Three Keys to the City:

Resources, Agglomeration Economies, and Sorting*

BY GERALD A. CARLINO

Metropolitan areas in the U.S. contain almost 80 percent of the nation's population and nearly 85 percent of its jobs. This high degree of spatial concentration of people and jobs leads to congestion costs and higher housing costs. To offset these costs, workers must receive higher wages, and higher wages increase firms' costs. So why do firms continue to produce in cities where the cost of doing business is so high? Economists offer three main explanations. First, cities developed and grew because of some natural advantage, such as a port. Second, as cities grew, the resulting concentration of people and jobs led to efficiency gains and cost savings for firms, creating agglomeration economies. Finally, the presence of a talented and flexible labor force made it feasible for entrepreneurs to start new businesses. This third reason for the growth of cities is called sorting. In this article, Jerry Carlino looks at recent developments in measuring each of the sources of city productivity and discusses the policy implications of this research.

Although metropolitan areas account for only 16 percent of the total land area in the United States, they contain almost 80 percent of the nation's population and nearly 85 percent of its jobs. This high degree of spatial concentration of people and jobs leads to congestion costs, such as increased traffic and pollution, and higher housing costs. To offset these congestion costs, workers must receive higher wages, and higher wages increase firms' costs.

Jerry Carlino is a senior economic advisor and economist in the Research Department of the Philadelphia Fed. This article is available free of charge at www.philadelphiafed.org/research-and-data/publications/.

*The views expressed here are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

So why do firms continue to produce in cities where the cost of doing business is so high? Economists offer three main explanations.[1] The first explanation is that cities developed and grew because of some valuable natural advantage, such as a source of raw materials or a port that allowed businesses to save on transportation costs. For example, because of its access to a deep harbor and because of its central location, Philadelphia was the largest and most important trading and merchant center in North America during the nation's colonial period.

But, as Satyajit Chatterjee points out in an earlier *Business Review* article, a natural advantage, such as a harbor, was not the main reason for Philadelphia's subsequent growth into the fourth largest metropolitan area in the country. As colonial Philadelphia grew, the resulting concentration of people and jobs led to efficiency gains and cost savings for firms, efficiency and savings that arose from being close to suppliers, workers, customers, and even competitors. This second reason for cost savings in cities is referred to as agglomeration economies. Finally, as Joseph Gyourko points out, the early growth of Philadelphia was aided by its large and relatively highly skilled labor force. The presence of a talented and flexible labor force made it feasible for entrepreneurs to start new businesses

[1] The terms city, metropolitan area, and their adjectives are being used to designate a metropolitan statistical area (MSA). In general, MSAs are statistical constructs used to represent integrated labor market areas. They typically are geographic areas combining a large population nucleus with adjacent communities that have a high degree of economic integration with the nucleus.

in Philadelphia. This third reason for the growth of cities is called sorting: A disproportionate share of highly skilled (more productive) workers choose to live in large cities, making big cities more productive than small ones. Other things equal, firms will have little incentive to move if congestion costs are balanced by the benefits of a natural advantage, agglomeration economies, and sorting.

At one time, economists tended to lump together the advantages of sorting and the advantages associated with urban agglomeration economies into a single measure. However, more recently, economists have examined how important each of the three reasons is in accounting for city productivity. Knowledge about the relative importance of each of the reasons is important to policymakers, too. If agglomeration economies kick in once a city reaches a critical size, urban planners might want to pursue policies that help a city reach that size. There is also mounting evidence that agglomeration economies depend on a city's ability to attract and retain high-skill workers. Edward Glaeser and Matthew Resseger find that agglomeration economies are much stronger in cities where workers are relatively highly skilled. Given the evidence that a high concentration of skilled workers enhances city productivity, policymakers may want to consider policies that attract and retain highly skilled people.

In this article I will look at recent developments in measuring each of the sources of city productivity and discuss the policy implications of this research.

SPATIAL CONCENTRATION OF PEOPLE AND JOBS IN CITIES: ROLE OF NATURAL ADVANTAGE, AGGLOMERATION ECONOMIES, AND SORTING

A location may attract households and firms because of the presence of valuable natural resources, such as petroleum, coal, lumber, or minerals, and proximity to a navigable river or a port. Although the availability of resources and other natural advantages varies from place to place, a diversity of resources cannot be the main reason for the existence of cities. According to Edward Glaeser and Janet Kohlhase, "The cost of moving a ton by rail has declined in real terms by more than 90 percent since the late 19th century and the rise in trucking has been even more dramatic." As a result, firms have become increasingly "footloose" with respect to a location's natural advantages, since easy access to rivers, other water systems, and raw materials has become less valuable over time. In studying the spatial concentration in manufacturing in 1987, Glenn Ellison and Edward Glaeser found that only about 20 percent of the spatial concentration of manufacturing plants can be accounted for by a location's natural advantages. Given that employment in manufacturing is continually being replaced with jobs in the service sector, the role of natural advantages in accounting for the geographic concentration of industries will continue to be less important than it was even as recently as 50 years ago.

Some economists believe that an increase in the capital stock of the public sector leads to increases in private-sector output and productivity because public infrastructure is an essential input into the production of private output.[2] For example, driver productivity increases when a good highway system allows truck drivers to avoid circuitous back roads and congestion and to bring supplies to a firm and goods to market more quickly. Similarly, well-maintained roads reduce wear and tear on commercial vehicles, lowering private-sector maintenance and replacement of these vehicles. Similar arguments can be made for the public provision of police and fire protection, water supply facilities, airports, and mass transit. An increase in the public capital stock, like an increase in any factor of production, increases private-sector output.

