The Economics of Urban Form: A Literature Review

United Nations Human Settlements Programme (UN-Habitat)

Contents

Executive Summary 3
Introduction 4
Density: Established Costs and Benefits 5
Trends 5
Low density cities 7
High densities 8
Centricity: An Unresolved Debate 10
Trends 10
Monocentricity 10
Polycentricity 11
Mixed Use Development 13
Effects of Policies 14
Equity Considerations 15
Concluding Remarks and Recommendations 16
Appendix 1 - Figures 19
Appendix 2 – Policy Applications 21
Consulted References 22

Executive Summary

This review compiles literature on the economic costs of urban form, as defined by density, centricity and city size. It shows support for the general conclusion that high-density monocentric forms and high-density polycentric forms offer the best balance of low transportation and infrastructure costs, low environmental impact, and high income-generation abilities. However, it is worth noting that polycentric cities are not as well understood as monocentric cities, and they may be an efficient way of mitigating the costs of density w hile still reaping the benefits. Currently, trends in both developed and developing urban areas point to de-densification and increasing decentralization and fragmentation, existing simultaneously with growth of both population and land-area.

The economic costs of moving towards lower densities include increased transportation costs, increased greenhouse gas emissions per capita, and rising obesity rates, in conjunction with decreasing productivity. The costs associated with high-density levels include congestion and high land prices. Ultimately, however, more economic benefits than costs are present in high-density areas, especially in less developed countries. Regarding polycentricity, the current process of decentralization, combined with de-densification, is inefficient, provides low levels of public transportation, and increases the mileage of commutes. However, there is evidence that higher density polycentric forms are the best way to minimize costs of high densities and large populations while maintaining benefits arising from these same characteristics.

The effects of varying levels of city size are interdependent with the effects of density and centricity. Increases in city size are understood to correlate with higher wages, higher proportions of educated citizens, and higher productivity. These result from economies of agglomeration, which are reliant upon increased proximity and scale afforded by larger cities. Given the importance placed upon context in this work, there is understood to be no uniformly optimal city size, but efficiency in city size is dependent upon local features and constraints.

Due to the costs associated with the movement towards low densities, de-densification and larger city sizes, there is a drive to craft policies to reverse or contain current trends. These are often unsuccessful, and impose unintended costs. However, policies addressing market failures, specifically those adjusting prices for congestion, development, and environmental impact, show promise. Similarly, the policy environment of a city (*e.g.* centrally-planned versus market-oriented) can also be leveraged to have positive effects. Ultimately, cities must contextualize their policies within the challenges of path dependency, political recalcitrance, and the durability of fixed capital investments, and they must consider the characteristics of the built environment, and social and equity concerns, before policies addressing form can bear fruit.

Introduction

The positive relationship between level of urbanization (as measured by percent of population living in urban areas) and per capita income highlights a need to understand the factors that drive and shape urbanization in order to illuminate how cities can better contribute to development (Paulsen 2012). The cities of both developing nations, where urban areas are often centers of manufacturing and growth, and developed countries, where cities could jumpstart stagnant economies of the Great Recession, are important loci of productivity and innovation (Dobbs et al. 2012; Istrate, Berube, and Nadeu 2011). Furthermore, an urban area's particular *form* imposes diverse economic costs and benefits and has implications for its economic success. Conversley, economic success (or lack thereof) has implications for urban size, density, and centricity (Gordon and Richardson 2012).

In this work, form is defined through density and centricity; [1] discussion of size is germane throughout, and complications are introduced through analysis of land use and welfare. Both centricity and density are used generally, and their extremes (high/low density; mono/polycentricity) are compared. The interaction of density and centricity with city size, as measured by population, is used to demonstrate a number of avenues for further research and to highlight salient urban dynamics. Generally, **increased city size produces economies of agglomeration, in which proximity and scale facilitate knowledge or human capital spillovers, lessen costs of inputs (e.g. of infrastructure), and reduce transaction costs** (Brugmann 2009; Rauch 1991; Segal 1976). These economic benefits could also be understood as resulting from firms' access to a larger market. As city size increases, however, cost of living, congestion, and occasionally inequality (in the case of cities with high primacy shares) also increase (Duranton 2009; Kim 2009). These more general effects of city size upon an urban economy could vary based upon interactions with other characteristics, such as density or centricity. This variance implies **that there is no one optimal city size, but that a city can have a unique efficient size depending on its own characteristics**, a view supported in Batty (2008), Capello and Camagni (1999), and Henderson's (1972) discussions of variations in size due to varied specializations.

The benefits of increased city size are similar to these of increased city density, ultimately because they are both derived from the benefits of agglomeration. Both higher densities and larger populations foster greater chances for productive encounters or knowledge spillovers, and present the opportunity to share infrastructure (and thus have lower fixed costs). Thus, when overlaid upon density, it would seem that an increase in population size acts as an intensifier of both the benefits and costs of density. The relationship of city size to centricity is more complex, and it is conjectured here that the costs of city size are felt more acutely in a monocentric city than a polycentric one, and thus that a polycentric city can more efficiently support a larger population.

Research on the effects of centricity and density upon economic growth, infrastructure provision, and the environment indicates that **high-density monocentric forms and high-density polycentric forms offer a balance of low transportation costs, low environmental impact, and high income-generation abilities**. However, there is still debate in literature as to which is more desirable, and there is evidence to

[1] See *fig.1*, for a matrix comparing the two lenses of analysis.

support both viewpoints. Furthermore, research on the drivers of urban form is heavily based upon the Alonso-Mills-Muth (AMM) monocentric model of urban spatial structure.[2] While there is evidence that urban forms can be robustly modeled by this monocentric theory (Paulsen 2012), we are witnessing strong trends away from monocentricity. Additionally, there is some research demonstrating that sub-centers, or secondary business districts (SBDs) may exert the same forces upon form as central business districts (CBDs), suggesting a need to explore a polycentric model (Durbin and Sung 1987). Finally, most urban form models like the AMM model rely on the context of developed countries and formal economies, neglecting the unique opportunities and constraints of developing countries and the possibly varied effects upon informal economies (Brugmann 2009; Dowall and Treffeisen 1991).

Though there are generally agreed upon costs and benefits to certain forms and configurations of urban areas, form is dynamic and a city that is now dense could become less so, or vice versa. **The current trends in both developed and developing urban areas point to de-densification and increasing decentralization and fragmentation, existing simultaneously with rapid increase in city size in terms of both population and land-area** (Anderson, Kanaroglu, and Miller 1996; Angel, Parent, and Civco 2011; Istrate, Berube, and Nadeu 2011). These shifts are generally seen as undesirable, but the efficacy of policies aimed at directly correcting for these trends is contested.

However, the broader policy environment in which an area urbanizes has long-term effects upon the form that the city will ultimately take. For example, the density distributions within the cities of Brasilia, Moscow, and Paris can be explained in part by the policy environments in which location decisions were made. In centrally planned Brasilia, they were decided *ex ante*; in Moscow, development has occurred largely without reference to markets and therefore the city has a relatively flat density distribution; and in Paris, location decisions, and therefore densities, were determined primarily by markets, resulting in a negative exponential density gradient. Thus, differing policy regimes generated cities with vastly different density profiles (Bertaud and Malpezzi 2003). Furthermore, altering pricing in cities in order to control for externalities demonstrates promise in shaping behavior of individuals to produce more efficient and productive city forms (Brueckner, Mills, and Kremer 2001; Gordon and Richardson 1997).

The difficulty of crafting effective urban policies demonstrates that the orderly implications of urban economics summarized previously are difficult to realize. In order to be relevant, recommendations must be situated in the larger context of considerations of fixed capital investments, questions of human capital, path dependency, and political milieus. While this contextualization can complicate the discussion of form, without context it is even more difficult to realize effective policies.

Density: Established Costs and Benefits

Trends

The question of residential and employment density in urban areas has implications for infrastructure provision (e.g. transportation), the environmental effects of

[2] The AMM model enumerates population growth, income per capita, and agricultural land rents as the shapers of urban spatial form. In the model, there is one central business district (CBD) that is the nexus of employment. Land costs fall as one moves further from the center, and further from employment.

conurbations, and the productive and income-generating abilities of an area. Residential and employment densities are experiencing marked shifts, with lower densities becoming the dominant trend as the built-up area of cities increases more rapidly than urban population. For example, from 1990-2000, richer countries saw their built-up area increase at five times the rate of population growth, whereas poorer ones grew at twice the rate of their population growth (Angel et al. 2005). Therefore, **while there is significant movement towards greater urbanization around the world in terms of the share of national and global populations living in urban areas, urban areas themselves are undergoing a process of de-densification** (Satterthwaite 2007). These effects are different in countries depending on their level of income; richer countries see de-densification at a more rapid pace than poorer countries do (Angel et al. 2005).

