is a transfer from person B to person A rather than a pure loss of welfare. Applying this logic to murder, however, is somewhat more problematic, since even if person A receives some psychic benefit from killing person B, few observers would be willing to include murderous enjoyment as a reasonable element in any social welfare function.

The pollution and congestion literatures focus more on the impact of regulations than on flexible incentives. Davis (2008) documents the impact on air quality in Mexico City of the Hoyo No Circula program, which limited cars ability to drive on certain days. Kreindler (2016) similarly shows that license-place based bans on driving effectively reduced congestion in Delhi.

The introduction of congestion pricing in London, Stockholm, Oslo and Singapore all provide case studies on the impact of pricing roads. Typically, the best that can be done with these interventions is to compare before and after congestion pricing, and it does appear that London's roads become more passable after it imposed its congestion charge (Leape, 2006). Yet it is not obvious the results for London will generalize to Jakarta, as in Hanna, Kreindler, and Olken (2018).

Kreindler (2018) estimates a model of demand for driving trips in Bangalore using an experimental structure where individual drivers were randomly offered incentives to avoid peak times on crowded roads. Strikingly, he found that the behavioral adjustment was modest, and Indian roads wouldn't flow that quickly even if congestion was reduced substantially. This type of experimental model has promise, yet any small experiment will shortchange the general equilibrium effects that are ubiquitous in cities.

In congestion, the key behavior that can reduce the benefits of new infrastructure is driving. In public health interventions, the usual problem is take-up where people choose not to pay connection fees that cover the "last mile." Ashraf, Glaeser, and Ponzetto (2016) note that both in New York City history and in African cities today poorer citizens were often unwilling to pay the marginal cost for connections to cleaner water sources. One empirical question is whether they will connect if given subsides, or whether penalties imposed on people who don't connect will be more effective.

Estimating the Social Benefits of Infrastructure

Randomized control trial methods are much harder to implement for infrastructure than for incentives because infrastructure impacts an area and because randomly relocating infrastructure is cost-prohibitive. In some cases, simple difference-in-difference methods can estimate the impact of infrastructure, as Alsan and Goldin (2019) did for sewerage in greater Boston or

Duranton and Turner (2011) did for roads within the U.S. Yet these estimates may tell us little about any particular new project in Delhi or Nairobi.

The primary tool that economists have brought to infrastructure is cost-benefit analysis, which attempts to catalogue the gains and losses from building new roads, tunnels, and sewerage systems. Typically, this work brings together the knowledge of economists and engineers, as in Meyer, Kain, and Wohl (1965). A central result of the early forays into urban infrastructure analysis was that bus systems, sometimes on dedicated lanes, are far more cost effective than rail systems. This analysis helped inspire the Bus Rapid Transit (BRT) systems that have been implemented in Curitiba, Bogotá, and elsewhere.

In early years, the benefits of infrastructure largely focused on the benefits gained by users directly. Infrastructure boosters then forecast high projected ridership levels which were disputed by economists (Kain, 1992). User fee financing creates some fiscal discipline, since projects are expected to cover their costs, but if user fees are too low to pay for total costs or even operating costs, then that discipline vanishes. Low fees are typically justified because marginal costs are below average costs or because of a desire to redistribute to poorer infrastructure users. As infrastructure investment increasingly relies on alleged agglomeration benefits, the scope for overselling becomes even larger, which only increases the need for the rigorous structural modelling that we discuss in Section IV.

New infrastructure projects are often given precedence over maintenance, which is especially problematic if there are particularly high returns to maintaining older roads and bridges (Gramlich, 1994). While World Bank statistics claim that Lusaka, Zambia, has almost complete water connections, in practice some areas of the city seem to lack viable connections much of the time (Ashraf et al., 2017). The quality of the management of infrastructure will depend on institutions and incentives. Ashraf et al. (2017) show that the water company in Lusaka is much quicker to respond to supply problems for customers who pay by the liter than for customers who pay by the month. We turn now to the institutional side of urban management.

