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Terrorism and the Resilience of Cities

- The September 11 attacks highlighted the vulnerability of major U.S. cities to terrorism, leading some observers to question whether cities will continue to thrive despite the risk of further assaults.

- Current economic theory provides a strong basis for arguing that cities can withstand terrorist attacks and other catastrophes. The same forces that are thought to lead to the formation of cities—namely, the gains derived from the proximity of firms to markets, suppliers, and a large labor pool—will help to preserve cities in the face of an attack.

- To be sure, the ongoing threat of terrorism—a kind of "tax" on a city's firms or residents that reflects the costs of fear, higher insurance premiums, and increased security spending—may temper the economic forces that sustain cities. Nevertheless, the available evidence suggests that the size of this tax is too small to undermine the viability of New York and other large cities.

Large American cities have thrived in recent decades despite the challenges of crime, congestion, and poverty. Can terrorism jeopardize this vitality? The September 11 attacks were targeted at two major U.S. cities. Although the loss of life and the destruction were unprecedented, in one key respect the attacks were typical: terrorism in the developed world has usually been concentrated against the financial and political centers of power. The attacks on the World Trade Center and the Pentagon have forced Americans to confront the fact that to live or work in a major city is to be at greater risk of large-scale terrorism.

In this article, we consider what these risks, and the public perception of them, mean for cities in general and for the future of New York City in particular. We begin by examining the question of why cities exist at all. Only by answering this important question can we think more clearly about the long-run effects of terrorism on cities.

The economic analysis of cities is an active area of research, and we draw on that work for our study. The consensus among economists is that there are a number of plausible explanations, or models, for the existence of cities. Accordingly, we apply two economic geography models—the "labor pooling" and "core periphery" models—to our analysis of the existence of cities and terrorism's effect on them. Our use of these two different theoretical models gives a broad perspective to our study.

Although the models differ, the conclusions we draw from them are similar. Namely, the very forces that lead to city

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The authors thank two anonymous referees, as well as Rohit Vanjani for excellent assistance. The views expressed are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

formation also enable cities to be highly resilient in the face of catastrophes such as terrorist attacks, because they create an impetus for the concentration of economic activity that is very difficult to overcome. In addition, although a continued threat of terrorism in large cities may make them a somewhat less attractive place to live and conduct business, terrorism is quite unlikely to cause massive changes in the structure of urban life. New York City in particular is likely to continue to thrive despite any ongoing threat of terrorist activity.

Why Do Cities Exist in the First Place?

A city is a dense concentration of people and economic activity. In an open society, where people and businesses are free to locate wherever they like, such concentrations can persist only if they are beneficial to the people and firms that locate there. In the language of economists, the existence of cities is part of a *market equilibrium*, where the benefits of being in a city are at least as large as the costs. Similarly, for those who do not reside in cities, the benefits of being outside a city must exceed the costs.

The study of the existence of cities in equilibrium is the province of economic geography. A general feature of economic geography models is that they include strong forces of circular causality: since there are benefits to being in cities, workers and firms move there, which increases the benefits of being in the city, causing more workers and firms to move there, and so on. An implication of circular causality is that, once formed, cities are highly robust. The large gains from being in a city mean that firms and workers are reluctant to forgo those gains even if the costs of being there rise.

What are the economic benefits of being in a city? For one, moving goods and people across space is costly in terms of time and money, and being in a city economizes on these transport costs. Transport cost benefits can be broken down further according to three forces:

- Market access—firms benefit from being close to large concentrations of consumers. For goods producers, this proximity is often a matter of economizing on shipping costs, while for many service firms (hotels, restaurants, most retailers), it is simply impossible to sell to distant consumers.
- Supplier access—producers benefit from quick access to a wide range of inputs. This access gives firms an incentive to locate near their suppliers and, since nearby suppliers are favored by producers, suppliers have an incentive to locate near their customers.
- Cost of living—consumers benefit from being near producers, since they will have less expensive access to a wide range of goods and services.

These three forces work together to create an incentive for agglomeration. A final force is the fact that workers have to live near their jobs. Because workers are also consumers, by coming together in a single location, firms can sell to each other as suppliers and to each other's employees as consumers. Economists have worked hard to tidy up the loose ends of this argument, but the intuition is clear enough: when there are transportation costs, agglomeration is an equilibrium.

An alternative, but complementary, reason for cities is that their existence makes it easier for workers and firms to find each other. With a large pool of workers to choose from, employers can quickly hire the people they need. Similarly, with many potential employers, workers can find a job quickly.

> *In the language of economists, the existence of cities is part of a* market equilibrium*, where the benefits of being in a city are at least as large as the costs.*

If firms' demand for labor fluctuates over time, this labor market pooling effect can be particularly valuable for both firms and workers: when a firm lays off workers, those workers can find new jobs more easily if they live in a big city than if they live in an isolated company town; conversely, when a firm is booming, it can more easily lure new workers if a large pool of job seekers exists.

An appealing aspect of the labor market pooling motivation for cities is that it does not rely on transport costs, except to the extent that workers need to live near their jobs. Even as economic activity becomes more "weightless" and easy to transmit over space at low cost, the labor market pooling motivation remains undimmed.

To see the possible relevance of labor market pooling to New York City, consider the financial services sector—the backbone of the city's economy and tax base. Financial services have evolved to the point where face-to-face interaction between customers and producers is almost completely unnecessary for many transactions, and access to a wide range of produced inputs is equally irrelevant.[1] Yet financial services firms remain in New York because that is where their workers are, and their workers are there because the firms are there. As long as some work needs to be done by groups of workers located in the same place, economic activity cannot be completely dispersed, and agglomeration will persist even if final sales can be transported at zero cost.[2]

However, along with the benefits of being in a city come costs. The most obvious is congestion: cities are crowded and urban land prices are high. Another drawback for firms locating in a city is the heightened competition that arises from locating in an area where there are already many firms selling similar products. In equilibrium, firms and workers balance the benefits and costs of locating in a city, and the size and durability of cities depends on this trade-off.

Once a city is formed, the cost-benefit calculations that led to its creation may no longer be relevant. This is because the existence of the city is in itself a reason for its persistence. In particular, the level of costs that could lead a city to erode is generally far higher than the costs sufficient to discourage city formation in the first place. In short, there is an *agglomeration rent*: once workers and firms are in a city, costs and conditions can deteriorate substantially without tempting them to leave.[3]

How Does Terrorism Affect a City?

The impact of September 11 on New York City was not limited to the death and destruction in Lower Manhattan. The cost of doing business in New York has risen, even for workers and firms quite distant from the disaster site.

Some of these costs include:

- slower and less efficient transportation, because of the physical disruption of transport links and the delays caused by increased security,
- greater security spending,
- higher insurance premiums,
- the emotional toll on workers who fear future attacks.

In brief, the ongoing costs imposed by September 11 are significant. Indeed, some of these costs are now being borne in many large U.S. cities, as citizens have seen the damage inflicted on New York and are taking cautionary steps in response. The effect of these increased costs is to make cities less attractive—an effect that will last as long as the threat of terrorism persists.

Having established that cities exist because of the decisions of millions of independent workers and businesses, we return to our central question: what are the implications of terrorism for the future of cities? To answer this question, we turn to two specific models of the existence of cities, and examine the effects of terrorism in these models. The models illustrate the robustness of cities: they suggest that even in the face of the large and continuing costs associated with terrorism, cities are likely to continue to thrive.

The Labor Pooling Model

For our first model, we use a modified version of a simple model of labor market pooling introduced in Krugman (1991). The details of the model are given in the appendix, but the economic intuition is explained here.

The ingredients of the model are firms, workers, and locations. Firms choose their location to maximize profits, while workers move to where wages are highest. In addition to labor, firms use land to produce their output, and land is in fixed and equal supply in each of two locations, A and B.

Firms want to locate where other firms are to reduce fluctuations in wages.

Firms face uncertainty, and dealing with this uncertainty is an important part of their business plans. The uncertainty can reflect fluctuations in demand or in productivity, and it is important to theorize that the uncertainty is imperfectly correlated across firms: when some firms face high demand and/or productivity, other firms face low demand and/or productivity.

Because of the fluctuations facing firms, wages will fluctuate in each location: when many firms face high demand or have high productivity, wages will be bid up, and wages will fall when labor demand is low. But the variability in wages in a given location will be lower the more firms are in that location. This relationship follows from the law of averages: firm-specific positive and negative fluctuations are more likely to cancel each other out if there are many firms. In this case, firms that benefit from high demand or high productivity will be able to hire new workers without bidding up wages. This would not be true if there are few firms in the same location, or if firms' shocks are correlated. Hence, a larger number of firms and more diversity in a location will raise average profits in that location. In brief, firms want to locate where other firms are to reduce fluctuations in wages.

Land is in fixed supply in each location, and since each firm needs land as well as labor, the price of land is higher where there are more firms. This introduces a trade-off for firms: by locating where other firms are concentrated, firms benefit from a larger labor supply, but they must pay higher rents.