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Historically, economists have focused on agglomeration economies to explain the high concentration of people and jobs found in cities, of which there are two broad types: business agglomeration economies and consumer agglomeration economies.

[2] See the article by Randall Eberts and Daniel McMillen for a review of the early empirical evidence on public infrastructure. This evidence indicated a strong response of private-sector output to increases in the capital stock of the public sector. More recent studies have not found such a strong link between the capital stock of the public sector and productivity. For example, looking at the role that public infrastructure plays in a state's economic growth, Andrew Haughwout finds that increases in a state's public capital stock did not dramatically raise a state's economic growth.

business agglomeration economies and consumer agglomeration economies. Business agglomeration economies can increase the productivity of firms and their workers. More recently, economists have underscored the importance of consumer agglomeration economies, which improve the quality of leisure activities, as a source of the continuing growth of cities. The bulk of the empirical evidence on agglomeration economies has focused on business agglomeration economies (hereafter referred to simply as agglomeration economies unless otherwise noted), so we will start there.

If agglomeration economies are important, they will make workers in large cities more productive compared with workers in small cities and rural areas. Since workers are paid according to their productivity, wages and the demand for labor reflect the advantages of agglomeration economies. Thus, early studies looked at the impact of agglomeration economies on average wages (wages averaged across all workers in a city). Since agglomeration economies are not directly observable, many studies have used some measure of urban size, such as the size of a city's population or its population density (the city's population relative to its land area), as a proxy for agglomeration economies. The idea is that the benefits of agglomeration economies increase with a city's population size or its population density.

Studies from the 1970s and 1980s found that a doubling in city population size could lead to a substantial 8 to 10 percent increase in manufacturing productivity.[3] More recent evidence indicates that the findings from these early studies most likely overstate the actual productivity gains associated with urban size. The contribution of population size to urban productivity may be overstated if the other factors thought to influence urban productivity are not taken into consideration. An important problem with these studies is that they did not control for one aspect of city population: the very real possibility that the more productive places will tend to draw people. Are cities large because they are more productive or more productive because of their size? In a 2010 article, Pierre-Philippe Combes and his co-authors refer to this issue of reverse causation as the *endogenous quantity of labor*. This issue was first raised by Ronald Moomaw in his critique of the early literature and first dealt with in a study by Antonio Ciccone and Robert Hall. Ciccone and Hall proposed using population from the distant past (in their case for 1850) instead of using current population to control for reverse causation. The idea is that the population from 1850 is likely to be correlated with the population size of today but not with productivity today. We will have more to say about this source of reverse causation later.

Another concern is that more highly skilled workers may sort themselves into cities because large cities offer greater opportunities for consumption. Rising real incomes mean that quality-of-life issues have become more and more important as determinants of where people choose to live. For example, growth in real income increases the demand for a greater variety of goods and services (more theaters, varied restaurant cuisine, and professional sports teams). This implies that large cities with more choices will attract high-income households that put a high value on variety. Members of these high-income households also tend to be highly skilled individuals. The concern is that highly skilled workers tend to earn higher wages, and this could account for some of the positive correlation found between city population size and average wages in cities. In their 2010 article, Pierre-Philippe Combes and his co-authors refer to this sorting of relatively high-skill (highly productive) workers in large cities as the endogenous *quality* of labor.

In sum, there can be two important sources of overestimation of agglomeration economies: More productive places may attract more people, and more productive people may sort themselves into large cities. That is, large cities may draw people, especially highly skilled ones, leading to a potential overestimation of city size's effect on city productivity. It is important for any study of urban agglomeration economies to control for both of these sources of upward bias.[4]

If agglomeration economies are important, they will make workers in large cities more productive compared with workers in small cities and rural areas.

[3] See the article by Randall Eberts and Daniel McMillen for a review of the early empirical evidence on agglomeration economies.

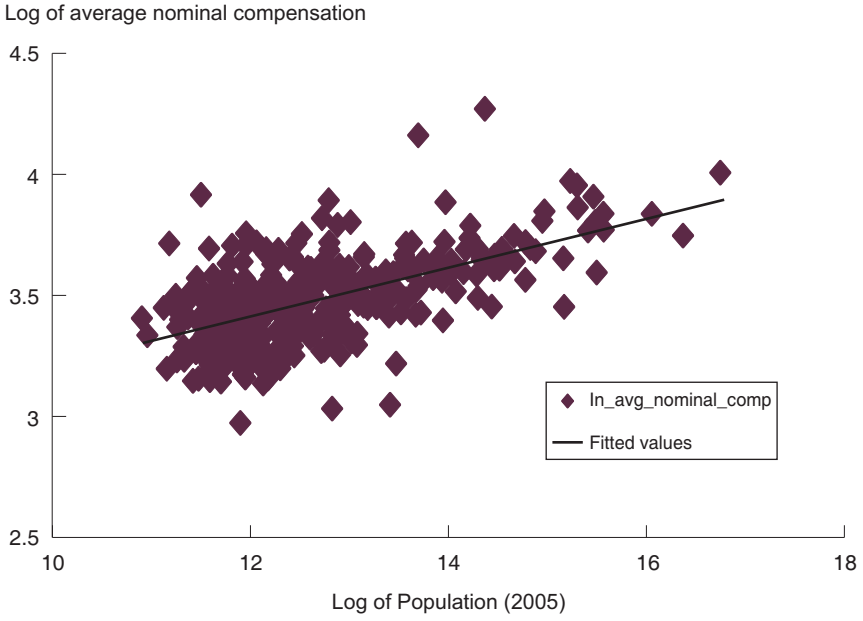
[4] See the article by Pierre-Philippe Combes, Gilles Duranton, and Laurent Gobillon for a discussion of a variety of solutions to address the overestimation of agglomeration economies.