Institutional Reform and Public Capacity

Public institutional capacity is a precondition for any meaningful reform, but it is often difficult to use modern empirical methods, like randomized control trials, to understand paths towards better institutions. Some studies measure whether changes in incentives can alter the behavior of public officials. Muralidharan and Sundararaman (2011) show that Indian teachers appear more often when pay is linked to performance. Ferraz and Finan (2011) show the Federal auditing of mayors in Brazil reduces corruption. Yet the impact of any incentives can easily be distorted in a corrupt institution, so that proving that an innovation can work is not the same as showing that it will actually change institutional performance.

Most work on the institutions that matter for developing world cities is descriptive or involves simple comparison. For example, Engel, Fischer, and Galetovic (2014) present a magisterial overview of Public Private Partnerships (PPPs) throughout the world. Their work typically reviews the performance of PPPs and sometimes compares that performance with governmental alternatives. Singh (2018) presents a similar, persuasive study comparing road roughness on Indian roads that are maintained by public and private entities. In that case, the private roads are far smoother than their public alternatives.

More generally, private provision of public services has a far more mixed track record. As Engel, Fischer, and Galetovic (2014) show, private companies often manage to renegotiate with public entities and radically increase their compensation. Theoretically, private entities should have better incentives to maintain quality because they can only reap returns if customers use them, but in some cases, even quality is poor. Certainly, private entities that are paid with public money have a strong incentive to subvert the system and extract more public resources.

While much institutional research focuses on the executive branch, the judiciary is also critical, for every market failure is ultimately a failure in the maintenance of property rights (Coase, 1960). If courts fail to protect land rights then people lack the incentives to develop that land. When courts fail, ordinary people waste time protecting their property from expropriation (Field, 2007).

Property rights over urban land are actually a nexus of rights including the right to use, the right to develop, the right to sell, the right to rent, and the right to mortgage. In many developing world cities, these rights are far more fragmented than they are in the west. For example, the

residents of informal settlements may well be protected in their right to use a particular piece of land, but since they have no title, they cannot sell that land or mortgage their property to start a business (de Soto, 2000). Economic theory makes predictions about the impact of limitations on property rights, but there is little research that fully teases apart the impact of partial control over urban land.

Housing, Planning, Public Finance, and Water and Waste Management

Four large policy areas relate to the downsides of density and the issues that we have just discussed: local finance, water and waste management, housing and urban planning and zoning. We now briefly discus the ways in which public capacity, behavioral responses and cost-benefit analysis play out in this core areas of urban policy-making in the developing world.

Municipal finance is particularly central to almost all efforts to improve urban quality of life. If a city can't raise public funds, then it will have trouble providing better police or fix potholes or manage waste. A city without public capacity it may find it difficult to collect the tax that it needs to fix its public capacity problems. Consequently, cities can get caught in a low capacity/low revenue trap that may be particularly problematic. Consequently, it is particularly valuable to learn whether some taxes, such as simple land value taxes, are easiest to collect in weak capacity environments.

Naturally, the ease of collection needs to be traded off against the other behavioral distortions induced by particular tax rates. There is a large literature on the behavioral impact of different tax rates in the wealthy world. The literature is smaller in the developing world, and there is a particularly a need to understand what taxes particular deter workers and firms from entering into the formal sector. The long run research goal should be to generate serious cost-benefit analysis of different taxes by combining evidence on implementation challenges with evidence on the magnitude of distortions.

When cities fail to provide decent waste and water management, their residents face the ancient urban scourge of contagious disease. The externalities that come from disease and waste disposal explain why governments have been engaged with these issues at least since Rome built is Cloaca Maxima under the Tarquin kings. Households appear to have a greater willingness to

pay for better water than to pay to dispose their waste, because it is their neighbors who largely pay from accumulated rubbish and excrement, but more research estimating private willingness to pay for water and waste management is important. Such work needs to be combined with larger estimates of the costs of water and waste management failure to understand the total benefits of provides better services. The gap between total benefit and private benefit can help inform any public decision either to subsidize adoption of better services or to tax non-adoption of those services.

Since water and waste management typically involve significant infrastructure, these policy areas also involve institutional choices. When should these services be provided be governments and when should cities turn to private provision? How does the institutional nature of service provision determine service quality and access? Are there particular local characteristics, such as public capacity, that should shape the choice of institutional forms?