Turning to the decisions of workers, we assume that they care only about average wages.[4] As a result, if average wages are the same in two locations, workers will be indifferent about where they live. Since wages are determined by supply and demand, wages will be equal in each location if the share of workers equals the share of firms in each location. We illustrate this relationship in Exhibit 1: let λ_F be the share of firms in location A, and λ_L be the share of workers in location A. The 45 degree line is where $\lambda_F = \lambda_L$ so that wages are equalized, and we label the 45 degree line *WW* to indicate this equality. Above *WW*, $\lambda_F > \lambda_L$, so the share of firms in A is higher than the share of workers; this means that wages are higher in A than in B. This would lead workers to migrate from B to A, and the opposite holds for points below *WW*. These potential migrations are indicated by the arrows in the exhibit. Thus, with free migration, *WW* is the labor market equilibrium condition.

The location choice for firms is a bit more complicated, since it is based on three considerations: the average level of wages, the variability of wages, and the cost of land. In equilibrium, it must be the case that average profits are the same in each location, otherwise firms would move to the more profitable location. This trade-off is illustrated in Exhibit 2, which, like Exhibit 1, has location A's share of firms, λ_F, and share of workers, λ_L, on the two axes. As we detail in the appendix, the $\pi\pi$ curve shows the combinations of λ_F and λ_L that are consistent with equal average profits in each location. Starting at the symmetric point where there are equal numbers of workers in each location ($\lambda_F = \lambda_L = 1/2$), we note that there are two possibilities:

- If the labor pooling motive is weak and/or if the price of land responds strongly to the number of firms, the $\pi\pi$ curve has a slope of less than 1, illustrated as $\pi\pi_1$.
- If the labor pooling motive is strong and/or if the price of land does not respond much to the number of firms, the $\pi\pi$ curve has a slope that is initially greater than 1, but then flattens out, as illustrated by $\pi\pi_2$.

In either case, points below $\pi\pi$ are combinations of λ_F and λ_L such that profits are higher in A than in B, so that firms will move from B to A, with the opposite holding for points above *WW*. These potential movements of firms are indicated by the arrows in Exhibit 2.

With the labor market and firm location equilibrium conditions established, we can now determine the overall equilibrium location of workers and firms. This is where the *WW* and $\pi\pi$ curves intersect. The case where $\pi\pi$ is fairly flat at $\lambda_F = \lambda_L = 1/2$ is not very relevant, since it implies that the two locations are symmetric and no city emerges, so instead we focus on the case where $\pi\pi$ is steep at $\lambda_F = \lambda_L = 1/2$ (Exhibit 3). There are two equilibria in this case, but the symmetric one at $\lambda_F = \lambda_L = 1/2$ is unstable: any slight increase in λ_F or λ_L away from this point will be self-reinforcing, as indicated by the direction of the arrows, and the economy will converge to the asymmetric equilibrium where

Exhibit 1
The Location of Workers

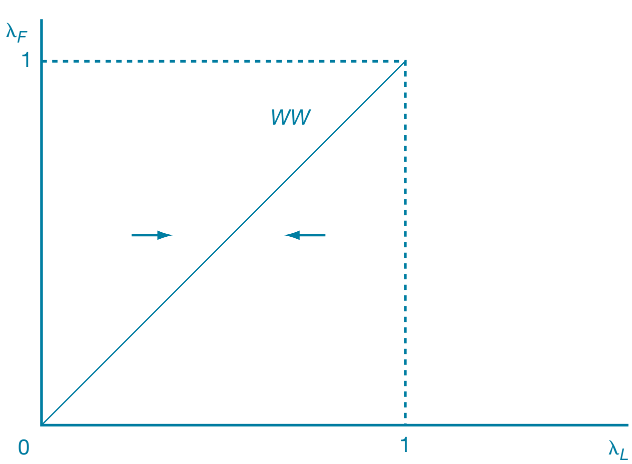


Exhibit 2
The No Agglomeration Case

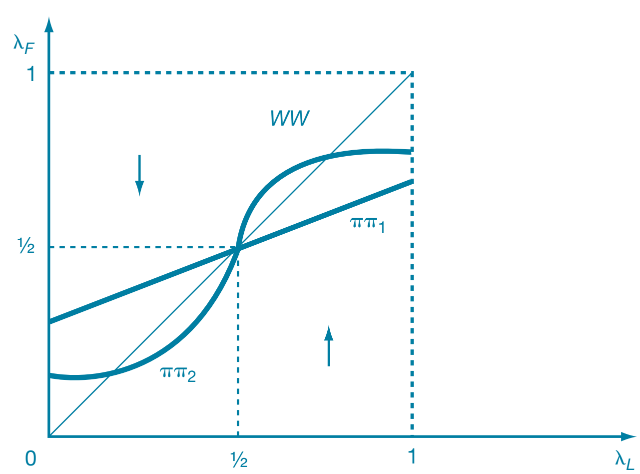
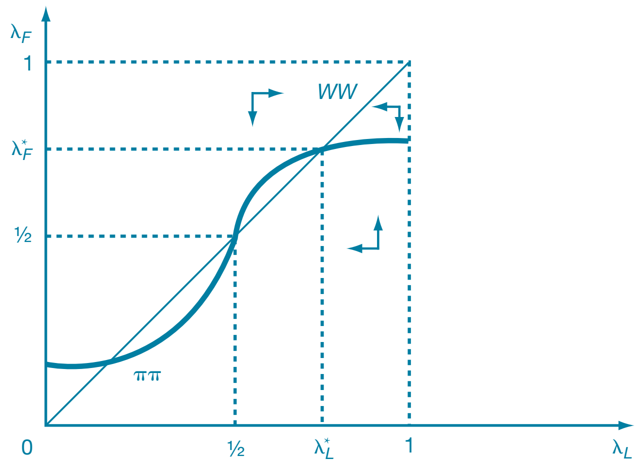


Exhibit 3
The Agglomeration Case



Note: We denote the equilibrium location of firms and workers as λ_F^* and λ_L^*, respectively.

one location is larger than the other ($\lambda_F{}^* = \lambda_L{}^* = 1/2$). At this equilibrium, location A (the city) has high land prices and firms benefit from labor pooling, while firms in location B (the nonurban location) forgo the benefits of labor pooling in exchange for lower land costs.[5]

Thus, in the labor pooling model, cities arise because the benefits to firms of a large and stable labor supply balance the high rents that must be paid in crowded locations.

The Effects of Terrorism in the Labor Pooling Model

As we have observed, terrorism targeted against large cities has two effects: the loss of life and the destruction associated with the attacks, and the costs of coping with any ongoing terrorist activity.

Perhaps surprisingly, a onetime incident in itself has no long-run effect on the size of cities in the labor pooling model. This is because even massive physical damage has no permanent effect on the underlying forces leading to the concentration of economic activity in a single location. Evidence to support our view is offered by Davis and Weinstein (forthcoming), who study the impact of the U.S. bombing of Japanese cities in 1944-45. They show that the damage to cities was both huge and very uneven, with some cities (such as Tokyo and Hiroshima) deeply affected and others relatively unaffected. However, fifty years later, the relative size of cities in Japan was the same as it was before the war; accordingly, the forces leading to city formation were left intact after the bombing stopped.

Nevertheless, *ongoing* costs can change the trade-off between concentration and dispersion, potentially leading to changes in the equilibrium amount of concentration. In the labor pooling model, terrorism in cities can directly affect firms through an increase in the cost of doing business, and affect workers through an increase in the perceived risk of living and working there. Because the decisions of firms determine local labor demand, any direct effect of terrorism on firms has an indirect effect on workers. Similarly, the direct effect of terrorism on workers' location decisions has an effect on firms because it influences local labor supply.

We first interpret the ongoing costs of terrorism as a cost that must be borne by firms that locate in the city. These costs include higher insurance premiums, direct spending on increased security, and reduced productivity associated with

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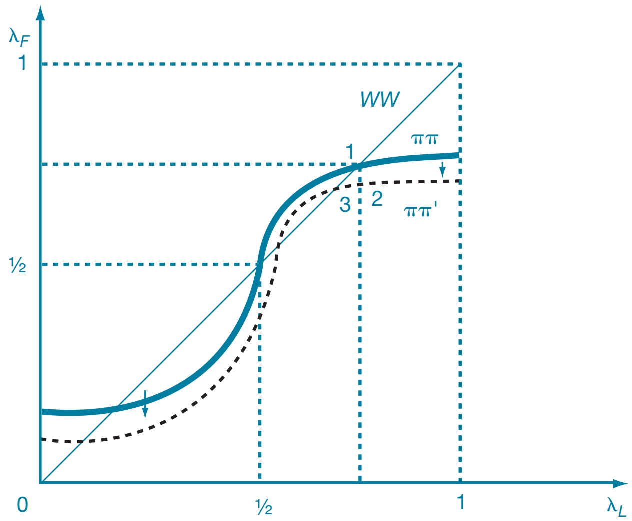
security-induced delays. We refer to these costs as a *terror tax*: the ongoing cost of doing business in a city threatened by terrorism.[6] Unlike a typical tax, this tax detracts from firm profits and worker income without funding improvements in infrastructure or services. Firms can avoid the terror tax by relocating to a smaller city, and it is this trade-off between security and agglomeration benefits that we analyze.