WHAT'S THE EVIDENCE?

One of the facts that support the existence of urban agglomeration economies is the positive association between average wages in a city and a city's population size. The idea is that if workers are paid according to their productivity (that is, there is perfect competition in local labor markets), wages and the demand for labor reflect the advantages of agglomeration economies. The figure shows that there is indeed a positive correlation between average annual wages (total annual wages relative to the total number of workers) and population in a sample consisting of over 300 metropolitan statistical areas (MSAs) in 2005. Population size alone explains about 16 percent of the variation in average wages across MSAs. The positive correlation depicted graphically in the figure is shown numerically in column 1 of the table, which shows that a doubling of MSA population size is associated with a 6.1 percent increase in average wages.[5] As we will see, this estimate falls to 3.8 percent once we control for both sources of upward bias.[6] As

FIGURE

Wages Increase with City Size



Average wages are equal to average worker compensation.

I have already indicated, estimates of agglomeration economies will be overstated if people move to high-productivity MSAs (the reverse causation issue). Column 2 of Table 1 shows the results when we use the 1920 level of an MSA's population to identify the effect of population (our proxy of agglomeration economies) on a city's average wages.[7] After controlling for reverse causation, the estimate for the effect of a doubling of city population size on average wages falls from 6.1 percent to 3.9 percent.

What would happen to our estimate of the city size wage premium after we control for the share of an MSA's population with a college degree? There is a strong positive correlation between the share of the adult population with a college degree and city size.[8] In fact, if a city were to double its share of the adult population (persons 25 years old and over) with a college degree, its average wages would increase almost 63 percent. While it is highly unlikely that most cities would be able to double their college share, a 10 percent increase would still bring nice returns in terms of average wages. For example, in 2000, almost 28 percent of the Philadelphia metropolitan area's population had a college degree. If Philadelphia's college

[5] Average wages could be higher in large cities if large cities tend to have a mix of industries that would pay higher wages even if they were located in medium size and small cities. If so, estimates of agglomeration economies will be overstated if we do not control for differences in industry mix across cities. All regressions reported in the table control for the 1970 employment shares in each of nine broad industries. We used 1970 industry employment shares to mitigate any feedback from average wages in 2005 on current industry employment shares. The industries consist of agriculture; mining; construction; manufacturing; wholesale trade; retail trade; finance, insurance, and real estate; services; and government (transportation is the excluded sector). All of the regressions include controls to indicate an MSA's region. The regions are New England; Mideast; Great Lakes; Plains; Southeast; Southwest; and Rocky Mountain (the Far West is the excluded region).

[6] See Table A in the appendix for a summary of the regression underlying the discussion in the text.

[7] The reason for using 1920 population is that a city's population today tends to be highly positively correlated with its population from long ago, but the forces giving rise to a city's productivity today are quite different from those of the distant past. For example, in 1920, high productivity in manufacturing would have resulted in the growth of a city and a high level of population. It's highly likely that the level of population in 2005 will be highly correlated with the level of population from 85 years earlier, but it's unlikely that the drivers of productivity in manufacturing matter very much for the services-oriented cities of today.

[8] The simple correlation between the college share and the log of population is 0.71.

TABLE

Effect on Average Nominal Wages Resulting from a Doubling of an MSA's Population Size†

	(1)	(2)	(3)	(4) †††
Population, 2005††	6.1			
Population, 1920††		3.9	3.8	3.6
Controls for the share of 1920 population with a college degree	No	No	Yes	Yes
Controls for natural advantage and infrastructure†††	No	No	No	Yes
No. of MSAs	313	309	309	254

†Results reported after controlling for the 1970 employment shares in each of nine broad industries and for eight broad regions and for the MSA's region. See the appendix for details.

††Indicates variable is in logs.

†††A city's distance to commercially navigable rivers in 1890 is used to control for a city's natural advantage. The square miles of interstate highway system planned for in 1947 for a city is used to control for infrastructure in that city.

share increased 5 percent, to just over 29 percent, we estimate that average wages in Philadelphia would increase 3.2 percent. Put differently, relatively small changes in an area's college share can lead to relatively large changes in its average wage.

This positive correlation between a city's average wages and its college share could lead to an overestimation of the city size wage premium if high-ability and highly productive people sort themselves into large cities (the issue of endogenous quality of the population). Including the college share in the analysis is one way to control for the sorting in an MSA's population. Column 3 of the table shows that the estimates of the city size wage premium are only slightly affected after controlling for an area's college shares, falling to 3.8 percent from 3.9. Thus, at least for average city wages, it is more important to control for reverse causation (the migration of workers into cities) than it is to account for sorting (the self-selection of highly skilled workers into large cities).

As discussed earlier, some economists believe that an increase in the capital stock of the public sector leads to increases in private-sector output and productivity because public infrastructure is an essential input into the production of private output. In addition, some natural advantages (such as access to a port, rivers, or lakes) that gave rise to large cities in the past may still influence productivity (and wages) today. Column 4 of the table shows that the estimate of the city size wage premium falls only slightly (from 3.8 to 3.6) after we control for both an MSA's urban infrastructure and its natural advantages.[9] This finding is consistent with those reported by Andrew Haughwout: Increases in a state's public capital stock did not dramatically raise state economic growth.