Cities typically manage their physical land areas, both through land use planning and housing policy. These policy actions can have profound long-run impacts on housing costs, urban mobility and the very shape of the city. Once again, policy action should be informed by basic studies that estimate the far-ranging impacts of planning decisions. The decision to provide public funding for housing can become better informed if there are better estimates of the long-run impacts of such housing on economic and social outcomes for its residents.

Access to public housing can be evaluated through randomized-control trials, but changes to zoning rules are far more complex to evaluate. As local land use rules can have complicated impacts that reverberate through the city, the structural models that we discuss in the next section seem particularly well suited for evaluating those rules. A final important question concerns the institutional choices for housing and planning authorities. How can public entities acquire the capacity to do these tasks well?

Cities and Climate Change

We end this section by noting the particularly critical issue of climate change, which may end up generating large costs for many of the world's cities. Holding wealth constant, urban density is associated with lower, not higher, carbon emissions (Glaeser and Kahn, 2010). Moreover, many

of the risks associated with climate change are far larger for subsistence farmers than for urbanites who are enmeshed in a global trading system, where food can be provided by formerly colder areas that may become more productive due to climate change.

Kahn (2010) argues that poorer countries will be able to adapt to climate change by moving population centers inland and towards higher elevation areas. As long as sea levels rise slowly, the adaptation process that Kahn envisions may be plausible. But if climate change is related to rare natural disasters, such as cyclones and tidal waves, then cities – particularly those in coastal areas – face tremendous risk.

Next Steps and Research Priorities

The unique nature of density's downsides in the developing world suggests that porting solutions from high income cities may be at best sporadically successful. More evidence is required to understand these downsides of density and the policies best-suited to limit them. Perhaps the most pressing question is how can sanitation and health services be provided to effectively maintain public health and a clean environment.

Second, can governments facilitate functioning land markets to allocate space efficiently and housing for lower income residents? There are a rich variety of housing policies, such as public housing projects, slum upgrading programs, and land readjustment, but we have limited evidence on the efficacy of many of these programs. One research agenda is to better evaluate the impact of these programs on resident welfare, land prices, productive activity and fiscal costs. Evidence on the effect of land use regulations, including rules that promote or reduce economic inclusion, would also help policy-makers understand the costs and benefits of those policies. Ideally, we would want to understand the consequences both for housing costs and for a wider range of social outcomes.

Third, research is badly needed on urban mobility. The costs of congestion, which include not only hours lost to traffic but also distortions in the land and labor markets, appear to be considerable. There is a dearth of evidence surrounding the informal networks that dominate transit in African cities. Can regulation or new technology improve its performance? Can these networks complement the more expensive mass rapid transit being introduced across the

developing world? Is it more cost-effective to invest in improving those networks or to introduce traditional mass transit systems? What do new technologies like ride sharing pose for the future of mobility in these cities?

Fourth, the challenges in managing and financing service provision suggest a great need for research about the functioning of government itself. Are there ways to enhance existing tax enforcement and compliance? What can new instruments, such as programs that capture land value, do for areas low state capacity and high rates of informality?

IV. The Structural Approach to Transportation and Land Use

To many architects and land use planners, the city is synonymous with the built environment. While urban economics emphasizes that cities are better seen as massed humanity, the physical city is still profoundly important. Land-use planning plays a particularly central role for many city governments. Yet typically, economists have had little to say about efficient land use rules or the costs of bad planning. The growing field of formal spatial modeling offers the possibility of delivering pragmatic tools that can help policy makers to plan better and more fully anticipate the far-ranging impacts of any large scale change to the built environment.

The randomized control trial approach to development economics is ideal when considering targeted interventions that are akin to medical drug trials. Large scale urban investments are more akin to macroeconomic policies, like changes to monetary or fiscal policy, that reverberate throughout the layers of the economy. Just as macroeconomics has turned to simulations using tools like dynamic stochastic general equilibrium models, urban economics has begun using complex structural models that largely rely on simulations to understand how new investments or policies will change life within a city.