In both developed and developing countries, however, **the drivers of de-densification include the affordability of personal motorized transportation, urban policies that favor road-building and home-ownership, increasing income per capita, individual preferences, subsidies to homeowners and infrastructure, and changes in economic structure** (Angel 2007a; Arias and Borja 2007; Charoentrakulpeeti and Zimmermann 2008; Diez 2010; Ewig 1994; Gordon and Richardson 2012; Persky and Wiewel 2012; UN Habitat 2012). The de-densification trends imply an increasing amount of energy use for transportation and electricity, which raises the emission of greenhouse gases and negatively affects the environment (da Silva, Costa and Brondino 2007; Newman and Kenworthy 1991). This is a concern for policymakers, as the trend towards lower densities implies the need to address the associated costs (Anderson, Kanaroglu, and Miller 1996). Schlomo Angel (2007a) argues that the growth of built-up areas and de-densification are inevitable, and recommends that governments plan in order to accommodate these trends. Policies should be adapted to expand jurisdictions, arterial grids, and infrastructure in order to prepare, given that the costs of not doing so are greater than the costs associated with lower densities themselves.

Though this de-densification is established in urban literature, there is some evidence that, for varied reasons, the low-density trend could be reversing itself and redirecting towards medium- to high-density polycentric forms. In the United States, "boomburbs," large suburban areas that have seen a recent surge in growth, are some of the fastest-growing US cities. They have begun to develop through infill in order to cultivate multiple high-density centers that concentrate both employment and housing (Berube, Katz, and Lang 2005; Lang, Nelson, and Sohmer 2008). A case study of Spain in recent years also shows a trend towards increasing densities, which may be driven by new economic activities in the "knowledge economy" that require face-to-face connections and human capital spillovers, and thus higher employment densities or larger populations (Arias and Borja 2007). At the end of the 20th century in Bogotá, increasing polycentricity was accompanied by increasing densities, as the middle and upper-classes began to favor multifamily buildings over single-family homes, often for reasons of safety (Dowall and Treffeisen 1991). Finally, the trend could be driven by policy-makers' awareness of the dominant trend and its possible negative effects. The effects of these policies are discussed in subsequent sections.

The density within a city itself is dynamic and driven by varied factors. According to evidence presented by Alain Bertaud and Stephen Malpezzi (2003), the population density gradient in a monocentric, market-driven city will be highest central business

district, CBD (the assumption being that that is where jobs are located), and will decline exponentially moving outwards, based on a similarly shaped price-of-land gradient.[3] This aligns with the traditional AMM model of cities where there is a downward sloping, continuous rent function emanating from the center of the city. Given this decreasing price of land further from the center, individuals will be able to afford larger plots and thus live in lower densities (Mills 1980; Dubin and Sung 1987). In centrally planned economies, policies are imposed without regard to the market signals, and distorted density gradients that are flat or inverted can arise. These tend to be *less efficient* than the high-density, monocentric forms created in market-oriented cities (Bertaud and Malpezzi 2003). Therefore, not only is the relative density of a city important, but its individual density profile merits consideration as well.

Low density cities

The compact cities movement, new urbanists, and smart growth proponents alike are quick to identify the costs of low densities, citing, for example, that transportation costs, and more broadly, infrastructure provision costs are higher with lower densities (Angel 2007a; Glaeser, Kolko, and Saiz 2001). Public transportation provision, therefore, is less than in higher density areas and trip length is longer (Gordon and Richardson 1997; Lang, Nelson, and Sohmer 2008; Stead and Marshall 2001). It is unclear how city size interacts with transportation provision and density, though one could extrapolate that city size is positively correlated to transportation provision given that as the city grows in population, the market for transportation rises. This effect would likely be stronger if high densities are present and weaker in lower densities.

Furthermore, there is evidence that innovation, the Schumpeterian driver of growth, is lower in low-density areas (Carlino, Chatterjee, and Hunt 2006). Others argue that agglomeration economies, and thus their productivity-enhancing effects, cannot exist without higher densities (Stead and Marshall 2001; Glaeser, Kolko, and Saiz 2001). The latter of these critiques carries the implication of lower productivity in low-density cities, with indifference towards size, an implication that is borne out robustly by empirical study, as a doubling of population density leads to a 6% increase in productivity (Ciccone and Hall 1996; Harris and Ioannides 2000). Through this logic, a dense city with a low population could be as productive as one that is highly populous at a similar level of population density. This implication seems to hold, at least in the case of manufacturing. Henderson (1986) suggests that small to medium sized cities can experience the benefits of agglomeration economies and increased productivity seen in large cities, as long as industries, and thus people, are clustering in more dense configurations.[4] Thus, the effect of density seems to be greater than that of city size.

There is also a consensus that low-density urban forms are undesirable from an environmental standpoint. Empirical studies on the consumption of gasoline, theoretical studies of varied urban forms, and case studies all show that density plays a large role in

[3] There is some early research (Dubin and Sung 1987) that looks at price gradients directly and does not find this negative exponential relationship. Rather, Dubin and Sung find that housing prices respond similarly to CBDs and secondary/suburban business and amenity centers – the primary CBD does not exert a dominant influence on the rent gradient.

[4] This case, however, does not diminish the positive role of increased city size alone, given the fairly established economies of agglomeration that come in to play in larger cities.

energy efficiency, with higher densities leading to greater efficiency and lower levels of pollution per capita (Anderson, Kanaroglu, and Miller 1996; Dobbs et al. 2012; Gaigné 2012; Stead and Marshall 2001). Cities typically have lower levels of per-capita greenhouse gas emissions than their national average (Dodman 2009; Newman and Kenworthy 1991).[5] This could in part be explained by the lower costs of public transportation infrastructure provision in higher densities (UN Habitat 2010). From this, one could conjecture that low-density cities with large populations would have even larger negative environmental effects than their smaller counterparts.

Finally, low-density cities are costly from a public health perspective as well, with lower densities being associated with less physical activity. In areas where the trend towards lower densities is a result of sprawl (forms created by both de-centralizing and de-densification trends), obesity rates increase. This holds in high-, middle-, and low-income countries (Rydin et al. 2012).

In sum, **lower densities increase transportation costs, negative environmental effects, and obesity while decreasing productivity**. Little research has been done on the economic benefits of low densities, but from what is available it would seem that the primary benefits are lower rents, and less congestion, the latter of which could increase efficiency to offset some of the productivity loss of low densities, (Henderson 2000; Harris and Ioannides 2000). These benefits are similar to those posed by small cities, given that the costs of both high density and large populations– increased cost of living and increased congestion – are similar.

High densities

The primary economic benefits of higher densities can be surmised from the discussion above, as higher densities are associated with lower transportation costs, increased ability to support public transportation, shorter trip-lengths, lower infrastructure costs, fewer negative environmental effects, less obesity, and higher productivity (Anderson, Kanaroglu, and Miller 1996; Dobbs et al. 2012; Ewig 1994; Frank and Pivo 1994; Gaigné 2012; Harris and Ioannides 2000; Rydin et al. 2012; Stead and Marshall 2001; UN Habitat 2010).

It is traditionally accepted that higher densities foster agglomeration economies and knowledge spillovers, which are thought to lead to the aforementioned higher levels of productivity (Henderson 2000). However, density alone is not the cause of these benefits. As discussed, the relationship between density and city size is intertwined, and larger city size can also positively affect the economics of a city because of economies of scale. Jeb Brugmann (2009), for example, argues that the two prime causes of the higher productivity of cities are their density and their large scale. Together, these can these increase productivity and spur growth.

However, given the existence of congestion in high densities (and in large cities), the ultimate impact of higher densities on the cost of transportation to consumers is debated. While higher densities support greater public transportation provision[6] and decrease the length of work-home commutes – decreasing the cost of transportation per

[5] Lariviere and Lafrance (1999) explore the connection between density and energy use and find that while density does affect energy use, other factors such as value system, standard of living, economic system, and geography must also be included to understand a city's energy-use patterns.

[6] Angel (2011) finds that 30 people/hectare is the density required to support public transportation, and the average in developing cities is 129 people/hectare.

commuter – large amounts of congestion can increase commute time and transportation costs. This could negate the other positive effects of higher density (Angel 2007a). Large congestion costs could also drive the twin processes of suburbanization and de-densification, as firms leave the center city in search of lower transportation costs and rents (Mattesson and Sjoelin 2001). These costs of congestion, however, are largely outweighed by the effect of agglomeration economies present in high-density areas. **Ultimately, more economic benefits than costs are present in high-density areas** (Gordon and Richardson 2012).

