Making Sense of Urban Patterns

Why do cities everywhere exhibit the same general patterns of density and development? And how can we explain some striking variations?

BY JEFFREY BRINKMAN

The streets of Philadelphia roll west through a collage of urban environments familiar to city dwellers nearly everywhere. From Penn Square, the central site of the iconic stone City Hall, Market Street traverses a canyon of concrete and glass office buildings that gradually give way to commercial and apartment structures and mixed uses. A mile from City Hall, the busy thoroughfare crosses the Schuylkill River, and density again picks up as the University of Pennsylvania anchors a second employment hub.

On tree-lined Baltimore Avenue a few blocks south of the bustling campus, streetcars pass tightly packed Victorian rowhouses and midrise apartment buildings. Small stores, restaurants, and scattered office structures dot the sidewalks. Farther west on the avenue, the relatively high-rent university area transitions into a lower-income neighborhood. Shorter buildings predominate, and some of the neighborhoods contain light industrial businesses.

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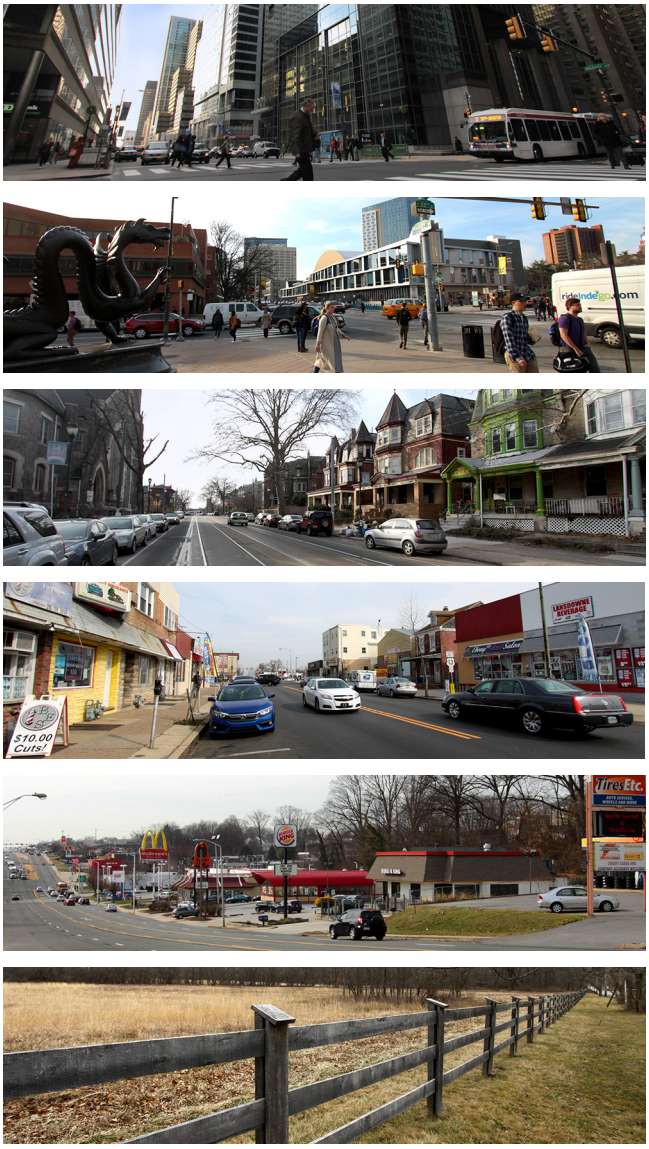
Eventually, the avenue leaves Philadelphia and passes through suburbs marked by detached houses on generally small lots. Some of these communities have commercial main streets, but strip-style development with ample parking is more common. Farther west, houses and yards are larger, fewer streets have sidewalks, and neighborhoods are almost exclusively residential. Beyond the city, houses and businesses become sparser as farms and open space appear.

While details vary, the broad patterns described here are common in and around cities throughout the world. As one travels outward from the downtown areas of most



Photos by Rich Wood

cities, building and population densities decline, residences replace commercial buildings, and open space increases.

From other viewpoints, however, patterns are not so clear. For example, the location and clustering, or *sorting*, of households by income or education vary among cities and over time, and employment subcenters often emerge outside a city's core business district. These collective patterns constitute *urban spatial structure*.

Economists and other social scientists have long sought a deeper understanding of the underlying determinants of the geographic distribution of population, firms, and land use within cities and their suburbs. These factors have important implications for policymakers charged with implementing and funding local services or infrastructure and land use planning.

Why do we observe persistent patterns in cities? And what causes these patterns to sometimes undergo big shifts, such as today's migration of young professionals to the heart of Philadelphia and other large U.S. cities? To shed light on these phenomena, we need a little urban spatial structure theory.