The Basic Form of Structural Urban Models

The first wave of urban models made drastic simplifications that reduce cities to a sequence of locations that differ only in their distance to a central business district (Alonso, 1964, Mills, 1967, Muth, 1969). A day spent exploring a real city's streets shows how this belies the

immensely rich spatial differences that make cities so complex and interesting. Economic activity, in fact, occurs in locations that vary in air quality, crime rates, infrastructure, and access to shops and restaurants. Recent models have combined rich spatially disaggregated data with tools from the trade and economic geography literature to confront this richness head on (see Redding and Rossi-Hansberg (2016) for a comprehensive review). These frameworks allow researchers to quantify the aggregate implications of economic policies, assess how their impacts reverberate through agents' behavioral responses and linkages across space, and simulate the effect of counterfactual policies to evaluate how competing approaches might best achieve policy goals.

Quantitative models consist of a series of building blocks whose elements are chosen to fit the focus of the research question and the type of data available: geography, workers, firms, the supply of land and housing, and general equilibrium conditions.

The geography of a city is comprised of a large number of discrete locations (such as census tracts or blocks). They differ in attributes such as the time it takes to commute to every other location, the supply of land available, and other exogenous characteristics (such as views, access to roads, or the type and slope of land) that affect its amenities, productivity, or the cost of housing development.

Workers must choose where to live and work across pairs of locations. This choice depends on attributes that determine how attractive locations are to live in (e.g. their level of amenities and residential floorspace prices), work in (e.g. the wage paid by firms), as well as on the cost of commuting between each pair. Depending on the model, residents can differ in their attributes (such as education or location of prior residence; Tsivanidis, 2019, Bryan and Morten, 2019), may make additional choices such as where to shop or which mode of transit to commute with (Allen, Arkolakis, and Li, 2015), and often have idiosyncratic preferences for each live-work pair (generating upward sloping resident and labor supply curves as functions of location attributes; Ahlfeldt et al. 2015).

Firms similarly must choose their locations. Production can potentially take place in every location, and depends on characteristics like productivity, access to labor, and supply of

commercial floorspace. Technologies can allow for perfect or imperfect competition, constant or increasing returns, fixed or free entry (Redding 2016), multiple industries (Caliendo, Dvorkin, and Parro, 2019), and differing extents of firm mobility (Fajgelbaum et al., 2018).

Housing supply and usable production space is constructed by developers using capital and developable land available in each location. Land use is determined by land owners who trade off the return to residential or commercial use, potentially subject to zoning restrictions (Ahlfeldt et al. 2015).

These individual optimization decisions are then connected through general equilibrium market clearing conditions that equate the demand and supply for each factor in each location and pin down prices. For example, equating the demand and supply for labor and floorspace determine wages and house prices respectively. These models also allow for externalities: the level of productivities, amenities, or travel time across (pairs of) locations are often endogenous (Ahlfeldt et al. 2015; Fajgelbaum and Schaal 2019). In this case, the levels of these variables taken as given by agents must be consistent with equilibrium choices.

Once the researcher fully specifies the model, three steps must be taken in order to conduct quantitative analysis. First, the "deep" parameters assumed to be invariant to the counterfactual policy must be estimated. These typically consist of elasticities that govern, for example, the sensitivity of commute choices to commute costs or of housing supply to housing prices. Second, the model's unobserved location characteristics (such as amenities and productivities) must be recovered. These models are typically exactly identified, so that there exists a unique mapping from observed data (such as residence, employment, and house prices in each location) to unobservables given the model's deep parameters. Third, the researcher can use the now-identified system of equilibrium equations to simulate the effects of alternative policy scenarios (such as new transport infrastructure or zoning regulations) on the full urban equilibrium.

What's different about the developing world?

The majority of these models have been developed within the contexts of cities in rich countries. Should we expect the results of frameworks built to fit Chicago or Berlin to port to Mumbai or Nairobi? Transit and land use are vastly different in cities of the emerging world characterized by poverty, informality, and coordination problems. The options available to financially and capacity constrained governments also differ. We now discuss recent work that has sought to adapt quantitative models to the context of cities in the developing world, and outline areas of promise for future work.

Bus rapid transit (BRT) systems have quickly become a popular alternative to subways in developing country cities. They provide similar reductions in commute times at a fraction of the construction cost. New public transit such as BRT may also have profound distributional implications, since the poor rely on public transit that is often slow in these settings due to the oversupply and lack of coordination amongst informal minibuses. In his analysis of the world's largest system in Bogotá, Colombia, Tsivanidis (2019) develops a model that allows for multiple skill groups of workers with non-homothetic preferences over different modes of transit. By accounting for the impacts of transit on the residence, employment, and transit mode choices of heterogenous workers, Tsivanidis uses the model to trace out the system's impact on aggregate performance not only through reducing time lost in transit but also by improving the allocation between workers and places of employment and residence. He finds the welfare gains are 20-40% larger after accounting for reallocation and general equilibrium effects.