A related characteristic of urban areas is urban concentration, which can be measured using primacy shares. Henderson (2000) proposes that there are "best degrees of primacy" for countries, which vary based upon a country's income level and size. High primacy shares imply a high concentration of persons in one city, enabling cities to benefit from the positive effects of high density enumerated above. These positive effects are most important in countries currently in early stages of economic development, and thus, these countries should aim for higher primacy shares. That is, **less developed countries should endeavor to foster higher levels of concentration than more developed countries in order to facilitate economic growth.** The ideal degree of primacy for more developed countries is lower because high levels of density can cause a city to become high-cost (e.g. congestion costs could reduce efficiency and growth). The benefits of urban primacy, however, should be tempered by evidence that some primate cities are such because of distorted and unequal political treatment. Primate cities that receive preferential treatment by the state disadvantage smaller cities, are harmful to efficiency and nation-wide development, and could lead to spatial inequality (Duranton 2009, Kim 2009). Thus, there seems to be a beneficial level of primacy that is country- and context-specific.

The many benefits of higher densities, however, should not lead one to uniformly advocate for policies that enforce high densities. Aside from their frequent failure, **high-density-promoting policies implemented without context could impose unintended costs.** For example, a sudden increase in density or size without careful planning can stress existing infrastructure and social services as seen in the case of Dakar (Cohen 2007). Furthermore, the cost of living seems to increase with city size and is not always accompanied by higher wages, meaning that policies intended to increase density by increasing population and city size may have the unintended effect of making life more difficult for the city's residents (Duranton 2009). Unwavering dedication to high densities could also cause policy makers to ignore and thus not plan for the undeniable trends towards de-densification. The costs of ignoring and not adapting to these trends could be significantly greater than the costs of the future lower densities (Angel 2007a). Furthermore, the benefits to density rely upon economies of scale and agglomeration; these take in to account the reality present in many developed countries, but neglect the informal economy that plays a strong role in developing country economies (Brugmann 2009; Duranton 2009). This lacuna in the literature could be explored to demonstrate the effects of urban form upon informal economies and vice versa.

Rather than micromanage cities in to high-density forms, governments and policymakers would do well to guide cities through ongoing monitoring projects and enact policies that both respond to market forces and adjust for price distortions (Bertaud and Malpezzi 2003).

Centricity: An Unresolved Debate

Trends

The concept of centricity, or the concentration of jobs and housing in one or multiple nuclei, is complex, and literature discussing the costs and benefits of different configurations of urban centers is less developed than that discussing density. Polycentricity itself is difficult to define – is a large polycentric region such as the Dallas-Fort Worth metroplex comparable to one with fewer citizens but higher density? Effects resulting from interactions of size and density with centricity are unclear, but there is a general agreement upon trends of centricity: **globally, cities are seeing a transition from primarily monocentric forms to forms which adhere less to a strong monocentric pattern and occasionally take polycentric forms** as employment and housing centers are dispersed from the center city (Angel 2007b; Dowall and Treffeisen 1991; Gordon and Richardson 2012). These trends towards polycentricity as manifested presently are accompanied by a movement to lower densities. The move can be treated as a "natural" evolution, which occurs as high costs and congestion incentivize the move further away from a singular high-density CBD. However, there is also evidence that the shift has been incentivized by government policies and personal preferences (Jenks 2008; Mattesson and Sjoelin 2001). Regardless of the cause, the trend towards decentralization is clear, but its ultimate economic impact is not (Gordon and Richardson 2012).

A different analysis of the de-centralization of urban areas posits that globalization and postmodernism drive the fragmentation of urban areas. Through this lens, fragmentation can be understood as the importation of urban typologies from the periphery to the center. For example, the privatization of formerly public lands in the CBD fragments and de-centralizes cities by creating exclusionary enclaves (Kozak 2008). Fragmentation can also manifest itself through the development of communities that are secluded and removed from the central city, as is the case in Bangkok. Here, accelerated road construction, a growing middle class, and shifting preferences have made gated communities more common, and have introduced urban typologies similar to those typically seen in the suburban United States (Graham and Marvin 2001; Karnchanaporn and Kasemsook 2008). Communications technology can also drive the fragmentation process, as distance becomes less of a barrier to communication. All of these forms of fragmentation carry equity concerns, as the division of land, utilities, infrastructure, and technology often results in an unequal distribution (Graham and Marvin 2001). They also create distinct patterns of spatial inequality, discussed in following sections.

Centricity can be understood through the lens of suburbanization, fragmentation, and varied typologies. As explored in the following sections, a preponderance of witnessed trends are decentralizing and de-densifying cities (alternatively referred to as sprawl or suburbanization), and have negative economic, environmental and social implications. Cities across the globe are decentralizing, often moving towards inefficient and unequal polycentric forms, rather than availing themselves of the possible benefits of polycentricity.

Monocentricity

In literature discussing urban form, the monocentric city tends to be the standard model examined. **Monocentricity gives rise to a single dense CBD, and falling densities as one leaves the CBD. There is evidence that this model of high-density**

monocentricity is the most efficient, most likely to support public transportation, and most likely to decrease mileage of commutes, but there is still debate on the topic (Bertaud and Malepzzi 2003; Glaeser, Kolko, and Saiz 2001). For example, there is some evidence that CBDs are not the prime force shaping the price gradient of a city. Instead, Durbin and Sung (1987) found that secondary business centers (SBDs), cultural centers, and other amenities similarly affected the price gradient, creating peaks and valleys in the supposedly monotonic, negative land rent function of the AMM monocentric model. This finding and other have not tempered the reliance upon the monocentric model as the standard urban form, and there is evidence that while city forms have become more multinucleated, they are still governed by the same forces as the monocentric model (Paulsen 2012).

Nonetheless, the benefits of the monocentric city may be overrepresented, given the dominance of and reliance upon the model in extant literature. The AMM model is well defined and amenable to manipulation and experimentation, whereas there is no comparable polycentric model with which to explore costs and benefits to polycentricity in its own right.

Excessive increases in size or density could minimize or nullify the benefits to the monocentric city. As city size and/or density increases, excessive scale could stress transportation networks and require higher maintenance costs, increase congestion and thus travel costs, and ultimately reduce efficiency. Polycentric models may offer forms that can better support this large-scale increase in population.

Polycentricity

There are two ideas concerning centricity in urban literature that highlight the importance of understanding polycentric urban forms. **First, the manner in which cities are currently morphing in to polycentric forms imposes more costs than benefits. Second, if pursued purposefully and with an emphasis upon density, polycentric forms could act as a second-best urban solution that is more economically advantageous than monocentricity when taking in to account externalities and present trends.** These two branches highlight the difficulty in distinguishing between undesirable sprawl and theoretically desirable kinds of polycentricity (Ewing 1994).

First, the idea that polycentric conurbations are increasingly becoming the predominant urban form is especially relevant in developed country cities (Gordon and Richardson 2012).[7] Of these polycentric cities, both large and small high-density polycentric cities should be able to support essential facilities, provide public transport, foster less car-dependence, and encourage productivity (*i.e.* avail themselves of the economic benefits of high densities regardless of their non-monocentric nature). However, research shows that instead of de-centralizing in to a dense polycentric form, **urban areas are decentralizing in to inefficient, low-density, fragmented forms** marked by gated and secluded communities, remote public housing provision, special economic zones, and privatization of public space (Jenks 2008). One analysis of the elite urban enclaves and far-flung centers of low-income housing in Buenos Aires demonstrates that the costs of fragmented polycentricity were higher infrastructure costs, lower quality of life, and increased transportation times (Diez 2010).

[7] While some refer to this trend as "sprawl," I avoid the term as it carries implications about density as well.

Furthermore, as they are developing **currently, polycentric forms are characterized by lower provision of public transportation**, which drives up the demand for car-based travel. This increased car travel exacerbates congestion on roadways, making cities less efficient, driving up transportation costs, and increasing negative environmental impacts. This can be seen in the case of Bangkok, where the trend towards polycentricity is accompanied by insufficient public transportation and exacerbated by a large population, causing perpetual congestion on the ring roads (Charoentrakulpeeti and Zimmerman 2008; Lo 1999).

Finally, **the current trends towards polycentricity may also have equity cost.** To begin, the predominance of car-based societies that is part of today's trends implies an equity trade-off in that those who do not have access to a car for legal, physical, or socio-economic reasons, stand at a disadvantage and are unable to fully participate in the marketplace (Ewing 1994). Furthermore, these trends often imply an exodus from the city center, in favor of distantly located suburban centers, especially in US cities. This demographic shift can be seen as a fiscal flight from the center city, placing a heavy burden on the now dwindling central-city tax base, resulting in the low-income urban centers common in the US today (Persky and Wiewel 2012). Common to US cities with a recently depressed urban core is contraction in city size, de-densification, and economic decline. The decline of these cities demonstrates that cities that were once beneficiaries of the economies of scale and agglomeration can lose their advantage. Further research on these cities should explore the interplay of city form and size with economic decline and vice-versa in order to understand how and if urban form can mitigate decline.

This spatial distribution of inequality that centers the poor in inner cities is not the only pattern that arises, however. As an alternative, there are cases like that of Buenos Aires, where the equity concerns run the opposite direction –low-income housing is provided on the outskirts of the city, or individuals live in removed squatter communities, and the wealthy remain in the center city or in isolated gated-communities situated on highways, where they are closer to infrastructure, and have lower transportation costs (Diez 2010). Thus, the spatial inequality that arises from today's trends towards polycentricity is shaped by housing policy, transportation costs, fuel costs, and car ownership. Literature addressing these variables and their impact upon the form of urban inequality could be expanded in order to develop a deeper understanding of fragmentation and polycentricity.