LOCATION, LOCATION, LOCATION

The relationship between access to cities and land prices has long been studied by economists. Johann Heinrich von Thünen was perhaps the first to generalize about the spatial structure of urban areas, in the early 19th century. The German economist described a town with a central market surrounded by agricultural land and posited that farmers chose locations based on two considerations: how much land they needed to raise their crops, and how much it cost to transport their crops to the center of town. The farmers' decisions reflected simple economics. Those whose crops could be grown on small fields or were relatively expensive to transport wanted land close to town, while those whose crops required more acreage and were cheaper to transport were willing to be farther away. The relative advantage of proximity dictated that land prices were higher near the market.

While von Thünen's application is antiquated, his basic insight remains powerful: Transportation costs and the importance of land in production or consumption drive land prices. This early theory formalized the concept of *bid rents*. Assuming that land markets function efficiently, the businesses and people that most value a location will pay the most for the property. Therefore, there is always an incentive to move farther from cities — the cost of land — pushing against the incentive to move nearer — the cost of transportation.

Does the Theory Explain Modern Cities?

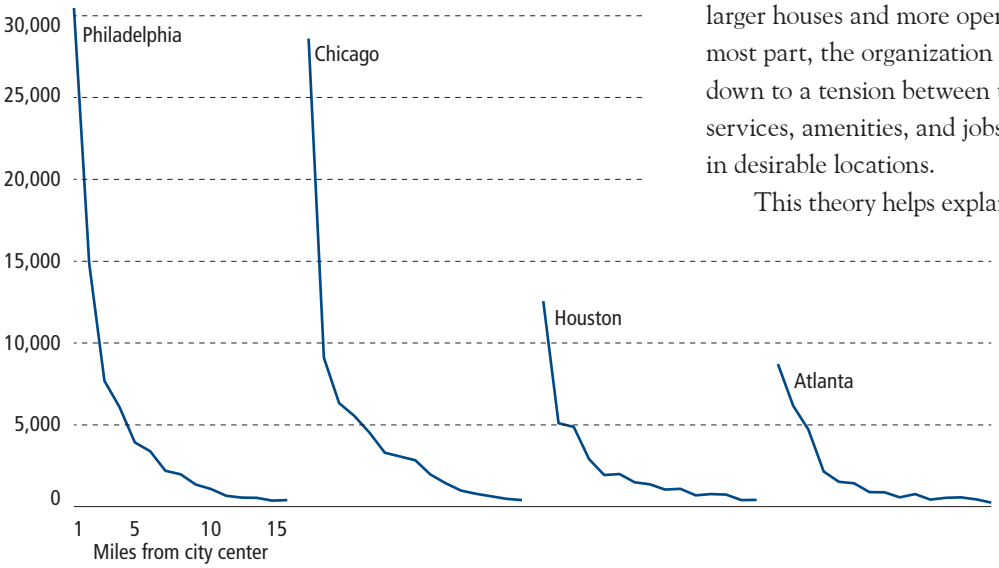
In the 1960s, Edwin Mills and other researchers adapted Von Thünen's ideas to better understand the urban structure of modern cities by considering a city where firms located in the center are surrounded by housing. Again, the basic trade-off is between access and the price of land. In this case, the access is derived from the cost of commuting to work in the center of the city. The insight is that workers face trade-offs between shorter commuting times on the one hand and larger houses and more open space on the other. For the most part, the organization of a metropolitan area comes down to a tension between the desire for access — to goods, services, amenities, and jobs — and the fixed supply of land in desirable locations.

This theory helps explain one of the most salient features of cities: Population density and land prices decrease as distance from the center increases. Population density as a function of distance to the city center for selected cities is shown in Figure 1. For each city, population density declines

FIGURE 1

Density Drops Off More Steeply Away from Some Downtowns

Population per square mile.



Source: Census Bureau: 2010 decennial census.

as distance from the center increases. However, the slopes of the lines are quite different. For example, central Philadelphia's high population density declines steeply as distance increases from the city center, while Houston, which has a comparable overall population, exhibits a flatter gradient.

One possible explanation is the difference in transportation infrastructure in the two cities. Philadelphia has extensive public transit, while Houston has invested heavily in expressways. These two transportation technologies pose different costs for commuters, both in terms of time and money, which could lead to different population patterns. Transit's lower speeds, for example, could induce people to live closer to work. Car commuting has high fixed costs of owning and maintaining a vehicle but usually is faster, particularly over long distances, and thus encourages the population to spread out.