As Exhibit 4 shows, the initial equilibrium is at point 1, and terrorism shifts down the $\pi\pi$ curve to $\pi\pi'$. Firms leave the city to avoid the costs related to terrorism, wages in the city fall in response to the fall in labor demand, and the equilibrium moves to point 2. At that point, however, wages are lower in the city so workers leave as well. The new equilibrium is at point 3, with wages and profits again equalized between locations, but with the city somewhat smaller. Profits decrease in both locations: in the city because of lower agglomeration benefits and the direct costs of terrorism, in the nonurban area because land rents are bid up. Hence, even though the direct effect of

Exhibit 4

The Effects of Terrorism on Firms in Large Cities



terrorism is localized, the indirect economic effect is ubiquitous because of firm and worker mobility.

However, agglomeration forces are still present, and location A remains big despite the terror tax, which causes some firms to leave location A for location B. The fact that gains to agglomeration still exist implies that one location is bound to have more firms and workers. Another way to say this is that an agglomeration rent exists in the city: even if the profits of firms in the large city are hit by a permanent increase in costs, most firms will want to stay to benefit from labor pooling. However, if the increase in costs is large enough, and the consequent shift of the $\pi\pi$ curve is large enough, then the terror tax will cause so many firms and workers to leave the city in location A that the benefits of labor pooling will dry up, and the city will no longer have an economic rationale.

To illustrate this point, we construct a simple numerical example. We choose parameters such that in the initial situation, with no terrorism threat, some stylized facts in urban economics are replicated (see appendix). The labor pooling gains are large enough that the equilibrium share of firms and workers ($\lambda_F = \lambda_L$) in the city is 80.5 percent, which is roughly the urbanization rate in the United States. The share of labor income in GDP is two-thirds and the land rent in the city is ten times the land rent in the nonurban area.[7] This ratio in land prices is a measure of the agglomeration rent, or extra profit to firms from being in the city: it reveals that firms are willing to pay rents that are ten times higher in the city in order to benefit from the presence of other workers and firms.

We look at different scenarios of permanent increases in the costs of doing business in the city. An important point is that these are not the costs of fighting terrorism at the federal level, which presumably are financed by all agents in the economy, but are the added costs of doing business in the city that do not affect firms in the nonurban areas.

We find that a permanent 1 percent terror tax for all firms in the city has little effect: the share of workers and firms in the city falls from 80.5 percent to 80 percent.[8] The main adjustment comes in the form of a decrease in the ratio of land rent in the city to the nonurban area, from 10 to 7.5. This adjustment in prices is clearly a stabilizing factor for the city as it retains firms. Hence, the agglomeration rent decreases but it remains very large. A 5 percent terror tax has a more pronounced effect, as $\lambda_F = \lambda_L$ decreases to 76.3 percent and the ratio of land prices falls to 6. In the numerical example, a 7 percent terror tax causes the city to cease to exist, as firms leave the city followed by workers. At that level, the terror tax is large enough to offset the gains from labor pooling in equilibrium, and firms and workers disperse across space to avoid the tax. (Nevertheless, we argue below that such a large increase in costs that would fall entirely on the city is very unlikely.)

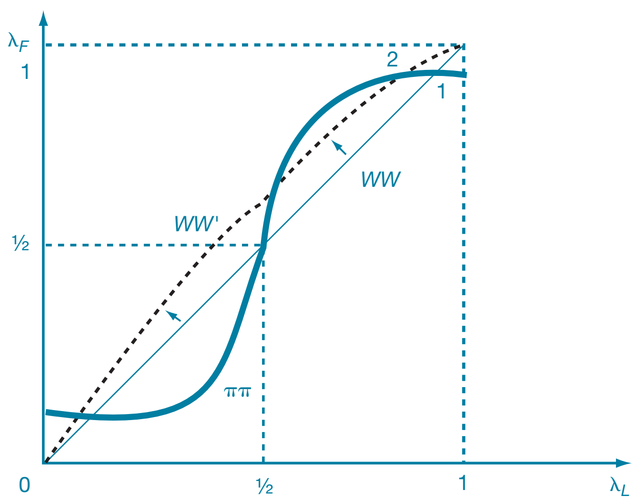
Thus far, we have assumed that the effect of a terrorist threat on cities operates through the increased costs that firms have to pay. But another effect of terrorism—and perhaps the one most desired by the perpetrators—is fear. Fear of terrorism may cause more than sleepless nights if people act on their fears by fleeing the city for locations perceived to be safer. Accordingly, it is reasonable to examine the effect that such fear has on cities in equilibrium.

Even if the profits of firms in the large city are hit by a permanent increase in costs, most firms will want to stay to benefit from labor pooling.

We model fear by supposing that workers are no longer indifferent between locations as long as wages are the same: at equal wages, they would rather be away from the city. Put differently, fearful workers demand a wage premium for working in cities because fear reduces the utility of living in the city.[9] Contrary to the case where the direct effect of terrorism is on firms, here the $\pi\pi$ curve is not affected but *WW* is, and shifts to the left (Exhibit 5). The equilibrium moves from point 1 to point 2 as both workers and firms leave the city. Profits in

Exhibit 5

The Effects of a Perceived Decrease in Safety in Large Cities



both locations decrease because of the increase in wage costs for the firms in the city and the reduction in agglomeration gains. As in the case where firms pay a terror tax, the city becomes smaller. However, if the agglomeration gains are sufficiently large, the city does not disappear, because labor pooling implies that firms are willing to pay a wage premium to retain workers in a single location, the city.

As we did with the terror tax, we construct a numerical example to illustrate the equilibrium effects of fear. Using the same parameters as before, we look first at what happens if the utility of workers living in the city is decreased by a fear factor equivalent to 1 percent of the wage.[10] The effects are found to be small: the share of workers in the city falls from 80.5 percent to 79.9 percent and the share of firms to 80 percent.[11] A 5 percent decrease in urban utility is found to have a larger effect: 76 percent of firms remain in the city and the share of workers falls to 75 percent. The city unravels abruptly when the fear factor rises to 7 percent of the wage: this exhausts the benefit to firms from labor pooling, and the economic rationale for the city is eliminated.

These numerical examples reveal a threshold effect of terrorism on the city. When the direct effect of terrorism on either the costs to firms or the peace of mind of workers is small enough, the equilibrium effect on city size is very small. But beyond a certain point (7 percent in both examples), the direct costs of terrorism have a catastrophic effect by wiping out the gains to labor pooling in the model, and the city loses its economic rationale.

Our conclusion from the labor pooling model is that the effect of terrorism on cities is discontinuous. Any ongoing costs of coping with terrorism, however, can lead to a limited reduction in the size of the city. The worst-case scenario—where the urban landscape ceases to exist—appears abruptly but only for large, permanent, increased costs of doing business in the city or for large increases in the perceived risk of living in the city.

The Core Periphery Model

The labor pooling model abstracts from transportation costs, except for the implicit assumption that workers need to live close to their jobs. But moving goods across space is costly, and transportation costs increase with distance. These facts offer an alternative explanation for the formation of cities that is independent of the labor pooling model. In the case of transport costs, businesses want to be near their customers (which may also be other businesses), and workers need to live near their jobs. Because workers are also consumers, by coming together in a single location, firms can sell to each other as suppliers and to their own and each other's employees as consumers.

To account for this interrelationship, we now apply a second model to the effects of terrorism on cities. The model we use, known as the core periphery model, is based on Fujita, Krugman, and Venables (1999). As with the labor pooling model, we begin with two *a priori* symmetric regions, and study the forces that might lead to a concentration of activity in one of the two regions (the technical details of the model can be found in the appendix).

Consider that each of two regions, A and B, is populated by an equal number of immobile workers, who we can think of as farmers.[12] There are two sectors: agriculture and manufacturing. The manufacturing sector has many firms that produce different goods and is subject to increasing returns, and manufactured goods are costly to transport. In particular, firms are assumed to incur a fixed cost for every production location, which gives them an incentive to concentrate production in a single place. Each manufacturing firm wants to sell to customers in both locations, but because of transport costs, firms will want to concentrate production in the larger market, so as to minimize their total transport cost bill. Aside from farmers, who are unable to leave their birthplace, there are manufacturing workers who are free to migrate in search of the highest real wages.