What does our estimate of an urban wage premium of 3.8 percent mean for wages in dollar terms? A typical city in our sample had a population of about 680,000 (about

[9] Recall that estimates of the city size wage premium could be overstated if we fail to control for urban infrastructure. Following the seminal work of Nathaniel Baum-Snow, we take the miles of highways planned for an MSA in the 1947 national interstate highway plan. These planned highway miles are divided by the square miles of an MSA's land area to arrive at the proxy variable used for MSA infrastructure. We used 1947 planned miles of highways, since it's likely that miles of highways today are highly correlated with planned miles, while productivity today is not likely to have caused the planned miles in 1947. We thank Matthew Turner for providing the data for the planned highway miles; see the article by Gilles Duranton and Turner for details. We use an MSA's distance to commercially navigated waterways in 1890 as our proxy for an MSA's natural advantages. We thank Jordan Rappaport for providing these data; see the article by Rappaport and Jeffrey Sachs for details.

the size of Springfield, Massachusetts) in 2005 and an average annual wage of almost $34,700 in 2005. A doubling in the size of a typical city to a city consisting of almost 1.4 million people (about the size of the Nashville, Tennessee, or the Austin, Texas MSA) would result in an increase in average annual wages of about $1,320. If the Philadelphia MSA grew to the size of the New York City MSA, the average wage in the Philadelphia MSA is estimated to increase by about $2,500. If the Allentown MSA grew to the size of the New York City MSA, the average wage in Allentown would increase by just under $5,500. While it's unlikely that either Philadelphia or Allentown will ever reach the population size of New York City, these examples demonstrate that the urban wage premium can be substantial.

While firms care about what they must pay workers in nominal dollars, workers care about the purchasing power of the wages they receive. Although money wages are higher in New York City than in either Philadelphia or Allentown, the cost of living is much higher in New York City, too. (See *Adjusting Wages for City Cost of Living Differentials*.)

Moving from Aggregate Data to Micro Data. In attempting to measure agglomeration economies, we dealt with the sorting issue by controlling for worker characteristics by what we could observe in the aggregate data, namely, the share of a city's adult population with a college degree. But there are plenty of other observable and unobserved worker characteristics that need to be considered in attempting to get the most accurate estimate of agglomeration economies. Some of these characteristics, such as a worker's years of experience and his occupation, can be observed. Yet a number of unobserved worker characteristics, such as motivation, dedication, and innate abilities, may also influence a worker's wages.[10] The role of agglomeration economies in urban productivity may be overstated if the more experienced workers or those with the most innate ability tend to sort themselves into large cities. Recently, economists have been using large data sets containing highly detailed information on individual workers (micro data) rather than aggregate data (summed across all workers in an area) in an attempt to account for the role that observed and unobserved worker traits play in productivity. For example, Edward Glaeser and David Maré report that workers in large U.S. cities have wages that are 33 percent higher than those of workers outside of cities. But they find that the urban wage premium shrinks dramatically once they control for individual worker characteristics.

In an important 2010 study, Pierre-Philippe Combes and his co-authors use French micro data to gather evidence on the relationship between urban density and the urban wage premium.[11] They find that a doubling of urban density is associated with an overall urban wage premium of about 5 percent. When they control for just reverse causation, the urban wage premium falls to 4 percent. If, instead, they control only for sorting, the urban wage premium shrinks from 5 percent to 3.3 percent. That is, sorting matters in that it accounts for about one-third of the overall wage premium. The premium shrinks to 2.7 percent after controlling for both sorting and reverse causation in regard to labor.[12] In comparison, using data for U.S. cities, we found a somewhat larger urban premium of 3.8 percent when looking at population size (the table on page 5 or Table A in the appendix) or a premium of 3.3 percent when looking at population density (Table B in the appendix). The smaller premiums found in the study using French data may be largely due to better controls on worker characteristics afforded by the use of worker-level data.[13]

Loosely applying the 2.7 percent urban wage premium to the aggregate data indicates that the premium

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[10] Recent work on skills in cities by Marigee Bacolod, Bernardo Blum, and William Strange, among others, acknowledges that skills are multifaceted and, therefore, may not be adequately summarized by using a measure of education, such as a city's college share.

[11] Some economists use population size as a proxy for agglomeration economies, while other economists use population density (population of an MSA divided by the MSA's land area) as a proxy for agglomeration. As the appendix to this article shows, the findings for aggregate average wages are quite similar whether we use population size or population density.

[12] Similar to studies finding an urban wage premium in the neighborhood of 2 percent using French micro data, a study by Giordano Mion and Paolo Naticchioni, using micro data from Italy, finds that a doubling of density increases wages by 1 to 2 percent.

[13] Using panel data for 22 U.S. cities for the period 1985-2006, Morris Davis, Jonas Fisher, and Toni Whited find an urban wage premium of 2 percent. They also find that this urban wage premium raises national long-run consumption growth by 10 percent. Also using data for the U.S., Baum-Snow and Pavan find that agglomeration economies and sorting each account for about one-half of the urban wage premium.