The second branch of thought on the role of centricity suggests that **polycentric cities are a way to minimize urban costs and maintain the benefits** (Cavailhès 2007). For example, in a hypothetical cost-benefit analysis of the decision between locating a firm in the city rather than in a suburban center, firms may face lower costs yet similar benefits in dense suburban areas when compared to the city center. This causes a tendency for firms to prefer polycentric forms (Persky and Wiewel 2012). As firms increasingly locate in suburban centers or SBDs, travel costs could remain constant or decline when compared to those of a monocentric city, as commutes are often within or between suburban centers, rather than from the periphery to a single CBD (Anas 2012; Gordon and Richardson 2012; Stead and Marshall 2001). Furthermore, some posit that in the second-best world where congestion costs are un-priced, polycentricity may be socially needed, not simply preferred by firms, to decrease the externality of increased congestion (Anas 2012). Large cities could temper this possible decline in travel cost,

however, as if there is a large amount of car-based travel, congestion could rise to meet that of monocentric forms

In terms of environmental effects, polycentric forms may be a realistic compromise between reduced energy use and accessibility that is not afforded by monocentric urban forms (Anderson, Kanaroglu, and Miller 1996). For example, in Gaigné (2012), if morphology and city size are both endogenously determined, and the movement of firms is allowed for, policies that encourage high densities in monocentric cities increase the emission of greenhouse gases. Conversely, policies that encourage creation of dense SBDs increase welfare and decrease greenhouse gas emissions. Finally, experiments with policies to promote multinucleated cities in the US that are transit-oriented, support mixed-use developments, and preserve open space have shown success in balancing low energy use and increased welfare (Anderson, Kanaroglu, and Miller 1996). These proposed benefits of polycentricity are not without their detractors, who claim that while beneficial polycentricity is theoretically possible, in reality it will produce cities that are unfriendly to public transit and inequitable in many ways (Bertaud 2004).

With current information, it is clear that current trends towards polycentricity are undesirable and that a more consciously pursued polycentricity could be more beneficial.

Mixed Use Development

Urban form also varies in development style, not only density and centricity, highlighting the need to discuss mixed-use development. Developments that contain diverse uses at city, neighborhood, block and building levels can be considered "mixed-use." These types of development seem to multiply the benefits of increased density, and mimic the theoretical benefits of polycentricity. In the United States, mixed-use development stands in contrast to the zoning codes that became popular in the early 20th century, upon which many cities were built (Grant 2002). In the post-war era, mixed-use developments gained in popularity, a sentiment perhaps best encapsulated in Jane Jacob's support of fine-grain mixed-use development as a way to create a diverse and vibrant community. Proponents argue **that mixed-use development reduces dependency on single-occupancy vehicles – thus reducing environmental impacts of conurbations – maximizes infrastructure use, offers more housing options for small families, revitalizes depressed neighborhoods, and preserves urban vitality**. Opponents propose that because mixed-use is so loosely defined and ambiguous, it is not an effective tool for urban development or regeneration. They also propose that there are negative public health effects of some types of mixed-use development, and that the effects cannot be easily mitigated on a city-wide level (Grant 2002; Hoppenbrauwer and Louw 2005; Rowley 1996).

Some research suggests that mixed-use developments, as measured by the job-to-housing ratio, have small or nonexistent effects on transportation choices. For example, in Giuliano and Small (1993) there is a small but statistically significant effect on work commute *time*, and in Ewing et al. (1996) there is in no relationship with trip *frequency* (both in Stead and Marshall 2001). However, there is strong evidence that mixed land use, as measured by an entropy index, is significantly related with reduced single-occupancy vehicle (SOV) use and increased transit use and walking (Frank and Pivo 1994).

There are several urban planning theories that rely on the supposed benefits of mixed use. The compact city movement is one such theory. Its proponents argue that compact cities, and mixed-use development by extension, encourage walking and cycling, support low energy consumption, and increase social interaction and safety (Dempsey 2010). The new urbanist movement also relies upon the positive benefits of mixed-use, highlighting walkability, connectivity, multiple transportation choices, sustainability, and quality of life as positive effects of adopting new urbanist theories and their mixed-use corollaries (Song and Stevens 2012). Furthermore, from a welfare standpoint, some argue that the poor are better off in mixed-use developments given the increased access to services and public transportation (Burton 2001). These benefits must be balanced with the finding there are large negative public health effects in economically poor mixed-use neighborhoods, because of the inclusion of heavy industries that does not typically occur in wealthy mixed-use neighborhoods (Angotti and Hanhardt 2001).

In practice, mixed-use development seems to emerge organically in the absence of strict separationist zoning laws. In Houston, where there is no city-wide zoning, but there are neighborhood-specific covenants, the areas which had the fewest governing covenants also had the highest proportion of mixed use development and highest proportion of renters (Qian 2008). Organic, incremental development in Tokyo post-WWII also produced higher incidence of mixing (Echanove, Matias, and Srivastava 2012). Finally, New York City has arguably the most mixed-use development in the US, as a result of having developed in part prior to the zoning laws of the 20th century (Angotti and Hanhardt 2001).

These trends seem to indicate that **mixed-use developments offer economic and transport benefits that must be balanced with the negative health effects** of certain kinds. It is also clear that it is easier to preserve and further develop existing mixed-use areas than it is to create one *de novo*. Policymakers should bear this balance in mind when seeking to promote mixed-use development.

Effects of Policies

Given the economic benefits to high density, the debated effect of polycentricity, and the promises of mixed-use development there have been several attempts at designing policies to encourage density, limit decentralization and mix land uses. Similarly, there have been many policies to curb the increase in size of cities, by limiting migration in to urban areas and restricting population growth (Angel et al. 2005). Many **direct, short-term policies do not have their intended effects**. Policies directed at containing growth and raising density through limitations, which are frequently framed in the sense of "limiting sprawl," are particularly vexed. For example, policies intended to restrict expansion through curbing car use, or by creating urban growth boundaries (UGBs) have both encountered only mixed success in the US (Gordon and Richardson 2012; McConnell and Wiley 2012). Proponents of UGBs argue that development in cities like Portland has become more contiguous, that public service provision cost has declined and open space has been retained (Song and Knapp 2004). Others cite difficulties in selecting an effective UGB size, and the failure to sufficiently raise density as reasons for which UGBs are wont to impose higher costs than benefits (Nelson and Moore 1993; Song and Knapp 2004). Other restrictive policies such as those seeking to directly limit

emissions and energy consumption, increase public transportation, limit population inflows, or preserve green space have also been ineffective (Angel, Sheppard, and Civco 2011). Likewise, severe limits (e.g. on floor-area ratios, FARs) can exacerbate de-densification trends, causing unnecessary sprawl and decreasing welfare of urban families (Brueckner and Sridhar 2012; Bertaud and Brueckner, 2004). The shortcomings of these policies which rely on strict limitations could stem from, political fragmentation, competing interests, discord between bordering jurisdictions, and tensions between varying level of governance which restrict the ability of policies to explicitly control density and centricity trends.

While government policies directed specifically at reversing trends of de-densification and de-centralization may be ineffective, **policies indirectly addressing undesirable trends through tackling market failures, specifically by adjusting prices for congestion and environmental impact, have shown promise in increasing welfare and mitigating externalities.** These policies allow for the socially necessary amount of de-densification and city footprint growth while adequately pricing externalities, notably that of congestion (Brueckner, Mills, and Kremer 2001; Gordon and Richardson 1997). For example, because vehicle miles traveled and fuel usage are responsive to price, policies adjusting these prices can minimize the externalities of congestion and greenhouse gases (Duranton and Turner, 2009; Sterner 2007). Even in second best situations, in which road and vehicle users are not charged their exact marginal utility, congestion pricing schemes could ameliorate externalities and increase welfare (Verhoef 2005).

Equity Considerations

There is not one form that is inherently more equitable than another; both high and low density forms can provide better opportunities for one group over another, and the same goes for polycentric and monocentric forms. Even the compact city, which has been lauded for its supposed benefits, does not intrinsically confer greater equality (Burton 1999). Instead, equity considerations should be analyzed in a contextual manner. That is, one can speculate on the effects of policies upon equity only at the intersection between form and other urban characteristics. For example, in the traditional monocentric model, both the concentration of services in a CBD, and the form's friendliness to public transportation could make facility and service access more equitable than in a polycentric, car-dependent form, assuming the modal shift to public transportation occurs in the monocentric city (Burton 1999). This type of intersection also merits application when considering environmental concerns. For example, there is evidence that increasing density in monocentric cities will decrease emissions only if there is a simultaneous modal shift to using mass transportation (Gaigné, Riou, and Thisse 2012). In both of these examples, form intersects with transportation mode to have implications for equity and the environment.