The model has two forces that encourage agglomeration:

- Market access—firms want to locate in the larger market so they can service customers without paying transport costs.
- Cost of living—if nominal wages are equal in both locations, workers would rather live where there are more firms because the price index, which includes transport costs, is lower.[13]

There is also one force opposing agglomeration:

- Competition—this force becomes more intense as more firms locate in a region, so profits become lower. Firms want to avoid competition, which gives them an incentive to locate in the region with fewer firms.

In equilibrium, the balance of these three forces depends on the detailed parameters of the model: agglomeration may be the only stable equilibrium, or it may not be an equilibrium at all. To see how the model works, it is helpful to begin by thinking about extreme cases. When it comes to very low transport costs, agglomeration is irrelevant and there is no reason for cities to exist at all, so half of all economic activity will be in each location. With very high transport costs, the benefits to firms of concentrating production in a single location are outweighed by the prohibitive costs of selling in distant markets; as a result, firms produce in both locations and there is no agglomeration.

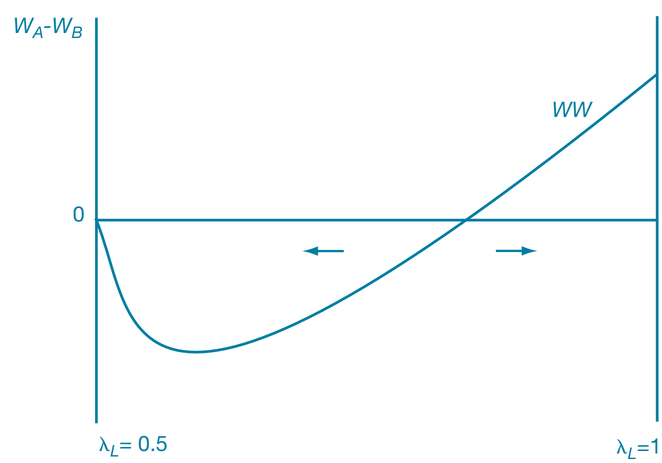
Because workers are also consumers, by coming together in a single location, firms can sell to each other as suppliers and to their own and each other's employees as consumers.

For intermediate levels of transport costs, which is the relevant real-world situation, there are two possibilities. The simplest scenario is the one where a city is inevitable: it will always pay for a worker to move to the location with more workers. Starting from symmetry, if one intrepid worker moves from location B to A, his wages will be higher, setting in motion a circular process that leads to a core periphery equilibrium, where all manufacturing is located in region A and where manufacturing wages are highest.

For our purposes, however, a second scenario is more applicable. Here, there are two locally stable equilibria, one symmetric (with half the manufacturers located in each region) and one core periphery. This scenario is illustrated in Exhibit 6, which shows λ_L as before the share of mobile workers in location A along the horizontal axis and the difference in real wages between locations on the vertical axis. The *WW* curve depicts the relationship between the real wage gap, $w_A - w_B$, and λ_L, and there are two locally stable equilibria, at $\lambda_L = 1/2$ (half of the mobile workers in each location) and at $\lambda_L = 1$ (all mobile workers in location A). To see that these equilibria are locally stable, imagine a worker in either equilibrium who decides to move to the other city: that worker will experience a drop in wages and will return home, as indicated by the direction of the arrows.[14]

The model is silent about which locally stable equilibria the economy is likely to end up in, but the core periphery equilibria at $\lambda_L = 1$ seems to be the relevant scenario for a world in which cities of unequal size coexist. Although the model is very simple, the core periphery equilibrium does have features that suggest the real world. First, there is circular causation in city formation: firms and workers want to be where other firms and workers are located. Second, wages are higher in the city, since $w_A - w_B > 0$ at $\lambda_L = 1$. Third, some economic activity (manufacturing) is concentrated in a city while other activity is spread more evenly across space.

Exhibit 6
Wages and Agglomeration



The Effects of Terrorism in the Core Periphery Model

The consequences of a onetime terrorist attack on a city in the core periphery model are similar to the effect in the labor pooling model: as long as the attack does not increase the ongoing costs of doing business in the city, there will be no long-run effect. The reason is that the underlying forces leading to city formation (a desire by firms to economize on transport costs) are unaffected by physical destruction of the city.[15]

A continuing terrorist threat that imposes ongoing costs, however, may have different consequences. As we did in the labor pooling model, we model the effect of terrorism in the city as a terror tax borne by firms. This shifts the *WW* curve down. Somewhat surprisingly, the equilibrium effect of terrorism on city size is either zero or enormous. For relatively small shifts in the *WW* curve, wages fall but remain higher in the city and there is no migration. This reaction illustrates the existence of an agglomeration rent: in the initial equilibrium, workers earn a premium for living in a city, and there is room for this premium to be eroded without causing any change in the equilibrium.

However, if the shift in the *WW* curve is large enough so that wages are lower in the city when the city exists ($w_A - w_B < 0$ at $\lambda_L = 1$), workers will start to leave the city, and the city will begin a vicious circle: as more workers and firms leave the city, the wage disadvantage persists, and the circular causation process goes into reverse (Exhibit 7). The new equilibrium is at $\lambda_L = 0.5$, where firms do not benefit from agglomeration but (by assumption) face no differential risk of terrorism because they are located in a city.

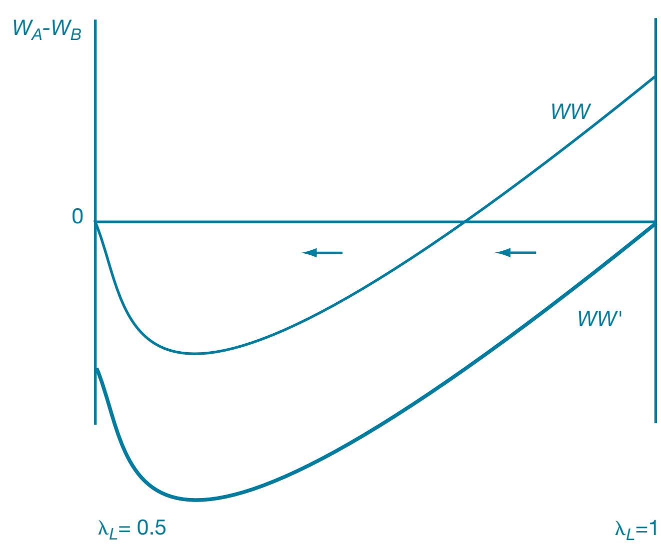
A striking aspect of this scenario is that even if the terrorist threat recedes, so that the *WW* curve returns to its original position, the dispersed equilibrium will persist. The reason is that, as noted above, there are two locally stable equilibria and the economy will tend to stay wherever it finds itself. Once the core periphery equilibrium is destroyed, it will not reappear. In such a case, the economy would be in a worse equilibrium than the one in which it began, with the efficiency gains of agglomeration permanently lost.

To offer a sense of the likelihood of the two possible scenarios, we present a numerical example. We choose parameters that imply markups of price over cost of about 25 percent, a share of goods in consumption of about 40 percent, and a level of transport costs (70 percent of sales value) that implies that there are two locally stable equilibria. This level of transport costs seems high at first glance, but it is more reasonable when nontradable goods such as most services are taken into account.

Beginning from a situation where the economy is in a core periphery equilibrium, we find that a terror tax of 1 percent or 5 percent of total costs has no effect on agglomeration: workers in the city are unhappy compared with the days before September 11, but are not unhappy enough to abandon the city. The critical value of the terror tax is 6.3 percent: if firms have to pay more than this amount to counter the effects of the ongoing threat of terrorism, they can no longer offer workers a wage premium for living in the city and workers will begin to move away, setting the vicious circle in motion. Interestingly, this critical level of the terror tax is close to the critical level of 7 percent found in the numerical examples of the labor pooling model.

In general, the vicious-circle scenario for the city is more likely to occur if the initial real wage advantage of residents is small, so that even a fairly small increase in costs in the city can tip the balance away from it as a place to work, starting the reverse cumulative process. Although this scenario seems extreme and is not likely to apply to New York City as a whole, it does make the general point that short-term disruptions to the benefits of agglomeration may have very long-term consequences.

Exhibit 7
The Effects on the City When the Terror Tax Is Large



Cities Are Unlikely to Disappear in the Face of Terrorism

We have presented two models in which an ongoing terrorist threat might jeopardize the existence of cities. The numerical examples used in the models, which we chose to reflect some of the relevant features of the U.S. economy, suggest that an ongoing terror tax (that is, higher costs paid by urban firms and residents that have no economic return) in the range of 5 percent to 10 percent might be enough to dissipate the economic rationale for the continuing existence of cities.

We should note that, despite their overall usefulness as measures of the vulnerability of New York or other cities, our numerical simulations probably understate the resilience of urban life substantially for the simple reason that each model examines just one motive for agglomeration in isolation. And although it is not possible to carefully analyze together all of the economic reasons why cities exist, it seems likely that cities are in fact much more robust than our models—which consider only one force at a time—suggest.