Known as the monocentric model, this theory remains a workhorse in urban economics because it describes the basic principle driving urban development. Furthermore, the model can help us understand how policies such as Philadelphia's investment in mass transit will affect population growth, congestion, incomes, and other economic outcomes. For example, the theory predicts that the creation of additional transportation infrastructure will reduce the time and cost to travel to jobs. As a result, people will be able to move farther from their jobs and take advantage of cheaper land to build larger homes, thereby diffusing the population and reducing density. Research by Nate Baum-Snow confirmed the prediction of the theory and showed that the federal interstate highway construction initiative started in the 1950s reduced central city populations by 25 percent — with significant implications for the economic health of cities and their suburbs.

Firms and Production in Cities

One additional important feature of metropolitan areas involves the location choices of businesses. Early theories assumed that all employment was located in city cores. This assumption might have been justified by history, given that the main driver of the location of businesses was access to transportation centers such as ports or rail hubs. However, advances in transportation and the transition to a service-oriented economy have made the monocentric model less relevant over time. Indeed, multiple employment subcenters are an important feature of today's urban-suburban landscape.

Newer theories hold that businesses receive some production benefits by being located close to one another. Thus, firms that are located in cities confront the trade-off between the cost of land and the production advantages of being located in dense business clusters. These production advantages, referred to as *agglomeration externalities*, can arise through a number of channels. It is generally accepted that these agglomeration externalities are strong enough to cause businesses to cluster. Gerald Carlino and Jeffrey Lin have discussed the theory and evidence of agglomeration economies in *Business Review* articles.

CONNECTING THE THEORY TO THE DATA

Although urban spatial structure theory continues to advance, the field still relies on a number of abstractions that can inhibit empirical work and policy analysis. One feature of urban economies that is not explained easily is why different lots in the same neighborhood might be used for different purposes. While the classic monocentric model is an important approximation of city structure, it predicts an abrupt transition between commercial and residential uses. In reality, there is typically a gradual transition from commercial uses in the center of the city to residential uses farther out and finally to open space at the edge of a city. And there is significant mixing of uses everywhere.

In Philadelphia, for example, commercial uses dominate at the city center but are quickly replaced by high-density residential uses and then by low-density residential uses farther away from the center. In the outskirts, other uses, mainly open space and agriculture, begin to dominate.

In a recent paper, I develop a model that can more realistically capture complex land uses by allowing for mixing of land uses in neighborhoods throughout a city.[1] In addition, I model the role of traffic congestion, which is an important factor that limits the size of cities and the concentration of economic activity. Traffic congestion has well-known negative effects on cities, including lost time for drivers and worsening pollution for everyone. Using data on population, employment, land prices, land uses, and commute times, I calibrate the model and then simulate a real-world congestion pricing policy. The idea of a congestion pricing policy is that charging a toll on overcrowded roads will ease some of these negative outcomes by reducing traffic and encouraging drivers to make better decisions in their commuting habits.

However, real-world decisions to implement this policy often fail to recognize the long-run impact on the structure of cities. The results of the research suggest that congestion pricing can hurt a city's economy. By increasing the cost of transportation into dense business districts, congestion

pricing has the unintended consequence of dispersing employment away from those areas. In other words, businesses will choose to locate farther away in the long run. Given what we know about agglomeration effects, this flight could lead to a loss of business productivity.

An additional challenge in doing empirical work in economics is establishing a causal relationship using observed data. Spatial data are no exception. Unlike other fields, social science is hard-pressed to run controlled experiments in labs and thus often relies on using observed patterns in the real world. However, this makes it hard to infer the actual causal effect of policies, given that there are often confounding factors. For example, if we want to know the effect of building a highway on population, we cannot simply look at the increase in population near a new highway because the road probably was built in response to pent-up demand.

Therefore, to identify causal relationships, economists often rely on *exogenous shocks* to the economy — that is, events that occur for reasons far removed from the economic decisions being investigated but that affect those decisions in an important way. For example, research by Gabriel Ahlfeldt, Stephen Redding, Daniel Sturm, and Nikolaus Wolf examines the rise and fall of the Berlin Wall to identify the magnitude of underlying determinants of city structure. By using a rich model of city structure and looking at the changes in population and employment patterns before and after the wall was constructed and torn down, they are able to measure the importance of agglomeration economies. The authors find that not only are agglomeration economies significant but that they also are very localized. Roughly speaking, the authors find that doubling the employment density increases productivity on the order of 8 percent but that the effects of these production externalities decline by 95 percent after less than a third of a mile.