Quantitative models can provide insights into what other policies might complement expensive infrastructure to maximize returns on investments. Tsivanidis shows the feeder bus system that reduces the last-mile problem of getting residents from poor, dense neighborhoods at the city's edge to the BRT improve welfare more than any single trunk line. He also runs a counterfactual exercise to show that welfare gains would have been 18% larger had the government implemented a land value capture scheme in which zoning densities were increased near stations with permits to build auctioned off to developers. Revenues from the permit sales would have covered around 10-40% of construction costs depending on the extent of in-migration from the

rest of Colombia.[13]Future work needs to incorporate more features of transit in developing country cities. First, we require evidence that quantifies the wider costs of congestion through distorting the behavior of firms and residents. New infrastructure may have different effects in Nairobi or Lagos than in Berlin or Bogotá due to the vast informality of jobs and housing.

Second, these models need to confront the fact that the vast majority of public transit is informal. Tools from industrial organization combined with recent work on routing and congestion (Allen and Arkolakis, 2019, Fajgelbaum and Schaal, 2019) should be used to understand how this industry responds to mass transit interventions, how policy makers can ensure it complements rather than competes with it, and what other forms of regulation could improve its performance.

Third, new technologies such as ride-sharing are changing the nature of mobility in cities. Work is needed to understand how developing country-specific variants such as motorbike hailing or Uber bus will impact mobility, demand for cars, and existing public transit services.

Land markets in developing country cities are characterized by a high rate of informality. To understand patterns of land use and density in these contexts, Henderson, Regan, and Venables (2016) develop a structural, dynamic, monocentric city model that allow for formal and informal construction. They use the estimated model to infer high costs of converting slums to formal use. Gechter and Tsivanidis (2018) develop a quantitative model that allows for formal and informal housing. They use the framework to quantify the implications for both equity and efficiency of the redevelopment of Mumbai's 58 textile mills during the 2000s. This increased the stock of formal housing in the city center but also displaced poor residents from nearby slums whose homes were converted following ensuing house price appreciation.

Quantitative models are well-placed to help inform policy makers about the consequences of zoning or land use policies. Allen, Arkolakis, and Li (2015) develop a model that allows them to characterize optimal zoning across residential and commercial use around an observed

[13] See Suzuki et al. (2015) for a comprehensive review of land value capture instruments.

equilibrium. Since agents do not account for the externalities arising from colocation in space, applying their framework to Chicago the authors find too little specialization of land use with excess residence (employment) in the city center (outskirts). Bird and Venables (2019) apply a similar framework to evaluate the impact of tenure reform in Kampala.

The prevalence of rent control, density restrictions, mixed use zoning, and minimum floorspace requirements for formal housing sector construction in developing country cities suggests a need for more work in this area. Governments will also spend vast sums on housing investments that reshape the structure of cities, from slum upgrading (Harari and Wong, 2018) to constructing massive new housing developments at the urban periphery (Franklin 2019). Quantitative work should strive to understand the trade-offs, equilibrium implications, and unintended consequences associated with this menu of options.

The degree of shared prosperity that arises from transit and housing policy also depends on the sorting response of residents. Will new transit or slum developments that increase surrounding property prices simply benefit rich land owners and displace poor renters? Tsivanidis (2019) shows that Bogotá's BRT increased the spatial segregation between low- and high-skilled workers, a feature that is replicated by the model due to the non-homothetic preferences for residential amenities. Couture et al. (2019) develop a model with non-homotheticities and find that sorting responses and endogenous amenities amplified the increase in wealth inequality in the US since 1990 by 1.7 percentage points in terms of welfare inequality. More work to understand the sorting of residents in developing country cities and its implications for the distributional consequences of spatial policies is clearly needed.