It is also worth noting that the level of terror tax that might cause cities to decline, as identified in our models, is far higher than anything that the war on terrorism thus far suggests is plausible. First, most of the costs discussed elsewhere in this volume (Hobijn 2002) are borne by the nation as a whole and are not disproportionately burdensome to New York or other cities. As a result, they are not an urban-specific terror tax of the kind that we analyze.

Nevertheless, one element of costs that does closely match our theoretical notion of a terror tax is insurance premiums, which can be expected to be disproportionately higher in New York as long as the threat of terrorism persists. The midyear outlook, published by Standard and Poor's in May 2002, reports that since September 11 "large commercial property insurance is commonly seeing rate increases of 50 percent-60 percent, with some policies exacting 200 percent-300 percent, along with more restrictive terms and conditions." These are large increases, and in New York some firms cannot buy insurance against the risk of terrorism at any price (Standard and Poor's Insurance 2002). However, insurance premiums do not constitute a large share of total costs. In a 1995 survey by the consulting firm Tillinghast-Towers Perrin, insurance premiums were reported to be 0.25 percent of the revenues of large firms (with more than $100 million in revenues). The amount is likely to be larger for smaller firms. For small and large firms combined, the burden of higher insurance premiums is estimated to be between 0.25 percent and 0.50 percent of firms' total costs. Yet even this small amount overestimates the urban insurance burden, because it does not measure the differential increase in costs between New York and the rest of the country.

Another element of costs specific to New York City is the ongoing disruption to transportation as a result of security delays and the destruction of the World Trade Center's Port Authority Trans-Hudson (PATH) train station. There is no way to estimate the costs of ongoing security-related delays at bridges and tunnels and the like, but anecdotal evidence suggests that the costs are not large. Bram, Haughwout, and Orr (2002) calculate that the time cost of a longer commute for former users of that PATH station is approximately $100 million per year, which is just 0.1 percent of gross city product.

Another way to think about the magnitude of the terror tax is to consider the actual dollar costs of September 11. Bram, Orr, and Rapaport (2002) estimate the value of wage losses associated with September 11 to be up to $6.4 billion and the value of physical destruction to be $21.6 billion. The size of New York's economy in 2001 is estimated to be between $381 billion (by the consulting firm DRI-WEFA) and $461 billion (by the New York City Office of the Comptroller). Assuming a 15 percent real rate of return on the destroyed capital stock (15 percent is roughly the aggregate rate of return on physical capital in the United States), the economic damage from the attack was on the order of 1.5 percent to 2.5 percent of the city's annual economic output. Although smaller than the calculations from our numerical examples, 2.5 percent is not a small number, and it might conceivably be large enough to threaten the future of New York—*if* the burden was ongoing and was not offset by insurance and federal assistance. However, as Bram, Orr, and Rapaport point out, most of the financial cost of September 11 will be covered either by private insurance or by federal assistance. Thus, the viability of urban life would be threatened only if *all* of the following conditions existed: firms were unable to obtain private insurance, the

One element of costs that does closely match our theoretical notion of a terror tax is insurance premiums, which can be expected to be disproportionately higher in New York as long as the threat of terrorism persists.

nation offered no financial assistance in the event of an attack, an attack of the destructiveness of September 11 was expected to occur every year, and the balance of forces that sustains agglomeration is even more fragile than our numerical examples suggest. It is safe to say that such a scenario is not likely.

We reiterate that our theoretical analysis of the terror tax suggests that only costs that are ongoing and specific to cities can diminish the powerful economic rationale for urban agglomeration. All available evidence suggests that the current size of the terror tax is small and is surely not large enough to threaten the viability of New York or other large cities. Moreover, the logic and the numerical simulations of the models examined suggest that in the most likely case, where agglomeration gains are sufficiently large, the effect on the size of the city will be quantitatively very small. By construction, in the core periphery model, there is no effect at all. The labor pooling model suggests that a terror tax on the order of magnitude given above would have very little negative effect on the size of the city and that the adjustment would take place through a decrease in the difference in land rents between the city and the nonurban areas. This small effect is not surprising given the circular causality mechanism at work in the model: the very fact that most workers and firms remain in the city is the source of the benefit of locating in the city. This also reflects the very nonlinear effect of terrorism on cities. It either eliminates the benefits of agglomeration or has no effect on them. Our evidence points to the latter conclusion—that terrorism will have very little effect on the size of cities.

Is There a Role for Policy?

From the standpoint of the health of cities, our analysis suggests that the best thing that government can do is to defeat terrorism, so that cities are not targets and do not have to bear its ongoing costs. That having been said, our two models suggest that, absent an expensive ongoing threat, cities will recover from terrorist attacks because physical damage does not affect the balance of forces that leads to agglomeration. If the threat of terrorism recedes, the city will return to its former size without government intervention. But in the unlikely event that terrorism does persist with very large costs, this balance of forces may be threatened, and the health of cities may be at risk. Then, and according to the logic of the models, a modest subsidy to economic activity in the city would be enough to buffer the city against the threat of firms and workers leaving. In an application of the precautionary principle, some may reasonably argue in favor of such a small subsidy as insurance against a very low-probability event.

Nevertheless, although both of our models suggest that an urban-specific subsidy may offset any negative effects of the terror tax, such a policy may not be needed. As our study indicates, it is unlikely that New York City or other cities will require subsidization to prevent them from declining in the face of potential terrorism.

Conclusion

Some observers have expressed concern that the September 11 attacks jeopardize both the present and future economic health of New York, Washington, and other major cities. In this article, we argue that the vitality of cities is unlikely to be diminished by the threat of terrorism. Rather, the forces that lead to city formation also enable cities to be highly resilient in the face of catastrophes such as terrorist attacks, because they constitute a force for agglomeration that is very difficult to overcome.

The two theoretical models that we examine suggest that the physical damage sustained from a single terrorist attack, despite its scale, is unlikely to represent a threat to the continued vitality of large cities. The effects of *ongoing* terrorist activity, however, are potentially greater, because the costs of dealing with terrorism can be viewed as a type of tax that may alter the balance of economic forces that leads to city formation. Although such a change in the attractiveness of doing business in cities may have a very modest effect, or no effect at all, there is at least the possibility that it could lead to a reversal of the circular causation that sustains the existence of cities.

Our analysis also suggests that cities in general, and New York City in particular, are highly unlikely to decline in the face of even a sustained terrorist campaign. Finally, our look at the data suggests that even a pessimistic view of the magnitude of the costs currently facing New Yorkers leads to the conclusion that the city's economic vitality is not at risk.

Appendix

In this appendix, we develop the math behind the models discussed.

The Labor Pooling Model

We use a modified version of a small model of labor market pooling that is introduced in Krugman (1991). We add to Krugman's analysis a market for land as well as shocks and uncertainty, specific to the threat of terrorism, that are concentrated in cities. In this model, the force behind agglomeration of economic activities in cities is very close to the Marshallian theory that a pooled market benefits both workers and firms. Uncertainty at the firm level plays a major role in this theory, and this type of uncertainty makes cities attractive to firms and workers.

The Basic Model

Suppose there are two locations, A and B; a total of *N* mobile firms; *L* mobile workers; and a given stock *F* of land in each region. n_A and n_B firms are located, respectively, in A and B. To simplify the scenario, we assume that firms, presumably because of the existence of high fixed costs, cannot have production sites in both locations. Firms are represented by a revenue function in which labor and land are the two arguments. As in Krugman (1991), we assume that the revenue function is the same in both locations, is quadratic, and that there are firm-specific shocks to the marginal product of labor:

(A1) $$R_{ij} = (\beta + \varepsilon_i)L_{ij} - \frac{\gamma}{2}L_{ij}^2 + \delta F_{ij} - \frac{\mu}{2}F_{ij}^2 - cN \quad i \in [1, N],\ j = A, B,$$

where $\beta, \gamma, \delta, \mu$, and *c* are positive parameters; L_i is the number of workers employed by the firm; and F_i is land used by firm i. ε_i is a firm-specific shock distributed normally $(0, \sigma_\varepsilon^2)$. The last term in equation A1 reflects the negative impact of competition on revenues and is not different across locations. The shocks are uncorrelated across firms. Both the labor market and the market for land are competitive and firms set the marginal products of the two factors equal to their price, respectively, *w* and *r*.