Adjusting Wages for City Cost of Living Differentials

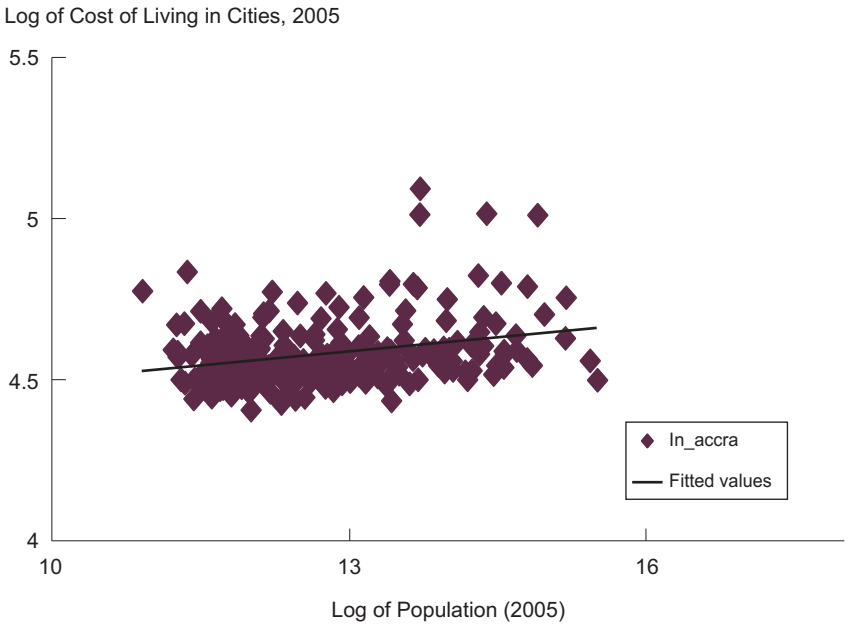
In the text, we looked at the effect agglomeration economies have on average nominal wages because this is the wage that firms care about. Since firms must compete in national and international markets, an area's nominal wage is important for firms' cost of doing business and may influence their decisions about where to locate a plant. From the viewpoint of workers, the possible advantages of working in an area with high nominal wages partly depend on how expensive it is to live there. Other things equal, workers should be indifferent between an area where wages and prices are at the national average and one where both the cost of living and wages are, say, 10 percent above average. In this case, real wages are equal in both areas. Thus, workers will choose a location in response to real wage differentials.

In the figure, we plot the cost of living in an MSA against the MSA's population size. As the figure shows, the cost of living is positively associated with city size.* Since the cost of living tends to rise with city size, the gap in *net* city size wage premiums (an area's wage premium due to agglomeration economies adjusted for its cost of living) across cities will not be as large as the gross wage premium. Other things equal, we would expect workers to migrate from areas with low real wages to areas with high real wages and that this process would eventually lead to real wages that are largely equalized across cities. In reality, real wages may not be equalized if workers trade off real wages for amenities, accepting lower real wages in high-amenity places and demanding higher real wages in low-amenity locations.

* Data for the cost of living by MSA are for 2005 and were obtained from the American Chamber of Commerce Research Association (ACCRA). The data show a moderate positive correlation of 0.2884 between the log of the cost of living and the log of MSA population size. The correlation between cost of living and city size falls to 0.2248 once we exclude the four outlier MSAs (Bridgeport-Stamford-Norwalk, CT; Honolulu, HI; San Diego-Carlsbad-San Marcos, CA; and San Jose-Sunnyvale-Santa Clara, CA) shown in the upper-center portion of the figure.

FIGURE

Cost of Living Increases with City Size



between the Philadelphia MSA and the New York City MSA falls from $2,500 to about $1,800 in nominal terms. Thus, the most comprehensive studies — those using micro data — find that the urban wage premium exists but it is much smaller than previously thought. The findings in the 2010 article by Combes and co-authors suggest that an important share of the measured agglomeration economies are, in fact, attributable to the sorting of highly skilled workers in denser locations.[14]

SKILLS AND CITIES

So far, we have summarized studies showing that productivity increases along with the population size or density of an area. We have seen that agglomeration economies are part of the story in any explanation of greater city productivity. We have also seen that there is a strong positive correlation between productivity in cities and the tendency for more skilled workers to locate in large cities. Economists cite several reasons why skilled workers matter so much for urban productivity. The high concentration of people in cities facilitates the exchange of knowledge among people. These exchanges, called knowledge spillovers, are likely to be enhanced in cities with highly skilled workers, who are better able to articulate and communicate ideas and may be better at adapting to new technologies. In a study of local innovative activity (measured by an MSA's patents per capita) that I co-authored with Robert Hunt, we found that a skilled work force (measured by the percent of the adult population with a college degree) was by far the most powerful determinant of innovative activity, even after controlling for other R&D inputs and other city characteristics. Specifically, we found that a 10 percent increase in the college share is associated with an almost 9 percent increase in patents per capita.

Economists cite several reasons why skilled workers matter so much for urban productivity.

A city may be highly innovative, but it may have trouble surviving if the benefits of this innovation largely accrue to other regions. As technology changes, cities need to adapt by reinventing themselves. Having a highly skilled labor force may be a crucial ingredient in the reinvention process. Edward Glaeser and Albert Saiz point out that skilled workers may adjust more rapidly to negative economic shocks and educated workers may find it much easier to adapt their activities to changing economic incentives presented by emerging technologies. In fact, Glaeser and Saiz argue that generating new technologies locally is not as important as having the ability to adapt to them. In a 2009 study, Jeffrey Lin provides evidence that the spatial concentration of skilled workers increases the rate of adaptation to new technologies.