Lastly, these models should address the coordination problems particularly salient in land markets of the developing world where urban growth is typically haphazard, unorganized, and sprawling. Motivated by the ring of vacant land surrounding Detroit's central business district, Owens, Rossi-Hansberg, and Sarte (2019) highlight the coordination problems between residents and developers in the presence of residential externalities. When amenities depend on the number of residents, land may remain vacant even if its fundamentals are sound. Dynamic inefficiencies may arise, for example, if land use is sticky and agents fail to internalize

agglomeration externalities in production. As more migrants arrive in a city, it may simply run out of large enough plots to allow for concentration of large manufacturing plants in accessible areas.[14] Empirical work by Brandily and Rauch (2018) and Michaels et al. (2018) highlight the dynamic consequences of land use planning in African cities. The dynamic quantitative models of Desmet and Rossi-Hansberg (2015) and Caliendo, Dvorkin, and Parro (2019) could be extended to understand these effects.

Providing Better Parameter Estimates to Make Structural Models More Useful

If quantitative models are to provide useful policy insights, their results have to be trusted. First, researchers must establish that their model captures relevant features of the data or (ideally) can replicate the real-world response to a policy change. Second, they must provide credible estimates of the model's "deep", policy-invariant parameters. The increasing availability of new, large-scale sources of data in developing country cities provides an immense potential to validate and estimate these models in the contexts of quasi-natural experiments or, occasionally, through randomized interventions.

The most basic form of model validation involves showing key parametric relationships defined in the model capture the salient features of the data relevant for the question at hand. For example, if a model is used to simulate the impact of new transit infrastructure then the relationship between commute times and behavior posited by the model should provide a tight fit to the data. Ahlfeldt et al. (2015) and Monte, Redding, and Rossi-Hansberg (2018) show how the log-linear gravity equations for commuting and migration delivered by their models fit the data in Germany and the United States respectively.

Our trust in these models increases if they can replicate the response of cities to real-world policy changes. Heblich, Redding, and Sturm (2019) estimate a quantitative model using one year of

[14] Gollin, Jedwab, and Vollrath (2016) discuss the service-led nature of urbanization in African cities which has missed the higher rates of industrialization commensurate with urban growth in other continents.

data from historical London, and then feed in a sequence of new commute times induced by the expansion of the city's railway system over an eighty year period. They find the model is able to replicate the gradual concentration of employment in the city center despite not being targeted in estimation. Tsivanidis (2019) shows that in a wide class of gravity models, the impact of changing transit infrastructure on equilibrium outcomes such as population or house prices is summarized solely by its effect on model-defined measures of accessibility. These models predict these relationships to be log-linear. Using the variation in accessibility provided by the construction of Bogotá's BRT, he shows this is precisely what occurs in the data. Future work should leverage increasingly available high frequency data discussed below to incorporate pre-analysis plans into structural work. If researchers can show that quantitative models accurately predict the effects of new infrastructure or other policy interventions they have yet to see, the model's insights will become yet more believable.

The next task is to credibly estimate the model's parameters. Some randomized interventions do exist. Akram, Chowdhury, and Mobarak (2018) assess the equilibrium impacts of urban emigration on rural villages by randomly varying the fraction of residents offered transport subsidies. Brooks and Donovan (2019) randomly construct bridges across Nicaraguan villages to evaluate their effects through reducing the market access risk posed by seasonal flash floods. In a more urban context, Gonzalez-Navarro and Quintana-Domeque (2016) exploit randomization in road upgrading across Mexican neighborhoods to examine its impact house prices.

A second approach is to estimate the parameters of a structural model by matching reduced form coefficients from (quasi-)experimental settings. Fogli and Guerrieri (2019) examine the extent to which spatial sorting and neighborhood effects amplify wealth inequality. The authors estimate the parameter governing the strength of neighborhood effects by ensuring a one standard deviation increase in neighborhood quality as a child delivers a 10% higher income as an adult in

their model simulations, precisely the estimate from Chetty and Hendren (2018).[15] Randomized housing interventions in developing country cities, such as the Ethiopian public housing lottery studied by Franklin (2019), could provide new sets of relevant estimates to calibrate these models.