(A2) $$w_j = \beta + \varepsilon_i - \gamma L_{ij}$$
$$r_j = \delta - \mu F_{ij} \quad i \in [1, N],\ j = A, B.$$

This implies a labor demand and a demand for land from each firm:

(A3) $$L_{ij} = \frac{\beta + \varepsilon_i - w}{\gamma}$$
$$F_{ij} = \frac{\delta - r}{\mu} \quad i \in [1, N],\ j = A, B.$$

For each location, both factor markets clear:

(A4) $$\sum_{i=1}^{nj} L_{ij} = L_j \quad \sum_{i=1}^{nj} F_{ij} = F \quad i \in [1, N],\ j = A, B,$$

so that factor prices are given by:

(A5) $$w_j = \beta - \frac{\gamma L_j}{n_j} + \frac{\sum_{i=1}^{n_j} \varepsilon_i}{n_j}$$
$$r_j = \delta - \mu\frac{F}{n_j} \quad i \in [1, N],\ j = A, B.$$

Hence, the expected wage in a region depends positively on the number of firms in the region, but the variance of the wage depends negatively on that same number:

(A6) $$E(w_j) = \beta - \frac{\gamma L_j}{n_j} \quad var(w_j) = \frac{\sigma_\varepsilon^2}{n_j} \quad j = A, B.$$

The reason is that as shocks are uncorrelated across firms, the effect of a positive labor productivity shock on one firm on the equilibrium wage rate will be compensated by other firms' negative shocks, the more so that more firms are located in that location. This is in essence a specific version of the Marshallian argument of labor pooling. The covariance of the wage with firms' specific shocks also depends negatively on the number of firms: $covar(w_j) = \frac{\sigma_\varepsilon^2}{n_j} \quad j = A, B$.

The equilibrium demand for labor from a specific firm depends positively on its shock and negatively on other firms' shocks:

(A7) $$L_{ij} = \frac{1}{\gamma}\left(\varepsilon_i + \frac{\gamma L_j}{n_j} - \frac{\sum_{i=1}^{n_j} \varepsilon_i}{n_j}\right) j = A, B.$$

Using the definition of profits as revenues minus factor costs, and equations A5 and A7, we can obtain the expected profits in each location:

$$\text{(A8)} \qquad E\pi_j = \frac{\gamma}{2}E(L_{ij})^2 + \mu\frac{F^2}{2n_j^2} - tN$$

$$= \frac{\gamma L_j^2}{2 n_j^2} + \frac{\mu F^2}{2 n_j^2} + \frac{(n-1)}{2n\gamma}\sigma_\varepsilon^2 - tN \quad j = A, B\,.$$

Note that the expected profits in a location depend positively on the number of workers in that location. This is simply because the wage rate decreases in the supply of workers. The expected profit in a location has a more ambiguous relation to the number of firms in that location. On the one hand, more firms implies a higher demand for factors that bid up their price and lower profits (the first two arguments of equation A8). On the other hand, a larger number of firms makes wage rates more stable, which in turn increases expected profits, as profits are concave in the wages and the productivity shock (the last argument of equation A8). Hence, labor pooling generates, as long as shocks are not perfectly correlated across firms, a pecuniary externality that increases expected profits. Note that risk (specific to the firm) is the crucial element behind this externality that will play the central role in the tendency for agglomeration.

The Location Equilibrium

Equations A6 and A8 give the expected wage and profit in each location. For a location configuration to be an equilibrium, both mobile firms and mobile workers must have no incentive to move. We assume that both must decide where to locate before shocks occur, which implies that expected wages and expected profits must be equalized across locations. We define $\lambda_L = L_A/L$ as the share of workers in location A and, similarly, $\lambda_F = n_A/N$ as the share of firms in location A. For expected wages to be identical, it must be that $\lambda_L = \lambda_F$, so that the share of firms is equal to the share of workers. The reason is that if firms move to one location, the wage rate will increase in that location, attracting workers up to the point where wages are equalized. This is the first equilibrium relation, which we call the *WW* schedule.

The equilibrium relation that implies that expected profits are equalized is a bit more complex. Solving $E\pi_A = E\pi_B$, we obtain a second relation between λ_L and λ_F, which we call the $\pi\pi$ schedule:

$$\text{(A9)} \qquad (1-2\lambda_F)[\gamma^2 L^2 \lambda_F^2 - N1 - \lambda_F \lambda_F \sigma_\varepsilon^2 + \gamma\mu F^2]$$

$$-\gamma^2 L^2 \lambda_F^2 (1-2\lambda_L) = 0\,.$$

It can be shown that, as long as it is continuous (that is, σ_ε^2 is not too high), the $\pi\pi$ schedule defines a positive relation between λ_L and λ_F. If workers move to a location, they will decrease wages in that location so that firms will also move. However, this positive relation between the share of workers and the share of firms in region A is nonlinear because of the presence of firm-specific shocks (the labor market pooling effect) and the impact on the land market. If these two effects were absent ($\sigma_\varepsilon^2 = \mu = 0$), the location equilibrium would then be indeterminate.

An obvious equilibrium exists—the symmetric equilibrium ($\lambda_L = \lambda_F = 1/2$) or the dispersed equilibrium. As usual in this literature, we can ask under which conditions this equilibrium is stable and under which conditions other equilibria exist, with one location arising as the main agglomeration with a majority of workers and firms.

Let us first consider the case where the symmetric equilibrium is stable. Estimated at the symmetric equilibrium, the slope of the $\pi\pi$ schedule is:

$$\text{(A10)} \qquad \frac{\partial\lambda_F}{\partial\lambda_L} = \frac{\gamma^2 L^2}{\gamma^2 L^2 + 4\gamma\mu F^2 - N\sigma_\varepsilon^2}\,.$$

Suppose first that the slope of the $\pi\pi$ schedule is less than the slope of the *WW* schedule. If we assume that workers move to the location with the higher expected wage, and that firms move to the location that offers higher expected profits, then the dynamics of the model are shown by the arrows in Exhibit 1.

The symmetric equilibrium is stable in the sense that if firms change locations, profits will increase in the location from which they leave and decrease in the other location. The same would happen to wages if workers were to leave a location. The slope in equation A10 is less than 1 when:

$$\text{(A11)} \qquad 4\gamma\mu F^2 > N\sigma_\varepsilon^2\,.$$

Not surprisingly, no agglomeration process takes place when: 1) wages and rents in a location react strongly to an increase in demand by firms relocating to that location (high γ, μ, and F), and 2) when N and σ_ε^2 are so small that the benefits of labor pooling for firms are small either because there are few firms to pool with or because the specific firms' shocks are small. It can be shown that the inequality in equation A11 is the same one that implies that no other equilibrium exists. This scenario is depicted in Exhibit 2.

When the inequality of equation A11 is reversed, the $\pi\pi$ schedule becomes steeper than the WW curve at the symmetric equilibrium and two other interior asymmetric equilibria appear, which are given by:

$$\text{(A12)} \qquad \lambda_F = \lambda_L = \frac{1}{2} \pm \frac{\sqrt{N^2\sigma_\varepsilon^4 - 4\gamma\mu NF\sigma_\varepsilon^2}}{2N\sigma_\varepsilon^2}.$$

Hence, one of the locations becomes an agglomeration, which attracts most workers and most firms. The equilibrium is such that wages and profits are the same in both locations. From equation A5, one can see that the price of land is higher in location A than in location B. The difference in land price reflects the benefit from labor pooling in location A.

The dynamics of the model that exist when agglomeration forces are strong enough are depicted in Exhibit 3. It can be shown that the two asymmetric equilibria are stable. As is usual in models of new economic geography with multiple equilibria, the identity of the location that ends up being the agglomeration is indeterminate. It can be interpreted loosely as the result of history and/or an initial small advantage. We choose location A as the location where most firms and workers concentrate.

Note that the higher the risk specific to firms (the higher σ_ε^2), the more firms and workers will want to concentrate in one location only. Hence, increased uncertainty is not, in itself, a force that leads firms to leave the urban, densely populated areas. In fact, this simple model shows that because of market pooling arguments, it may lead to an agglomeration process making the symmetric equilibrium unstable, and it may increase the attractiveness of the concentrated area once the agglomeration process is achieved.

To consider the possible effect of terrorism on the structure of cities, we start from the assumption that such an agglomeration phenomenon has indeed occurred, exemplified by New York City, so that location A has most firms and workers and that this equilibrium is initially stable.

There are different ways to interpret the impact of the events of September 11 on cities in terms of our model: 1) as an unexpected, negative onetime shock to firms based in the concentrated area, 2) as a permanent increase in expected costs in location A, the largest city, as future terrorist attacks might target this location (for example, because of the presence of financial markets, government activities, or other "symbolic activities"), 3) as a permanent increase in the disutility of workers who leave the concentrated location A, and 4) as a permanent increase in costs to firms as a function to the number of other firms in the same location.

An Unexpected, Negative Onetime Shock

In the first interpretation, and if we take strictly our assumption that the location choice is made before the shocks are realized, a onetime negative shock to profits in location A has no impact on location. Firms' profits decrease in location A. If the shock also affects labor productivity temporarily, wages in location A will decrease. A onetime unexpected shock has an impact on profits and wages, but not on the location equilibrium that results from a long-term choice. Another way to say this is that a temporary shock does not affect the economic forces that explain the agglomeration process in the first place (that is, the parameters that explain the instability of the symmetric dispersed equilibrium), nor does it affect the extent of spatial concentration (that is, the parameters that affect the share of firms and workers in location A in equation A12).