In addition to these trends emerging from intersections of density and centricity with other urban characteristics, the planning process and policy environment in which certain urban forms are pursued merits consideration. **Independent of the effects of their recommendations, planners and policy makers can influence equity through their processes of planning.** This can occur explicitly, when affected populations are left out of the planning process, and unintentionally, when consequences of urban policies are

left unanalyzed.

The former concern, lack of community consultation, repeats itself in the literature for both its importance and difficult implementation (Ahmed, Lu, and Ye 2009; Basiago 1999; Robinson and Shaw 1991). The latter, harmful effects on equity through unintended consequences, is perhaps more pernicious, given that it is part-and-parcel of supposedly beneficial policies. For example, the policies many cities pursue in order to revitalize their CBD and incentivize downtown job-growth could be economically inefficient misallocations of resources from the point of view of pro-poor planning (Heikkila et al. 1988). Similarly, the focus upon preservation of green space could come at the cost of overcrowding in low-income areas of the city (Arnott, Anas, and Small 1997). The observed trend that policies implemented with the prime objective of achieving a particular form (e.g. to limit outward expansion, or put a cap on density) through restrictions such as FAR limits and urban growth boundaries are particularly at risk of harming welfare (Bertaud and Breukner 2005) could also be due to the omission of careful analysis to identify consequences of policies. These examples demonstrate the need to explore equity trade-offs to policies before they become established unintended consequences.

Active community consultation and careful analysis to avoid unintended outcomes may still not remedy lack of equity in urban planning. Both of these could contain blind spots caused by the use of rigid definitions of urban density, centricity and mixed-use development. Variants of density, variants of centricity, the intersection of the two with one another, and the intersection of the two with other urban characteristics like transportation and land use, will produce vastly different equity effects and urban fabrics. For example, as Foster (2011) discusses, Dharavi's *low-rise* variant of high-density functions well in terms of spurring productivity. When planners attempted to replace the low-rise density with high-rise density, ostensibly to preserve productivity and increase quality of life, productivity fell, and the project was abandoned. Similarly, the granularity of mixed-use developments could have different equity effects in different cities, countries, and regions.[8]

Furthermore, form may not even be the best entry point to the discussion of equity. For instance, Burton (1999; 2001) found that high-density public housing and locally provided services and facilities are more indicative of equity than compactness levels. These possible effects of form and other urban characteristics indicate a need for integrated urban policies to address equity issues (see Basiago (1999) for case studies). Planners and policymakers should take care to consider both the physical manifestations of their policies, given that one theoretical form can take many physical and practical shapes, and the possibility that other urban characteristics may come in to play when considering equity.

Concluding Remarks and Recommendations

This work has endeavored to clarify the costs and benefits to different extremes of density and centricity while incorporating considerations of size, land use and equity. Of the four constellations of different levels of density and centricity, presented in *fig. 1*, the

[8] Fine grain mixed-use, such as the mixing of business and residential tenants in individual buildings, stands at the opposite end of the spectrum from large-grain mixed-use development, which would deal with large tracts of land.

combination of high density, monocentric (HDMC) characteristics is the depiction of the traditional, efficient, city. The HDMC city is used in most of the literature reviewed here as a baseline from which trends are analyzed and costs calculated. The benefits of the HDMC form are the ability to leverage knowledge spillovers, and agglomeration and scale economies; a reduced per-person environmental impact; increased economic productivity and innovation; a higher use of public transportation; and shorter travel distances. These benefits are also cited when discussing benefits of increased size, suggesting a need to further parse out the benefits of size from those of density. Similarly, both large and dense cities face increasing costs of congestion and high rents.

A branch of research exploring polycentricity challenges the preeminence of the HDMC model, by positing that polycentricity is not only a trend, but also is necessary to address the shortcomings of the monocentric model. Research promoting the benefits of polycentricity suggests that it can mitigate the costs associated with HDMC cities, namely high costs to firms, and congestion. If the polycentric form is also dense (HDPC), polycentricity offers a way of still harnessing the benefits of density, while addressing the costs through an amount of de-centralization. Through this lens, the benefits of the HDPC form are equal to or greater than to those of the HDMC form. By mitigating urban costs, HDPC cities could also support cities with greater populations. Conversely, increases in city size could better serve economies of polycentric cities than their monocentric counterparts, given the former's ability to mitigate costs. Therefore, on a theoretical level, the benefits to certain urban forms are well established, yet in practice there is no universal panacea.

From this research, it would seem that **high-densities can generally be promoted for cities, with the understanding that there could be unanticipated negative externalities**, such as congestion and increase in housing prices, and that high densities can vary in manifestation, and high-rise high density may not be appropriate in all situations. Furthermore, high-density form may have exaggerated negative effects in monocentric cities or, conversely, boosted positive economic effects in mixed-use developments. To this end, **fine-grain mixed-use developments can be also be promoted for cities**. Both of these recommendations stem from their promotion of public transportation, economic efficiency, and possibility for strengthening equity and accessibility. A final recommendation stems from the conclusion that unguided trends towards polycentricity or decentralization are inefficient from economic and social equity perspectives. Therefore, cities should strive to **create comprehensive planning mechanisms that mitigate undesirable trends, such as decentralization and de-densification, and maximize the benefits of non-monocentric forms.**

Regarding the literature more generally, support for both the HDMC and HDPC models is longstanding, and polycentricity is not a new concept. However, literature that discusses polycentricity in its own merit is sparse, and it would appear that ideas supporting polycentricity have failed to gain traction. This could be because polycentricity is difficult to define, measure, and evaluate. Literature combining various aspects of urban form, such as integration of conversations of size with those on either or both centricity and density is also uncommon. This demonstrates a need to both consider the interaction between different urban qualities and analyze trends with more granularity (*e.g.* going beyond the oft-repeated idea that high density is beneficial to examine *where* and *when* high densities are beneficial). Through this more nuanced, and inclusive

understanding of urban form, research can better contextualize questions of urban economic growth, development and equity (for a series of exploratory policy applications of this review, see Appendix 2, which follows).

Appendix 1 - Figures

	High density (HD)	Low density (LD)
Monocentric (MC)	*Costs:* -High levels of **congestion** - **Firms** face higher costs than in HDPC scenario *Benefits:* - **Agglomeration** & scale economies, and knowledge spillovers - Fewer negative **environmental** effects than LD (emissions per person) - Higher levels of **productivity and innovation** - Highest use of public **transportation** - Traditionally thought to have **shorter travel distances** - Traditionally depicted as most **efficient** - Lower **infrastructure costs**	*Costs:* - Expensive **transportation** infrastructure, longer trip distances to jobs, car dependence - Limited/no **agglomeration** economies - **Environmentally** harmful *Benefits:* - Less **congestion** than HDMC
Polycentric (PC)	*Costs:* - May have higher **transportation and infrastructure costs** than HDMC *Benefits:* - Should demonstrate existence of **agglomeration** & scale economies, and knowledge spillovers - Could possibly have even less of an **environmental** impact than HDMC - Higher levels of **productivity and innovation** - Could sustain public **transportation**; **travel distances** equal to or less than HDMC - Lowers costs to **firms**	*Costs:* - Possibly expensive **transportation** infrastructure, lower provision of public transport, longer trip lengths, car dependence - Lessened effect of **agglomeration** economies - **Environmentally** harmful - Higher levels of **obesity** *Benefits:* - Becoming the dominant trend (sprawl) - Less **congestion** than HDMC

Fig. 1 - Density and centricity matrix

City size	Low density	High density	Monocentric	Polycentric
Under 2 million[1]	Public transportation, and infrastructure are expensive, while productivity remains relatively low given the lack of density and economies of agglomeration. Congestion could be low, but travel distances are likely long regardless of centricity. Few incentives for firms to locate here.	Public transportation and infrastructure will be cheaper to provide, but given relatively small market, may not be demanded. Congestion could be lower than in a larger city, but is likely still detrimental. Density could incentivize firm relocation, though firm diversity may not be found.	Public infrastructure provision is likely low (without density), but cost of infrastructure may be lower than in polycentric model. Firms may not find incentives to locate here. High per capita environmental effects in both high and low density situations.	Though small in population, proximity to many SBDs might incentivize firms. Perhaps some public transportation between SBDs, especially if density is high. Could mitigate some congestion and thus environmental effects, but low density forms would have large effects.
Over 2 million	Public transportation and infrastructure are likely still expensive, but productivity may be higher given economies of scale. Congestion is likely higher given the long travel distances due to density and possible congestion from size. Market size could bring in firms.	Possibly lowest infrastructure costs, given market size and density factors. Firms may find this an attractive market given size and density, however, high congestion costs could be a deterrent. Low greenhouse gas emissions per capita.	Could have large transportation costs and large amount of congestion, in both high and low-density scenarios. Should have significant transportation provision and lower instrastrucure costs. Environmental effects are likely low, though polycentricity might offer further reductions.	Provides much incentive for firms (agglomeration economies, lower costs, large market). Congestion is likely increasing, but mitigated by polycentricity. Infrastructure costs may be higher than in monocentric form. Very environmentally damaging if it is low density; could be very efficient if it is high density.