In another study, Joseph Gyourko points out how Philadelphia has successfully reinvented itself several times. Until the mid-19th century, Philadelphia was the largest and most important trading and merchant center in North America. However, in the early 19th century, New York overtook Philadelphia as the leading center, but Philadelphia successfully reinvented itself and became a major center of highly skilled manufacturing activity. Up until the mid-19th century, Philadelphia was also able to benefit from its central location among North American cities. But the rise of rail transportation in the mid-19th century threatened Philadelphia's survival by drastically reducing the cost of shipping goods and the price of traded goods, allowing other cities to compete with Philadelphia.

However, Philadelphia figured out how to turn this potential liability into an asset and reinvented itself by exploiting the city's proximity to the coal fields of northeastern Pennsylvania. The rise in coal as an energy source not only increased the volume of shipping through Philadelphia (as witnessed by the development of the Philadelphia and Reading Railroad), but it also facilitated the transition to steam-powered machinery, a move that reinforced the city's position as an important manufacturing center.

The reinvention of Pittsburgh is a more contemporary example. As President Obama noted on September 8, 2009, Pittsburgh has "transformed itself from the city of steel to a center for high-tech innovation — including green technology, education and training, and research and development." Pittsburgh was chosen to host the G-20 Summit in 2009 both

[14] Another potential way in which agglomeration economies could be overstated is if only the strongest (most productive) firms survive in large cities. That is, the existence of a large number of firms in large cities gives rise to greater competition among firms and may lead to an exodus of less productive firms. This "selection" of the most productive firms in large cities could result in an overestimation of agglomeration economies if researchers fail to account for this potential source of bias. A 2009 study by Pierre-Philippe Combes and co-authors, using French establishment-level data, finds that this selection bias does not appear to be important in estimating agglomeration economies.

in recognition of and to highlight this transformation.

The evidence suggests that a city's prosperity and growth depends crucially on its ability to attract and retain highly skilled workers. Recently, economists have started to more closely examine the role of consumer agglomeration economies in the growth and development of cities. Jesse Shapiro has shown that the amenities that cities offer are especially attractive to high-skill workers, who, as we have already discussed, can stimulate employment and population growth.

In a study I conducted with Albert Saiz, we used the number of leisure tourist visits to cities as a proxy for the amenities offered in these cities. The idea is that leisure visitors are attracted by an area's special traits, such as proximity to the ocean, scenic views, historic districts, architectural beauty, and cultural and recreational opportunities. But these are some of the very characteristics that attract households to cities when they choose these places as their permanent homes. We found that the decadal population growth rate for the typical city during the 1990s would be 2.2 percentage points higher and its decadal job growth would be 2.6 percentage points higher in a city with twice the level of leisure tourists as another city. While more evidence is needed, my research with Saiz suggests that consumer agglomeration economies can be a future source of growth for cities.

CONCLUSION

Progress has been made in obtaining better estimates of both business and consumer agglomeration economies. Currently, the best evidence suggests that a doubling of city size increases productivity between about 3 to 4 percent. Still, the limitations of the data preclude us from speculating on the exact channels that explain business agglomeration economies. For example, we do not know the extent to which agglomeration economies arise from the sharing of specialized inputs by many firms in a common city.

Another possibility is that cities facilitate learning, since the exchange of ideas among individuals is enhanced in dense locations. Yet another possibility is that cities allow for better matches among workers and firms and better matching improves overall city productivity. Recent studies have identified the importance of some of these mechanisms. For example, in a *Business Review* article, Jeffrey Lin describes his paper with Hoyt Bleakley in which they evaluate one potential mechanism: better matching between job seekers and firms in dense MSAs. Still, no study that I'm aware of considers the relative importance of the various mechanisms. It is difficult to formulate specific policy recommendations without precise estimates of the *relative* importance of these various channels for agglomeration economies.

It is natural for local policymakers to think about the benefits of agglomeration economies for their own cities. But if city A increases its population size at the expense of other cities, any gains from agglomeration economies in city A might be offset by reductions in agglomeration economies in other cities. This suggests that agglomeration economies can have different policy implications for national as opposed to local policymakers. As Edward Glaeser points out, "The existence of agglomeration economies does not itself give guidance about optimal regional policy." It is difficult to formulate a national regional policy based on estimates of how agglomeration economies affect cities on average. Policymakers would need good estimates of how agglomeration economies affect different cities. Precise estimates of agglomeration economies for specific cities are an important next step for future research and for policy design.

REFERENCES

Bacolod, Marigee, Bernardo S. Blum, and William C. Strange. "Elements of Skill: Traits, Intelligences, Education, and Agglomeration," *Journal of Regional Science*, 50 (2010), pp. 245-80.

Baum-Snow, Nathaniel. "Did Highways Cause Suburbanization?" *Quarterly Journal of Economics*, 122 (2007), pp. 775-805.

Baum-Snow, Nathaniel, and Ronni Pavan. "Understanding the City Size Wage Gap," unpublished manuscript, Brown University (February 2010)

Bleakley, Hoyt, and Jeffrey Lin. "Thick-Market Effects and Churning in the Labor Market: Evidence from U.S. Cities," Federal Reserve Bank of Philadelphia Working Paper 07-23 (2007).

Carlino, Gerald A., and Robert Hunt. "What Explains the Quantity and Quality of Local Inventive Activity?" in G. Burtless and J. Pack, eds., *Brookings-Wharton Papers on Urban Affairs*. Washington: Brookings Institution Press (2009), pp. 65-109.

Carlino, Gerald A., and Albert Saiz. "City Beautiful," Federal Reserve Bank of Philadelphia, Working Paper 08-22 (September 2008).