A Permanent Increase in Costs in Large Cities

In the second interpretation, we assume that costs increase permanently in location A by an amount T_A. This could be due to the fact that the threat of terrorism induces higher costs in terms of security and insurance. Using equation A9, we see that the $\pi\pi$ schedule then becomes:

$$\text{(A13)} \qquad (1-2\lambda_F)[\gamma^2L^2\lambda_L^2 - N(1-\lambda_F)\lambda_F\sigma_\varepsilon^2 + \gamma\mu F^2] \\ - \gamma^2L^2\lambda_F^2(1-2\lambda_L) - 2T_A\gamma N^2\lambda_F^2(1-\lambda_F)^2 = 0.$$

It can be shown that the $\pi\pi$ schedule is shifted downward and becomes flatter, and that $\partial\lambda_F/\partial T_A$ is always negative when evaluated at the "high" equilibrium, that is, in the equilibrium with concentration in location A. This is shown in Exhibit 4.

In this case, the equilibrium becomes less concentrated as firms leave location A for location B. However, agglomeration forces are still present, and location A remains the largest city despite the fact that due to the terrorism threat, the costs of firms have increased permanently. The fact that agglomeration gains (the labor pooling argument) still exist implies that one location is bound to have most firms and workers. In models of economic geography with multiple equilibria, history provides a strong advantage to the city with the initial concentration. This model shares this property. Another way to say this is that an agglomeration rent exists in the city: even if in the specific city the profits of firms are hit by a permanent shock to costs, most firms will want to stay to benefit from labor pooling. Of course, if the shock is large enough, that is, if the $\pi\pi$ schedule moves downward sufficiently, the equilibrium of concentration in location A could disappear. In this case, agglomeration would shift to the other possible equilibrium, location B. But the agglomeration gain derived from labor pooling would still imply an equilibrium with high concentration: another way to say this is that the symmetric equilibrium remains unstable.

Note that profits also decrease in location B when location A experiences this permanent decrease in profits. To show how the adjustment takes place, we write the level of profits in A (we know that in equilibrium profits must be equal in B) as a function of the share of workers and firms in region A:

$$\text{(A14)} \qquad \pi_A = \frac{\gamma}{2}\frac{\lambda_L^2 N^2}{\lambda_F^2 L^2} + \left(1 - \frac{1}{N\lambda_F}\right)\frac{\sigma_\varepsilon^2}{2\gamma} + F^2\mu\gamma\frac{N^2}{\lambda_F^2} - T_A - tN .$$

The first element of the profit level is the one linked to labor use by the firms. In equilibrium, we know that $\lambda_F = \lambda_L$, so that the permanent increase in costs through T_A does not alter profits in an indirect way through labor use and wages. The reason is that as firms leave location A, workers also leave, so that wages are unaffected. The second element is linked to the agglomeration benefits that come from labor pooling. As λ_F decreases due to the increase in T_A, these agglomeration benefits also decrease, which puts further downward pressure on profits in location A. The third element is linked to the cost of land. As firms leave location A, that is, as λ_F decreases, the demand for land decreases as well as its cost. Hence, this mitigates the fall in profits in A.

In location B, for the same symmetric reasons, wages are not affected, the agglomeration benefits of labor pooling increase, and land costs increase. In equilibrium, the cost-of-land increase in location B must be large enough to more than compensate for the positive effect of the labor pooling mechanism on profits.

To infer the transitional dynamics implied by the permanent increase in costs in location A, we retain the assumption that firms move with profit changes and that workers move with wage changes. In this case, when costs to firms rise, profits decrease and the equilibrium goes from 1 to 2 (Exhibit 3), so that firms leave the large city. This decreases wages in the city and leads workers to follow the firms at point 3, which can be considered the long-term equilibrium. Note that there is an amplifying effect due to the interaction of firms and workers. More firms leave in the long term than in the short term (λ_F is lower at point 3 than at point 2): the reason is that as workers leave city A, labor supply goes down and wages increase. This leads more firms to move as labor costs increase in city A.

Note that in this interpretation, wages are not affected in the long-term equilibrium but decrease in location A in the short term. If firms move first and workers second, wages will overshoot downward in the short term in location A and then increase back to the initial level.

The fact that wages do not change in the long term may not be true if some of the labor pooling mechanism were to increase labor productivity and therefore the demand for workers. In this case, wages would be negatively affected in the long term by the fact that firms and therefore workers become less spatially concentrated.

The numerical example described in this article uses these parameters: $L = 10$, $N = 5$, $\sigma_\varepsilon^2 = 0.5$, $\mu = 2$, $\gamma = 0.4$, $F = 0.7$, $\beta = 1.3$, $\delta = 1.5$, $c = 0.19$. With these parameters, both the average wage and productivity and its variance at the firm level are 0.5.

A Permanent Increase in Perceived Risk to Agents in Large Cities

Up to now, we have assumed that agents, when choosing where to live, only care about wages. Obviously, this does not take into account other important aspects of location choice. The concern for safety should be an important one, and one way to interpret the events of September 11 is that the perception of safety has decreased permanently in large cities. Suppose we now assume that agents equalize utility rather than wages, and that utility is simply the wage minus a risk parameter (call it R_A), which was permanently increased in New York City after the attack. City A becomes a perceived target because it is the biggest city but also presumably because of other specific factors such as the presence of financial markets. Hence, the *WW* schedule is now changed. It becomes:

(A15) $\lambda_F^2 NR_A + \lambda_F(\gamma L - NR_A) - \gamma L \lambda_L = 0$.

There is still a positive relation between λ_F and λ_L, which is given in Exhibit 5. As the *WW* schedule shifts up from "zero risk" to the schedule with the specific risk associated with city A perceived by agents, the equilibrium is such that both workers and firms move out of the city. The equilibrium shifts from point 1 to 2 in Exhibit 5. The dynamics are such that as workers move out of the large city, wages increase there with a negative effect on profits, so that firms also move out. Note, however, that in equilibrium, the share of firms in the big city is larger than the share of workers, so that wages are higher in city A than in city B. The difference in wages is the risk factor. The reason for this is that to retain workers in city A, firms must pay higher wages there. However, utility decreases in both locations.

The increase in wages has a negative effect on profits. It can be shown that firms' profits decrease in both locations. This comes from higher wages in the big city and also from the fact that the gains from labor pooling have declined with lower concentrations of workers and firms in the big city. From that point of view, economic geography becomes less efficient, as it was in the previous case.

Again, a large enough shock could make the big city "disappear" and reappear in location B. If we exclude this unlikely scenario, the important conclusion to draw is that because the threat of terrorism does not eliminate the labor pooling gains, the symmetric equilibrium with dispersion will not emerge as a stable equilibrium and city A will remain the location with most firms and workers.

An Increase in Costs Linked to Industrial and Population Density

In the previous interpretations of the economic effects of September 11, the increased risk factor either to firms or agents was specific to a city, city A in our example. We now analyze how the results differ when the effect on firms' costs is linked not to a specific city but to the density of the location, based on the idea that cities with more firms are more likely to be the target of terrorist attempts. Hence, we now assume that profits are given by:

(A16)
$$\pi_{iA} = R_{iA} - w_A L_{iA} - T(2\lambda_F - 1)$$
$$\pi_{iB} = R_{iB} - w_B L_{iB} - T(1 - 2\lambda_F)$$
$$T(0) = 0 \,;\; T' > 0 \,.$$

The condition that expected profits and expected wages are equal across locations still determines the location equilibrium. The symmetric equilibrium with $\lambda_F = \lambda_L = 1/2$ is a possible equilibrium. The $\pi\pi$ schedule has the same form as before but is flatter, as its slope, when estimated in the symmetric equilibrium $\lambda_F = \lambda_L = 1/2$, is now:

(A17)
$$\frac{\partial \lambda_F}{\partial \lambda_L} = \frac{\gamma^2 L^2}{\gamma^2 L^2 + 4\gamma\mu F^2 - N\sigma_\varepsilon^2 + \gamma L^2 T'(2\lambda_F - 1)} \,.$$

The fact that locations with a higher share of firms are more likely to be targeted and therefore see the costs of doing business increase is similar to a congestion cost.[16] This interpretation is different from the one in the previous section, where the terrorism threat did not alter the fundamental benefit of being spatially concentrated. In this interpretation, the two equilibria with spatial agglomeration could disappear and the dispersed equilibrium could become the unique stable equilibrium if the expression in equation A17 becomes less than 1. In this case, Exhibit 2 would become the valid description of the equilibrium.

This interpretation of September 11 basically says that the benefits of labor pooling (and others not modeled here) would be overcome by the congestion cost linked to increased security, itself linked to the share of firms in the city. In this interpretation, a small negative shock to the large city would make firms leave. This would depress wages there and lead workers to move out. As firms leave the city, the gains from labor pooling unravel and the dispersed equilibrium with two cities of equal size becomes the unique stable equilibrium. For such a scenario to become possible, the cost linked to the terrorist threat in a city needs to increase strongly with the share of firms in that city: $T'(2\lambda_F - 1)$ must be high enough. In this case, spatial dispersion becomes an insurance device.