The third and most common approach is to use quasi-natural experiments directly as sources of identifying variation. This has long been popular in trade and economic geography (Donaldson and Hornbeck, 2016, Donaldson, 2018) but has become increasingly popular in urban economics. The seminal work by Ahlfeldt et al. (2015) exploits the construction and fall of the Berlin wall as quasi-random variation in the density of economic activity. This allows them to estimate the strength of agglomeration spillovers across space. Recent examples in Colombia and India use large scale transit and land use policy changes to estimate quantitative urban models in poorer countries (Tsivanidis and Gechter, 2018, Tsivanidis, 2019).

Quantitative work has so far focused on rich countries due to data availability, but new sources of large-scale data will allow researchers to increasingly take this class of models to cities of the developing world. Machine vision techniques have opened up the possibility of using daytime satellite imagery to measure slums (Gechter and Tsivanidis, 2019) and urban areas (Vogel et al. 2019). Google Streetview can be used to predict income (Naik et al. 2015). Cellphone metadata, Google Maps, and credit card data can be used to measure commute flows, congestion, and consumption across space (Blondel, Decuyper, and Krings, 2015, Kreindler and Miyauchi, 2019, Akbar et al., 2019, Donaldson et al., 2019).

These datasets nevertheless have drawbacks, often related to sample selection. The people or countries who use cellphones and credit cards may be very different to those who do not. This threatens to bias analyses, and runs the risk of steering urban work towards higher income

[15] Faber and Gaubert (2018) estimate the spillover parameters of a quantitative spatial model in Mexico through an indirect inference approach that ensures the coefficient from an IV regression of employment on tourism attractiveness on data generated from their model matches that from the reduced form analysis.

settings where digital traces are available. While large scale administrative datasets pose promise (albeit with their own concerns of misreporting), there remains huge value in primary collection efforts to uncover high-quality, representative data to complement and validate those from alternative sources.

Structural work has limitations. These models make strong functional form assumptions for tractability that are typically log-linear. Parameter estimates will therefore reflect first order approximations around an observed equilibrium, but may no longer be invariant to large policy changes considered in counterfactuals. Slight deviations from these functional forms may deliver very different policy implications (Glaeser and Gottlieb, 2008). Static models used to evaluate the impact of transit infrastructure, for example, may ignore adjustment costs involved in individuals relocating from one neighborhood to another or the larger impacts this churn may have on children. The results of structural models should therefore provide one additional input to inform policy by quantifying the effects of alternative options along clearly stated dimensions, rather than act as a sole guide to policy decisions.

Next Steps and Research Priorities

Two classes of research questions are particularly well-suited to the structural approach. The first is one in which spillovers, linkages and general equilibrium effects may be important but hard to disentangle from reduced form analyses. For example, investments in infrastructure, housing stock or public goods like education may induce a host of sorting responses by households and firms as well as feedback effects through prices. The second is one in which policy makers seek to understand the aggregate impacts of recent policies or potential impacts of future reforms. How large are the aggregate gains and tax revenues from infrastructure investments? Given the unplanned expansion of cities, is the current spatial configuration of the city (such as the location of ports, markets and schools in central areas) efficient given the current urban organization and the opportunity cost of allocating that land to other purposes? These are first order questions where parsimonious models estimated using developing country city data are well-positioned to develop new insights.

V. Conclusion

The population of the world's poorest cities is growing massively and will continue to expand for decades. The existing empirical evidence suggests that agglomeration economies may be particularly large the developing world, which suggests that urbanization can provide a pathway from poverty to prosperity. Large cities in Africa and South Asia have long been conduits from poor countries to rich countries that enable trade and the spread of knowledge, crucial ingredients for long-term growth.

Yet even when rural-urban migrants come for economic opportunity, many of them remain poor and live in slums for decades (Marx, Stoker, and Suri, 2013). Slum dwellers often face risks from both criminal gangs and contagious disease. Many urbanites struggle with long commutes and relatively high housing costs. More effective government may be able to alleviate these downsides of urbanization, and more research is needed to learn how to make government more effective. One great hope is that the process of urbanization itself will lead to improvements in governmental accountability and competence.

We conclude this paper with one clear message. The cities of the developing world are the stage on which the lives of billions will be played out. These places are vitally important to the future of the world and deserve far more research. Two-thirds of Africa's cities are yet to be built. If these cities can be made safer and more efficient, then the prospects for Africa's economic growth could be enormous.

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