Chatterjee, Satyajit. "Agglomeration Economies: The Spark That Ignites a City?" Federal Reserve Bank of Philadelphia *Business Review* (Fourth Quarter 2003).

Ciccone, Antonio, and Robert E. Hall. "Productivity and the Density of Economic Activity," *American Economic Review*, 86 (1996), pp. 54-70.

Combes, Pierre-Philippe, Gilles Duranton, Laurent Gobillon. "The Identification of Agglomeration Economies," unpublished manuscript (April 2010).

Combes, Pierre-Philippe, Gilles Duranton, Laurent Gobillon, and Sebastien Roux. "Estimating Agglomeration Economies with History, Geology, and Worker Effects," in Edward L. Glaeser, ed., *Agglomeration Economies*. Chicago: University of Chicago Press, 2010.

Combes, Pierre-Philippe, Gilles Duranton, Laurent Gobillon, and Sebastien Roux. "The Productivity Advantages of Large Cities: Distinguishing Agglomeration from Firm Selection," unpublished manuscript (February 2009).

Davis, Morris, Jonas Fisher, and Toni Whited. "Macroeconomic Implications of Agglomeration," unpublished manuscript, University of Wisconsin (December 2009).

Duranton, Gilles, and Matthew A. Turner. "Urban Growth and Transportation," unpublished manuscript, University of Toronto (November 2008).

Eberts, Randall W., and Daniel P. McMillen. "Agglomeration Economies and Urban Public Infrastructure," in P. Cheshire and E. Mills, eds., *Handbook of Regional and Urban Economics, Volume 3: Applied Urban Economics*. New York: Elsevier Sciences, 1999.

Ellison, Glenn, and Edward L. Glaeser. "Geographic Concentration of Industry: Does Natural Advantage Explain Agglomeration?" *American Economic Association Papers and Proceedings Review*, 89 (1999), pp. 311-16.

Glaeser, Edward L. "Introduction," in Edward L. Glaeser, ed., *Agglomeration Economies*. Chicago: University of Chicago Press, 2010.

Glaeser, Edward L., and Matthew Resseger. "The Complementarity Between Cities and Skills," *Journal of Regional Science*, 50 (2010), pp. 221-224.

Glaeser, Edward L., and Janet E. Kohlhase. "Cities, Regions and the Decline of Transport Costs," *Papers of the Regional Science Association*, 83 (2004), pp. 197-228.

Glaeser, Edward L., and Albert Saiz. "The Rise of the Skilled City," in W. Gale and J. Pack, eds., *Brookings-Wharton Papers on Urban Affairs*. Washington: Brookings Institution Press (2004), pp. 47-94.

Glaeser, Edward L., and D.C. Maré. "Cities and Skill," *Journal Labor Economics*, 19 (2001), pp. 316-42.

Gyourko, Joseph, "Looking Back to Look Forward: Learning from Philadelphia's 350 Years of Urban Development," in G. Burtless and J. Pack, eds., *Brookings-Wharton Papers on Urban Affairs*. Washington: Brookings Institution Press (2005), pp. 1-58.

Haughwout, Andrew. "The Paradox of Infrastructure Investment," *Brookings Review*, 18:3 (Summer 2000).

Lin, Jeffrey. "Urban Productivity from Job Search and Matching," Federal Reserve Bank of Philadelphia *Business Review* (First Quarter 2011).

Lin, Jeffrey. "Technological Adaptation, Cities, and New Work," Federal Reserve Bank of Philadelphia Working Paper 09-17 (2009).

Mion, Giordano, and Paolo Naticchioni. "The Spatial Sorting and Matching of Skills and Firms," *Canadian Journal of Economics*, 42 (2009) pp. 28-55.

Moomaw, Ronald L. "Productivity and City Size: A Critique of the Evidence," *Quarterly Journal of Economics* 96 (1981), pp. 675-88.

Puga, Diego. "The Magnitude and Causes of Agglomeration Economies," *Journal of Regional Science*, 50 (2010), pp. 203-19.

Rappaport, Jordan, and Jeffrey Sachs. "The United States as a Coastal Nation," *Journal of Economic Dynamics and Control*, 8 (2005), pp. 5-46.

Shapiro, Jesse M. "Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital," *Review of Economics and Statistics*, 88 (2006), pp. 324-35.

APPENDIX

As pointed out in the main text, agglomeration economies increase worker productivity, and in competitive labor markets, this increased productivity will show up in the wages workers are paid. Thus, it has become customary for economists to estimate a wage equation of the following type:

$$\ln(\text{Average Total Wages}_i) = C + \alpha \ln(\text{MSA Pop}_i) + \beta(\textit{controls}_i)$$

where estimates of α are the parameters of interest and the controls (such as city's college share and its mix of industries) differ in different studies. The findings reported in this study are based on the estimation of the following wage equation:

$$\ln(\text{Average Total Wages}_i) = C + \alpha \ln(\text{MSA Pop}_i) + \beta(\text{College Educated}_i) + \delta_j \sum_{j=1}^{8} (\text{Industry Mix}_{j,i})$$
$$+ \phi_k \sum_{k=1}^{7} (\text{Region}_{k,i}) + \varphi \ln(\text{Planned Highway Miles}_i) + \gamma \ln(\text{Navigable Rivers}_i)$$

where

Average Total Wages$_i$ = Total wages and salaries divided by total number of workers for 2005 in MSA *i*

MSA Pop$_i$ = Two alternative measures are used:

in Model 1: MSA Pop$_i$ = the *level* of population in MSA *i* (either for 2005 or for 1920);

in Model 2: MSA Pop$_i$ = population *density* = population in MSA *i* divided by square miles of land area in MSA *i* (either for 2005 or for 1920).