A close analysis of the preceding scenario would interpret the threat of terrorism as a decrease in the variance of firms' specific shocks relative to shocks specific to a location, which affects all firms. In this case, the very benefits of spatial agglomeration (at least those of labor pooling) would be reversed: the insurance mechanism that led firms to agglomerate would lead them to disperse.

In the scenario in which the increase in costs to large cities is not enough to make the symmetric equilibrium a stable equilibrium, the analysis is similar to the one in this article. The large city loses firms and workers to the smaller city but remains the location with the majority of firms and workers. The analysis would be similar in the case where the cost affects workers rather than firms.

The Core Periphery Model

Our second model, the core periphery model of Fujita, Krugman, and Venables (1999), offers one explanation for agglomeration. The ingredients of the model are two locations, each endowed with an equal amount of an immobile factor (the authors call this factor agricultural labor). There are two goods in the model: a numeraire, produced under constant returns and traded freely (the agricultural good), and a differentiated manufactured good, produced under increasing returns with monopolistic competition modeled à la Dixit-Stiglitz. Unlike the labor pooling model, the core periphery model is a general equilibrium model, where all agents maximize and all markets clear.

Shipping costs for manufactured goods are modeled as an iceberg. This means that to deliver one unit to the other region, a manufacturer must ship $T > 1$ units, $T - 1$ of which "melt" in transit. In addition, firms in the big city must pay an iceberg "terror tax," $\tau > 1$: to produce one unit of a good that can be sold, each firm must spend $\tau - 1$ units of output on security, insurance, and associated inefficiencies.

Introducing some necessary notation, we give the statement of the model by way of a system of eight equations:

$$\text{(A18)} \qquad Y_A = \mu\lambda w_A + \frac{1-\mu}{2}$$

$$\text{(A19)} \qquad Y_B = \mu(1-\lambda)w_B + \frac{1-\mu}{2}$$

$$\text{(A20)} \qquad G_A^{1-\sigma} = \lambda(\tau w_A)^{1-\sigma} + (1-\lambda)(Tw_B)^{1-\sigma}$$

$$\text{(A21)} \qquad G_B^{1-\sigma} = \lambda(T\tau w_A)^{1-\sigma} + (1-\lambda)w_B^{1-\sigma}$$

$$\text{(A22)} \qquad w_A^{\sigma} = Y_A\left(\frac{G_A}{\tau}\right)^{\sigma-1} + Y_B\left(\frac{G_B}{T}\right)^{\sigma-1}$$

$$\text{(A23)} \qquad w_B^{\sigma} = Y_A\left(\frac{G_A}{T\tau}\right)^{\sigma-1} + Y_B G_B^{\sigma-1}$$

$$\text{(A24)} \qquad \omega_A = \frac{w_A}{G_A^{\mu}}$$

$$\text{(A25)} \qquad \omega_B = \frac{w_B}{G_B^{\mu}}.$$

This is less imposing than it looks at first, although the model can only be solved numerically. Equations A18 and A19 give income in each region, which is composed of labor income from manufactured workers plus the wages of agricultural workers. The total number of manufacturers, and the share of manufactured goods in Cobb-Douglas utility, is μ. The share of mobile workers located in region A is λ, and w_r is the nominal wage in region $r \in \{A, B\}$. The number of agricultural workers in each region is 1/2.

The next two equations define the price indexes for manufactured goods in each region, G_r, and are derived from a CES (constant elasticity of substitution) utility function with parameter $\sigma > 1$ and the assumption of iceberg transport costs.

The nominal wage equations A22 and A23 are a consequence of the zero-profit equations for manufactured goods. Finally, equations A24 and A25 give the definition of real wages, ω_r, in each location; recall that agricultural goods have a price of 1 and a weight of $(1-\mu)$ in the utility function of workers.

The equilibrium division of labor across regions is what the model aims to explain. Since the manufactured good is costly to ship between regions, firms will want to locate near their customers. If one region has more firms than the other, then the cost of living will be lower there because fewer goods incur transport costs, which makes it an attractive place for workers to locate. These two forces for agglomeration are called the "market access" and "price index" effects, respectively. They are balanced by a force that favors dispersion—that is, firms prefer less competition, which gives them an incentive to locate away from other firms.

We model terrorism in the city as an increase in the cost of doing business there. To see how this affects equilibrium agglomeration, start in the core periphery equilibrium and consider an increase in τ from its initial level of 1. The model is analytically intractable, but we can illustrate numerically the result that you would expect: a small increase reduces the real wage gap between the city and hinterlands but does not overturn it, while a larger increase reverses the real wage gap and causes the city to cease to exist.

In particular, consider starting at the core periphery equilibrium with $T = 1.7$, $\sigma = 5$, and $\mu = 0.4$. With $\tau = 1$ (the September 10 equilibrium), workers in location A get a real wage premium of 0.02. If we increase the tax to $\tau = 1.05$, the real wage premium falls to 0.004, and if we increase the tax to $\tau = 1.10$, the real wage gap becomes -0.012. So a terror tax of 5 percent has no effect on agglomeration, while a 10 percent tax causes location A to spiral downward, which only stops when $\lambda = 1/2$. With these parameters, $\lambda = 1/2$ is a stable equilibrium, so even if the terror tax is removed, location A will remain no larger than B if the terror tax was onerous enough to cause a disagglomeration.

Note that it is not terrorism per se that causes people to leave the city; rather, it is the loss of the economic rationale for agglomeration that causes workers and firms to disperse. In the presence of a terror tax, the benefits of agglomeration (market access, cost of living) are counteracted: the tax reduces the effective size of the market that firms can access and raises the cost of living for workers. Note, though, that the cost of living also rises for workers in the hinterlands, since they must now pay the terror tax on goods that they import (along with the usual transport costs). So, for a given distribution of firms, the relative cost of living does not change, but the smaller effective market size in the city reduces the nominal wage gap between city and hinterland labor.

Endnotes

1. Although distance does not matter for some financial transactions, it still matters for others. For example, Petersen and Rajan (2000) show that most bank lending still occurs over fairly short distances, although the average distance between lender and borrower has increased over time.

2. Gaspar and Glaeser (1998) offer another reason why there may be agglomeration of producers of weightless goods, such as financial services and software. They argue that information technology may be a complement to, rather than a substitute for, face-to-face interaction, so that greater ease of electronic communication *increases* the incentive to locate near other producers.

3. Although we concentrate on the labor pooling and increasing returns/transport costs motives for agglomeration, we acknowledge that there are other economic explanations for city formation. The most well-known is the spillover model, set out most thoroughly in Henderson (1988). In Henderson's model, agglomeration raises the productivity of firms that locate near other firms in the same line of business.

4. This is purely a simplifying assumption. If workers also disliked uncertainty, our results would actually be stronger. We return to the issue of workers' risk-aversion in our discussion of the effects of terrorism.

5. There is also a mirror-image equilibrium where $\lambda_F = \lambda_L < 1/2$, but we omit it to simplify the analysis.

6. We do not assume that the smaller city is free from the threat of terrorism, nor do we assume that the terror tax falls to zero once firms cross the city limits. Our analysis simply supposes that the tax is higher in big cities than it is elsewhere.

7. From Haughwout and Inman (forthcoming), it is possible to infer that a lower bound for this ratio is around 7. For New York City, it is much higher. The results are not very sensitive to this inference.

8. Profits decrease by 0.2 percent in both locations, as does economywide GDP. The impact on profits and GDP is less than the direct effect on costs because firms can and do take advantage of the alternative location where they can avoid the terror tax.

9. More precisely, we assume in this case that workers equalize utility across locations. Utility is the wage minus the fear factor.

10. The fear factor should not be interpreted here as the loss due to terrorism felt by all in the country. In a much narrower sense, it is the difference of utility due to a future terrorism threat perceived by those living in the city.

11. The wage increases in the city by 0.2 percent and decreases in the nonurban area by 0.4 percent. Profits decrease in both locations by 0.8 percent. In the city, this occurs because of higher wages and lower agglomeration gains; in the nonurban areas, it occurs because of higher rents. The ratio of rents between the two locations decreases from 10 to 7.4. Again, this is a stabilizing factor for the city.

12. Regions A and B in this model differ from those in the labor pooling model.

13. Residents of large cities, particularly New York, may disagree with the notion that the cost of living is lower in these cities. Here, we abstract from land and housing prices, and interpret transport costs broadly to include the costs of consuming a wide variety of goods. For goods that are available only in the city (such as fine restaurants and unique entertainment), their cost for those outside the city includes airfare and hotel bills.

14. There is one other equilibrium between $\lambda_L = 0.5$ and $\lambda_L = 1$ where the real wage gap is zero, but it is unstable.

15. This is the interpretation of the post-war Japanese experience offered by Davis and Weinstein (forthcoming).

16. If we were to make this cost a function of the share of workers in each location, the qualitative results would be similar.

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