Fig. 2 Size matrix

[1] This threshold was selected due to Segal (1976) and Echeverri-Carroll and Ayala (2011) who found two million and 1.5 million, respectively, to be important cut off points. Echeverri-Carroll and Ayala found that at human captical density peaked at a city size 1.5 million people, while Segal (1976) found economies of agglomeration to be strongest in cities of two million or more inhabitants.

Fig. 2 – Size matrix.

Appendix 2 – Policy Applications

The preceding analysis of literature on the effects of urban form can inform distinct scenarios and provide policymakers with specific policy objectives. Below, lessons are applied to two unique urban realities: the first in which density is at a high enough level to support public transportation and leverage economies of scale and agglomeration, yet investment in productivity and enhancing infrastructure is low; and the second in which density is also high, yet trends are moving the form towards a more de-centralized and less-dense shape.

African cities possess some of the fastest urbanization rates of all cities, stressing unprepared conurbations with the needs of thousands of new residents. Pre-existing infrastructure provision tends to be low, informal settlements dominate urban landscapes, and there is a need for higher levels of productivity that is both poverty-reducing and equality-enhancing. From a theoretical perspective, the benefits of increased levels of population density could be many – increased productivity, more efficiently used infrastructure, more viable public housing, and development of equality- and productivity-enhancing public transportation systems. In reality, many cities like these already have very high levels of density[9] that are holding steady or increasing, but they lack the provision of infrastructure and services, formalization, and secure land tenure. For example, in cities such as Lagos, which has underdeveloped sewage-treatment and transportation infrastructure, efforts should be made not to further increase population density, but to focus investment upon improving infrastructure and public transportation in order to capture the benefits of high densities. Policy objectives in cities like Lagos could include: increasing access of formal and informal residential areas to public services and infrastructure; and encouraging the adoption of mixed land uses, even in already developed areas.

For cities in which decentralization and de-densification are salient trends, mitigating the negative effects of these trends should be a high policy objective. Many large cities in South-East Asia are experiencing unplanned and uncontrolled decentralization in to mega-regions, and are experiencing the costs outlined in the preceding discussion. In the last few decades, for example, Bangkok has been expanding in an unplanned, leapfrog fashion along major highways through low-density, single-use developments (McGee and Robinson 1995). Since this is unplanned, de-centralization cannot leverage the possible benefits of polycentricity. Policymakers should aim to regain control of the pattern of development by creating policies that incentivize the development of high-density and mixed-use developments, rather than allowing distorted markets to continue incentivizing the creation of far-flung enclaves. In order to mitigate the negative effects of the recently built lower-density areas, these should become foci of investments aimed at bringing in public transportation access so as to dull the negative effects of increased SOV use.

[9] Angel (2011) finds that 30 people/hectare is the density required to support public transportation, and the average in developing cities is 129 people/hectare.

References

Agbola, Tunde and Elijah M. Agunbiade. 2009. "Urbanization, Slum Development and Security Of Tenure: The Challenges of Meeting Millennium Development Goal Seven in Metropolitan Lagos, Nigeria" In *Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned*, edited by A. de Sherbiniin, A. Rahman, A. Barbieri, J.C. Fotso, and Y. Zhu, 78-106. Paris: Committee for International Cooperation in National Research in Demography.

Ahmed, Qureshi Intikhab, Huapu Lu, and Shi Ye. "Urban transportation and equity: A case study of Beijing and Karachi." *Transportation Research Part A* 42: 125-139.

Anas, Alex. 2012. "Discovering the Efficiency of Urban Sprawl." In *The Oxford Handbook of Urban Economics and Planning,* edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 123-147. New York: Oxford University Press.

Anderson, William P., Pavlos S. Kanaroglu and Eric J. Miller. 1996. "Urban form, Energy, and the Environment: A Review of Issues, Evidence, and Policy." *Urban Studies* 33: 7-35.

Angel, Schlomo. 2007a. *Making Room for a Planet of Cities*. Draft, 9 May.

Angel, Schlomo. 2007b. "On the Declining Population of the Centre: A Research Note." *Built Environment* 33: 249-253.

Angel, Schlomo, Jason Parent, Daniel L. Civco, and Alejandro M. Blei. 2011. *Making Room for a Planet of Cities*. Cambridge, MA: Lincoln Institute of Land Policy.

Angel, Schlomo, Stephen C. Sheppard, Daniel L. Civco, Robert Buckley, Anna Chabaeva, Lucy Gitlin, Alison Kraley, Jason Parent, and Michah Perlin. 2005. *The Dynamics of Global Urban Expansion.* Washington D.C.: The World Bank, Transport and Urban Development Department.

Angotti, Tom, and Eva Hanhardt. 2001. "Problems and Prospects for Healthy Mixed-use Communities in New York City." *Planning Practice and Research* 16 (2): 145-154.

Annez, Patricia Clarke and Robert M. Buckley. 2009. "Urbanization and Growth: Setting the Context." In *Urbanization and Growth,* edited by Michael Spence, Patricia Clarke Annez, and Robert M. Buckley. 1-46. Washington, DC: Commission on Growth and Development.

Arias, Albert and Jordi Borja. 2007. "Metropolitan Cities: Territory and Governability, the Spanish Case." *Built Environment* 33: 170-183.

Arnott, Richard, Alex Anas, and Kenneth Small. 1997. "The Welfare Economics of Urban Structure." *Boston College Working Papers in Economics* no. 388.

Arnott, Richard. 2009. "Housing Policy in Developing Countries: The Importance of the Informal Economy." In *Urbanization and Growth,* edited by Michael Spence, Patricia Clarke Annez, and Robert M. Buckley. 167-196. Washington, DC: Commission on Growth and Development.

Basiago, A.D. "Economic, Social, and Environmental Sustainability in Development Theory and Urban Planning Practice." *The Environmentalist* 19: 145-161.

Batty M. 2008. "The Size, Scale, and Shape of Cities." *Science* 319 (5864): 769-771.

Bertaud, Alain. 2004. "The Spatial Organization of Cities: Deliberate Outcome or Unforseen Consequence?" *Institute of Urban and Regional*

Bertaud, Alain, and Jan K. Brueckner. 2004. "Analyzing building height restrictions:

predicted impacts, welfare costs, and a case study of Bangalore, India." Washington, D.C.: World Bank.

Bertaud, Alain, and Jan K. Brueckner. 2005. "Analyzing Building-Height Restrictions: Predicted Impacts and Welfare Costs." *Regional Science and Urban Economics* 35: 109-125.

Bertaud, Alain and Stephen Malpezzi. 2003. "The Spatial Distribution of Population in 48 World Cities: Implications for Economies in Transition." *The Center for Urban Land Economics Research.*
Development, University of California at Berkeley Working Paper 2004-01.

Berube, Alan, Bruce Katz, and Robert Lang. 2005. *Redefining urban and suburban America: evidence from Census 2000. Vol. 3*. Washington, D.C.: Brookings Institution.

Boarnet, Marlon G. 1993. "The Monocentric Model and Employment Location." *Journal of Urban Economics* 36: 79-97.

Bontje, Marco. 2001. "Dealing with Deconcentration: Population Deconcentration and Planning Response in Polynucleated Urban Regions in North-west Europe." Urban Studies 38 (4): 769-785.

Bosselmann, Peter. 2008. *Urban Transformation: Understanding city design and form.* Washington D.C.: Island Press.

Brooks, Nancy, Kieran Donaghy, and Gerrit Knaap, eds. 2012. *The Oxford Handbook of Urban Economics and Planning*. New York: Oxford University Press.

Browder, John O., and James R. Bohland. 1995. "Patterns of Development on the Metropolitan fringe." *Journal Of The American Planning Association* 61: 310.

Brueckner, Jan K., Edwin Mills, and Michael Kremer. 2001. "Urban Sprawl: Lessons from Urban Economics [with Comments]." *Brookings-Wharton Papers on Urban Affairs* 65-97.

Brueckner, Jan and Kala Seetharam Sridhar. 2012. "Measuring Welfare Gains from Relaxation of Land-Use Restrictions: The Case of India's Building-Height Limits."

Brugmann, Jeb. 2009. *Welcome to the Urban Revolution: How Cities are Changing the World*. New York: Bloomsbury Press.

Burapatanta, Tanat and William Ross. 2007. "Bangkok: Suburbanizing and Unsustainable." *Environment and Natural Resources Journal* 5: 59-68.

Burton, Elizabeth. 2000. "The Compact City: Just or Just Compact? A Preliminary Analysis." *Urban Studies*. 37: 1969-2001.