RECENT TRENDS AND FUTURE RESEARCH

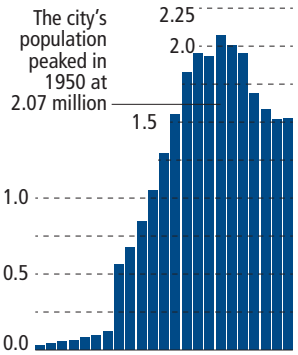
Many uncertainties remain about urban spatial structure. One timely question pertains to the increasing concentration of young, educated professionals in the core of large cities. For example, scores of upscale rowhouses and high-rise condominiums are being built in areas surrounding Center City Philadelphia. The development is consistent with U.S. trends in which multifamily construction has driven the housing market recovery since the most recent recession in a way that is unprecedented in recent U.S. history.

Philadelphia's population peaked at 2.07 million in 1950 and fell to 1.5 million in 2000 before rising to 1.6 million in 2015 (Figure 2). A 2012 U.S. Census Bureau report showed significant population growth near city halls (a good marker of the city center), particularly in large cities, between 2000 and 2010.[2]

FIGURE 2

Historic Population of Philadelphia

1790–2010, millions of people.



Source: Census Bureau.

While there are certain robust patterns in cities, the patterns related to income sorting can vary across cities, over time, and across cultures. Thirty years ago, the dominant pattern in the U.S. was that average income increased with distance from the center of the city. However, this pattern was not universal. In many European cities, for example, incomes have traditionally been higher in the central city and remain so today.

Cities in the U.S. are beginning to change, as city centers show notable increases in population, driven by inflows of educated young people. Figure 3 shows the percentage change in the young, educated population for four U.S. cities as a function of distance from the cities' center. All show large increases close to the city center, with Houston showing a 130 percent increase within a mile of the city center. Outlying areas show no change or even declines in the young, educated population.

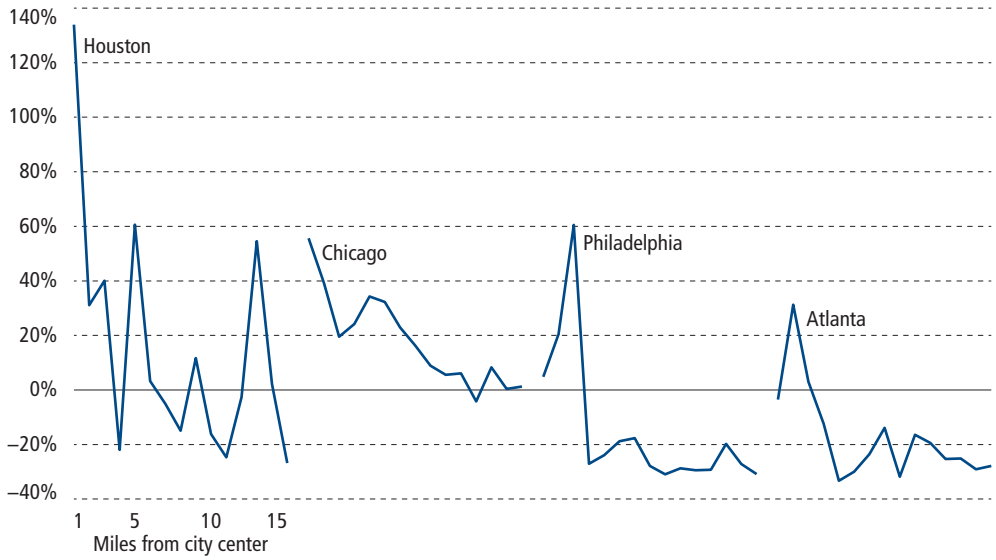
Urban spatial theory has the potential to help illuminate the reasons for this change. Although there is currently no consensus on the causes, possible factors could include the perceived value of urban amenities, reductions in crime, transportation costs, the production technologies of firms, and demographics. Two recent studies provide evidence that changing tastes for urban amenities are playing some role in this trend.[3]

A better understanding of these changes will help policymakers predict how their decisions will affect their cities' economies in the future and make better judgments about the provision of services, infrastructure planning, and other urban needs. Whatever the underlying cause, it will be related to the classic trade-off between access and the scarcity of land illuminated nearly 200 years ago by Johann Heinrich von Thünen.

FIGURE 3

Educated Young People Are Moving Downtown

Percent change from 2000–2010 in the share of college-educated residents age 25–44 as a function of distance from the centers of selected cities.



Source: Census Bureau: 2010 decennial census.

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NOTES

[1] See my 2016 article in the *Journal of Urban Economics*.

[2] A press release summarizes the report, https://www.census.gov/newsroom/releases/archives/2010_census/cb12-181.html.

[3] See the 2016 working papers by Victor Couture and Jessie Handbury and by Nathaniel Baum-Snow and Daniel Hartley.