Percent College Educated = Percent of 1920 population with at least a college degree in MSA *i*

Industry Mix$_i$ = 1970 employment shares in each of nine broad industries in MSA *i*

Region$_i$ = A dummy variable indicating each MSA's region

Planned Highways Miles = 1947 planned miles of interstate highways for MSA *i* relative to square miles of land area in MSA *i*

Navigable Rivers$_i$ = Distance from navigable rivers in 1890 for MSA *i*

The dependent variable refers to average annual total private-sector wages divided by the number of private-sector workers in an MSA in 2005. The dependent variable is a proxy for MSA productivity. In general, deeply lagged values of the independent variables are used in this article. This reduces the simultaneity and reduces concerns about direction-of-causation issues, since 2005 values of the dependent variable are not likely to affect deeply lagged values of the independent ones. Two population measures are used as proxy variables for agglomeration economies. In Model 1, population size is used because sometimes researchers use MSA population size as a proxy for agglomeration economies. Alternatively, in Model 2, we use population density as the proxy variable because more recent studies have chosen density measures over measures of size. For comparative purposes, 2005 values for population size/density are used and reported. Since 2005 values are likely to be endogenous, we will use MSA population size and MSA population density in 1920, since this reduces the simultaneity and reduces concerns about direction-of-causation issues.

The industry mix variables consist of the 1970 employment shares in each of nine broad industries: agriculture; mining; construction; manufacturing; wholesale trade; retail trade; finance, insurance, and real estate; services; and

APPENDIX *(continued)*

government (transportation is the excluded sector). The region variables consist of a set of dummy variables to account for the MSA's region. The regions are New England; Mideast; Great Lakes; Plains; Southeast; Southwest; and Rocky Mountain (the Far West is the excluded region). We use planned highway miles as a proxy for urban infrastructure. Specifically, we use the miles of highways planned for an MSA in the 1947 national interstate highway plan. These planned highway miles are divided by the square miles of an MSA's land area to arrive at the proxy variable used for MSA infrastructure. Finally, we use an MSA's distance to commercially navigated waterways in 1890 as our proxy for an MSA's natural advantages.

The models were estimated using ordinary least squares (OLS) methods with White robust standard errors to take heteroskedasticity into account.* The results of the regression using population size are presented in Table A and a portion of the results are given in the table in the text. All of the variables in the model have the expected sign, and the coefficients on the variables for population size and college share are highly significant. Since the estimated coefficients can be interpreted as percentage changes, column 1 of Table A shows that a doubling of an MSA's population size is associated with a 6.1 percent increase in average wages. As indicated, our estimate of agglomeration economies can suffer from reverse causation bias. Therefore, column 2 of Table A shows the results when we use the 1920 level of an MSA's population to identify the effect of population on a city's average wages. After controlling for reverse causation, the estimate for the effect of a doubling of city population size on average wages falls from 6.1 percent to 3.9 percent.

Next, we add the 1920 college share variable to the regression to control for a sorting bias. Column 3 of Table A shows that the estimates of the city size wage premium are only slightly affected after controlling for college shares, falling to 3.8 percent from 3.9 percent. Finally, column 4 of Table A shows that the estimate of the city size wage premium falls only slightly (from 3.8 percent to 3.6 percent) after controlling for both an MSA's infrastructure and its natural advantage.

Table B summarizes the findings for the regression results when we use population density measures instead of population size measures. The results for density presented in Table B are quite similar to the results reported in Table A for size. At least for the aggregate data we considered, it makes little difference for the estimates of the urban wage premium whether size measures or density measures are used to proxy for agglomeration economies.

* Alternatively, we used a two-stage least squares (2SLS) procedure to estimate the parameters of the model. The 2SLS procedure confirmed that 1920 values for population size and population density are strong instruments for 2005 values of these variables. The findings from the 2SLS regressions are mostly similar to those based on the OLS method described in the text, and Hausman tests do not identify any systematic differences between the OLS and 2SLS coefficients in these regressions. We therefore present the results from the OLS regressions.

APPENDIX *(continued)*

Table A. Effect on Average Nominal Wages Resulting from a Doubling of an MSA's Population Size†

	(1)	(2)	(3)	(4)
Population, 2005†	**6.1***			
Population, 1920††		**3.9***	**3.8***	**3.6***
Share of 1920 Population with a College Degree			**62.8***	**65.9***
1947 Planned Highway Miles††				1.1
Distance from Navigable Rivers in 1890††				-0.004
No. of MSAs	313	309	309	254
R^2	0.6630	0.6207	0.6448	0.6567

Table B. Effect on Average Nominal Wages Resulting from a Doubling of an MSA's Density†

	(1)	(2)	(3)	(4)
Population Density, 2005†	**7.1***			
Population Density, 1920††		**3.4***	**3.3***	**3.6***
Share of 1920 Population with a College Degree			**61.4***	**66.8***
1947 Planned Highway Miles††				0.6
Distance from Navigable Rivers in 1890††				-0.004
No. of MSAs	313	309	309	254
R^2	0.6541	0.6060	0.6291	0.6430

*Indicates statistically significant from zero at the 1 percent level.

†Results reported after controlling for the 1970 employment shares in each of nine broad industries and for the MSA's region.

††Indicates variable is in logs.