Burton, Elizabeth. 2001. "The Compact City and Social Justice." Presented to the Housing Studies Association Spring Conference, *Housing, Environment, Sustainability*. University of York.

Capello, Roberta, and Roberto Campagni. 2001. "Beyond Optimal City Size: An Evaluation of Alternative Urban Growth Patterns." *Sage Urban Studies Abstracts* 29 (3): 275-406.

Carlino, Gerald, Satyajit Chatterjee, and Robert Hunt. 2006. "Urban Density and the Rate of Invention." *Federal Reserve Bank of Philadelphia Supersedes Working Paper* 04/16-R.

Carruthers, Robin, Malise C. Dick, and Anuja Saurkar. 2005. "Affordability of public transport in developing countries." Washington, D.C.: World Bank Group.

Cavailhès, Jean, Carl Gaigné, Takatoshi Tabuchi, Jeaques-François Thisse. 2007. "Trade and the structure of cities." *Journal of Urban Economics* 62: 383-404.

Champion, A.G. 2001. "A Changing Demographic Regime and Evolving Polycentric Urban Regions: Consequences for the Size, Composition and Distribution of City Populations." *Urban Studies* 38 (4): 657-677.

Charoentrakulpeeti, Wanpen and Willi Zimmermann. 2008. "Staunchly Middle-class Travel Behaviour: Bangkok's struggle to achieve a successful transport system." In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 303-320. New York: Routledge.

Cheshire, Paul and Stephen Sheppard. 2002. "Taxes versus Regulation: The Welfare Impacts of Policies for Containing Sprawl." *Williams College, Economics Department Working Paper* No. 2002-04.

Ciccone, Antonio and Robert E. Hall. 1996. "Productivity and the Density of Economic Activity." *NBER Working Papers* 4313. National Bureau of Economic Research.

Cohen, Mike. 2007. "Aid, Density and Urban Form: Anticipating Dakar." *Built Environment* 33: 146-156.

Dave, Seema. 2010. "High Urban Densities in Developing Countries: A Sustainable Solution?" *Built Environment* 36: 9-27.

Dempsey, Nicola. 2010. "Revisiting the Compact City." *Built Environment* 36: 5-8.

Dempsey, Nicola and Mike Jenks. 2010. The Future of the Compact City. *Built Environment* 36: 116-121.

Diez, Fernando. 2010. "Buenos Aires: Involuntary Incentives to Metropolitan Dispersal." *Built Environment* 36: 157-169.

Dobbs, Richard, Jaana Remes, James Manyika, Charles Roxburgh, Scen Smit, Fabian Schaer. 2012. *Urban world: cities and the rise of the consuming class.* McKinsey Global Institute, McKinsey & Company.

Dodman David. 2009. "Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories." *Environment and Urbanization* 21 (1): 185-201.

Dowall, David E., and P. Alan Treffeisen. 1990. "Spatial transformation in cities of the developing world: multinucleation and land-capital substitution in Bogotá, Colombia." *Regional Science and Urban Economics* 21: 201-224.

Dubin, Robin A., and Chein-Hsing Sung. 1987. "Spatial Variation in the Price of Housing: Rent Gradients in Non-Monocentric Cities." *Urban Studies* 24: 193-204.

Duranton, Giles. 2009. "Are Cities Engines of Growth and Prosperity for Developing Countries?" In *Urbanization and Growth*, edited by Michael Spence, Patricia Clarke Annez, and Robert M. Buckley. 67-114. Washington, DC: Commission on Growth and Development.

Duranton, Gilles, and Matthew A. Turner. 2009. "The Fundamental Law of Road Congestion Evidence from US Cities." *National Bureau of Economic Research Working Paper* 15376.

Echanove, Matias and Rahul Srivastava. 2012. "The High Rise and the Slum: Speculative urban development in Mumbai." In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 789-

813. New York: Oxford University Press.
Echeverri-Carroll, Elsie, and Sofia G. Ayala 2011. "Urban Wages: Does City Size Matter?" *Urban Studies* 48 (2): 253-271.
Ewing, Reid H. 1994. "Characteristics, causes, and effects of sprawl: a literature Review." *Environmental and Urban Issues* 21 (2).
Fahmi, Wael Salah. 2008. "The Right to the City." In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 261-291.New York: Routledge.
Ferdous, Nazeen, Abdul Rawoof Pinjari, Chandra R. Bhat, Ram M. Pendyala. 2010 "A comprehensive analysis of household transportation expenditures relative to other goods and services: an application to United States consumer expenditure data." *Transportation* 37 (3): 363-390.
Foster, Norman. 2011. "Norman Foster: Lecture" *Humanitas - Visiting Professorships at the Universities of Oxford and Cambridge*. http://podcasts.ox.ac.uk/norman-foster-lecture-audio.
Frank, L. D., and G. Pivo. 1994. "Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking." *Transportation Research Record* (1466): 44.
Gaigné, Carl, Stéphane Riou, and Jaques-François Thisse. 2012. "Are Compact Cities Environmentally Friendly?" *Journal of Urban Economics* 72: 123-136.
Gandy, Matthew. 2006. "Planning, anti-planning and the infrastructure crisis facing Metropolitan Lagos." *Urban Studies* 43 (2): 371-396.
Glaeser, Edward L. 1991. *Growth in cities. National Bureau of Economic Research Working Paper* 9733.
Glaeser, Edward L. 2011. *Triumph of the City: How our Greatest Invention Makes us Richer, Smarter, Greener, Healthier, and Happier.* New York: Penguin Press.
Glaeser, Edward L., Jed Kolko, and Albert Saiz. 2001. "Consumer City." *Journal of Economic Geography* 1: 27-50.
Gordon, Peter, and Harry W. Richardson. 1997. "Are Compact Cities a Desirable Planning Goal?" *Journal of the American Planning Association* 63(1): 95-106.
Gordon, Peter and Harry W. Richardson. 2012. "Urban Structure and Economic Growth." In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 98-122. New York: Oxford University Press.
Grant, Jill. 2002. "Mixed use in theory and practice: Canadian experience with implementing a planning principle." *Journal of Planning Literature* 16 (4): 561-643.
Griffith, Daniel A. 1981. "Evaluating the Transformation from a Monocentric to a Polycentric City." *Professional Geographer* 33(2): 189-196.
Harris, Timothy and Yannnis M. Ioannides. 2000. "Productivity and Metropolitan Density." *Tufts University, Department of Economics Discussion Papers Series no. 0016.*
Heikka, E., P. Gordon, J.I. Kim, R.B. Peiser, H.W. Richardson, D. Dale-Johnson. 1989. "What Happened to the CBD-distance gradient?: Land Values in a Policentric City." *Environment and Planning A* 21: 221-232.
Henderson, J. Vernon. 1972. "The sizes and types of cities." *Queen's University*

Department of Economics Working Paper No. 75.
Henderson, J. Vernon. 1986. "Efficiency of resource usage and city size." *Journal of Urban Economics* 19 (1): 47-70.
Henderson, J. Vernon. 1996. "Ways to Think about Urban Concentration: Neoclassical Urban Systems versus the New Economic Geography." *International Regional Science Review* 19 (1-2): 31.
Henderson, J. Vernon. 2000. "The Effects of Urban Concentration on Economic Growth." *National Bureau of Economic Research Working Paper* 7503.
Henderson, J. Vernon. 2010. "Cities and Development." *Journal of Regional Science* 50: 515-540.
Hoppenbrouwer, Eric, and Erik Louw. 2005. "Mixed-use development: Theory and practice in Amsterdam's Eastern Docklands." *European Planning Studies* 13 (7): 967-983.
Huang, Jingnan, X.X. Lu, and Jeffrey Sellers. 2007. "A global comparative analysis of urban form: Applying spatial metrics and remote sensing." *Landscape and Urban Planning* 82: 184-197.
Ilesanmi, Adetokunbo Oluwole. 2010. "Urban sustainability in the context of Lagos mega-city." *Journal of Geography and Regional Planning* 3(10): 240-252.
Irwin, Elena G. and Nancy E. Bockstael. 2007. "The Evolution of Urban Sprawl: Evidence of Spatial Heterogeneity and Increasing Land Fragmentation." *Proceedings of the National Academy of sciences of the United States of America* 104: 20672-20677.
Istrate, Emilia, Alan Berube, and Carey Anne Nadeau. 2011. "Global MetroMonitor 2011: Volatility, Growth, and Recovery." *Brookings Institute.*
Jenks, Mike, Daniel Kozak, and Pattaranan Takkanon, eds., *World Cities and Urban Form: Fragmented, polycentric, sustainable?* New York: Routledge, 2008.
Jones, Gavin W. 2002. "Southeast Asian Urbanization and the Growth of Mega-urban Regions." *Journal of Population Research* 19 (2): 119-136.
Jun, M. 2005. "The effects of Portlands urban growth boundary on urban development patterns and commuting." *SAGE Urban Studies Abstracts* 33 (3).
Karnchanaporn, Nuttinee and Apiradee Kasemsook. 2008. "'World Class' Living?" In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 293-302. New York: Routledge.
Kim, Sukkoo. 2009. "Spatial Inequality and Economic Development: Theories, Facts, and Policies." In *Urbanization and Growth,* edited by Michael Spence, Patricia Clarke Annez, and Robert M. Buckley. 134-166. Washington, DC: Commission on Growth and Development.
Kozak, Daniel. 2008. "Assessing Urban Fragmentation." In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 239-258. New York: Routledge.
Krugman, Paul R. 1991. "Cities in Space: Three Simple Models." *National Bureau of Economic Research Working Paper 3607.*
Kundu, Amitabh. 2012. "Globalization and urban Growth in the Developing World with Special Reference to Asian Countries." In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit

Knaap, 845-847. New York: Oxford University Press.
Lang, R. E. 2002. "Open spaces, bounded places: Does the American west's arid landscape yield dense metropolitan growth?" *Housing Policy Debate* 13 (4): 755-778.
Lang, R. E., Arthur Nelson, and Rebecca Sohmer. 2008. "Boomburb Downtowns: The Next Generation of Urban Centers." *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 1(1): 77-90.
Lang, R.E., Edward J. Blakely, and Meghan Z. Gough. 2005. "Keys to the New Metropolis." *Journal of the American Planning Association* 71(4): 381-390.
Lariviere, I., and G. Lafrance. 1999. "Modeling the Electricity Consumption of Cities: Effect of Urban Density." *Energy Economics* 21 (1): 53.
Lo, Fu-chen, and Yue-man Yeung. 1999. "The Urbanization of Bangkok: Its Prominence, Problems, and Prospects." in *Emerging World Cities in Pacific Asia*. Tokyo: United Nations University Press.
Marvin, Stephen, and Simon Marvin. 2001. *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*. London: Routledge.
Mattsson, Lars Göran, and Lina Sjolin. 2001. "Transport and Location Effects of a Ring Road in a City with or Without Road Pricing." *Journal of Transport Economics and Policy* 35: 417-456.
McCann, Philip. 2012. "The Role of Industrial Clustering and Increasing Returns to Scale in Economic Development and Urban Growth." In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 167-200. New York: Oxford University Press.
McConnell, Virginia and Keith Wiley. 2012. "Infill development: Perspecitves and evidence from economics and planning." In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 473-502. New York: Oxford University Press.
McGee, T. G., and Ira M. Robinson. 1995. *The mega-urban regions of Southeast Asia.* Vancouver: UBC Press.
Mills, Daid E. 1980. "Growth, Speculation and Sprawl in a Monocentric City." *Journal of Urban Economics.* 10: 201-226.
Mindali, Orit, Adi Raveh, and Ilan Salomon. 2004. "Urban density and energy consumption: a new look at old statistics." *Transportation Research. Part A, Policy and Practice* 38A (2): 143-162.
Moretti, Enrico. 2003. *Human Capital Externalities in Cities*. *National Bureau of Economic Research Working Paper* 9416.
Murakami, Akinobu, Alinda Medrial Zain, Kazuhiko Takeuchi, Atsushi Tsunekawa, and Shigehiro Yokota. 2005. "Trends in urbanization and patterns of land use in the Asian mega cities Jakarta, Bangkok, and Metro Manila." *Landscape and Urban Planning* 70 (3): 251.
Olufemi, Ogunkoya Adeniyi. 2008. "Public Transport Innovation: The Impact of BRT on Passenger's Movement in Lagos Metropolitan Area of Nigeria." *Pakistan Journal of Social Sciences* 5(8): 845-852.
Olvera, Lourdes Diaz, Didier Plat, Pascal Pochet. 2008. "Household transport expenditure in Sub-Saharan African cities: measurement and analysis." *Journal of*

Transport Geography 16 (8): 1-13.
Paulsen, Kurt. 2012. “Yet Even More Evidence on the Spatial Size of Cities: Urban Spatial Expansion in the US, 1980-2000.” *Regional Science and Urban Economics* 42: 561-568.
Persky, Joseph and Wim Wiewel. 2012. “Urban Decentralization, Suburbanization, and Sprawl: An Equity Perspective.” In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 150-166. New York: Oxford University Press.
Punpuing, Sureeporn, and Helen Ross. 2001. “Commuting: The human side of Bangkok's transport problems.” *Journal of Planning Literature* 16 (1): 80-163.
Qian, Zhu. 2008. “Planning a ‘World Class’ City without Zoning.” In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 219-236. New York: Routledge.
Rauch, James E. 1991. “Productivity Gains from Geographic Concentration of Human Capital: Evidence from the Cities.” *National Bureau of Economic Research Working Paper 3905*.
Reynolds-Feighan, Aisling and Vickerman, Roger. 2012. “Transportation Economics for Planners.” In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 545-561. New York: Oxford University Press.
Robinson, Fred and Keith Shaw. 1991. “Urban regeneration and community involvement.” *Local Economy: The Journal of the Local Economy Policy Unit* 61:61-73.
Rowley, Alan. 1996. “Mixed-use Development: Ambiguous concept, simplistic analysis and wishful thinking?” *Planning Practice and Research* 11 (1): 85-98.
Rydin Y., et al. 2012. “Shaping Cities for Health: Complexity and the Planning of Urban Environments in the 21st Century.” *Lancet* 379: 2079-108.
Satterthwaite, David. 2007. “The Transition to a Predominantly Urban World and its Underpinnings.” *Human Settlements Discussion Paper Series,* International Institute for Environment and Development.
Segal, David. 1976. "Are There Returns to Scale in City Size?" *The Review of Economics and Statistics* 58 (3): 339-350.
Simmonds, Roger, and Gary Hack. 2000. *Global city regions: their emerging forms.* London: Spon Press.
Sintusingha, Sidh. 2006. “Sustainability and urban sprawl: Alternative scenarios for a Bangkok superblock.” *Urban Design International* 11 (3-4): 151-172.
Song, Yan, and Gerrit-Jan Knaap. 2004. “Measuring Urban Form: Is Portland Winning the War on Sprawl?” *Journal of the American Planning Association* 70 (2): 210.
Song, Yan and Mark Stevens. 2012. “The Economics of New Urbanism and Smart Growth: Comparing Price Gains and Costs between new urbanist and conventional developments.” In *The Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit Knaap, 502-552. New York: Oxford University Press.
Stead, D., and S. Marshall. 2001. “The Relationships Between Urban Form and Travel Patterns: An International Review and Evaluation.” *European Journal of Transport and Infrastructure Research* 1 (2): 113–141.

Sterner, Thomas. 2007. “Fuel Taxes: An Important Instrument for Climate Policy.” *Energy Policy* 35 (6): 3194-3202.

Townsend, Craig, and John Zacharias. 2010. “Built environment and pedestrian behavior at rail rapid transit stations in Bangkok.” *Transportation* 37 (2): 317-330.

Tacoli, Cecilia. 2008. “Links between Rural and Urban Development in Africa and Asia.” Population Division, Department of Economic and Social Affairs, United Nations.

UN Habitat. 2010. *State of the World’s Cities 2010/2011: bridging the urban divide.* London: Earthscan.

Urban Age Programme. 2009. *Cities and Social Equity: Detailed Report.* London: Urban Age Programme, London School of Economics and Political Science.

Vernter, Christo, and Roger Behrens. 2005. “Transport Expenditure: Is the 10% Policy Benchmark Appropriate?” *The 24th Annual South African Transport Conference SATC 2005: Transport challenges for 2010*. CSIR Conference Centre, Pretoria, South Africa, 11 to 13 July, 2005. Irene, South Africa.

Verhoef, Erik T. 2005. “Second-Best Congestion Pricing Schemes in the Monocentric City.” *Journal of Urban Economics* 58 (3): 367-388.

Weitz, Jerry, and Terry Moore. 1999. “Development inside urban growth boundaries: Oregon's empirical evidence of contiguous urban form.” *Journal of Planning Literature* 13 (4).

World Bank. 2009. “Nigeria: Lagos Urban Transport Project (LUTP).” Last modified 2009. http://go.worldbank.org/7G70R82OL0

Wu, J., G.D. Jenerette, A. Buyantuyev, and C.L. Redman. 2011. “Quantifying spatiotemporal patterns of urbanization: The case of the two fastest growing metropolitan regions in the United States.” *Ecological Complexity* 8 (1): 1-8.

Xian, George, Mike Crane, and Cory McMahon. 2008. "Quantifying Multi-temporal Urban Development Characteristics in Las Vegas from Landsat and ASTER Data.” *Photogrammetric Engineering and Remote Sensing* 74 (4): 473.

Yang, Perry Pei-Ju. 2008. “Tracking Sustainable Urban Forms and Material Flows in Singapore.” In *World Cities and Urban Form: Fragmented, polycentric, sustainable?* edited by Mike Jenks, Daniel Kozak, and Pattaranan Takkanon, 259-268. New York: Routledge.