C H A P T E R 6

# The Nation's Infrastructure

Our economy depends on infrastructure that allows goods, people, information, and energy to flow throughout the Nation. This infrastructure—ports, roads, airports, communication networks, power lines, and many other systems—represents an important input into the economy. Just as firms must use labor and raw materials to produce output, they must also use airports and power lines. Similarly, consumers rely on cell phone towers and highways in their daily lives.

Infrastructure is often provided either directly by government agencies or by firms regulated by the government. Accordingly, the quantity and quality of infrastructure available to a firm or consumer often depends on government policy in addition to market forces. In recent years, the United States has experienced growing demands on its infrastructure, thanks to economic growth and successful deregulation in sectors that are heavy users of infrastructure. The policy challenge is how best to respond to these increased demands.

"Infrastructure" is a broad term, and this brief chapter does not provide a comprehensive review of all of the U.S. infrastructure systems. Instead, it discusses some of the economic issues associated with major transportation, communication, and power transmission systems, and some of the policy challenges in each. The key points of this chapter are:

- Infrastructure typically requires large capital investments to build and maintain capacity. Once built, however, the cost of allowing an extra person to use the capacity is typically low, as long as the number of users is less than the infrastructure's capacity. This cost structure often means that infrastructure cannot be provided efficiently by a competitive market. As a result, many types of infrastructure are instead provided by Government-regulated companies or, in some cases, by the Government itself.
- Demands on the U.S. infrastructure grow as the economy expands, and Government policies often determine how effectively infrastructure can accommodate that growth. Properly designed user fees can help ensure efficiency by revealing information about what infrastructure consumers value most.
- The price people pay for using infrastructure should reflect the extra cost associated with its use. This includes the cost of maintaining the infrastructure itself, as well as delays caused by increased congestion.

- The private sector plays an important role in providing infrastructure. However, lack of competition in markets for infrastructure raises concerns about market power, so that Government oversight is sometimes necessary. Government must continually reassess the need for oversight in the face of changing market conditions.

## The Basic Challenge of Infrastructure Policy

As the economy grows, demands on our infrastructure increase. Since 1980, vehicle traffic on U.S. roads has nearly doubled, passenger-miles of air traffic have increased by more than 150 percent, and ton-miles of freight on U.S. railroads have increased by more than 80 percent. The Nation's growing demand for energy resources, together with a greater emphasis on new sources of power, is placing new demands on our energy infrastructure. And the growth of the Internet and information technology means that telecommunications networks are becoming more central to the U.S. economy.

Infrastructure systems—whether pipelines, roads, fiber optic networks, or port facilities—require large investments in long-lived capacity. Once this capacity is in place, however, small increases in usage may cost relatively little to provide. *Marginal cost* refers to the extra cost associated with a small increase in production of a good. Infrastructure investments produce goods, like passenger trips or phone calls, that typically have low marginal cost as long as total demands on the infrastructure do not approach the capacity it was designed to support. Once usage approaches capacity, however, marginal cost can increase substantially as extra use makes the entire system less effective.

These features create certain policy challenges that are common to many types of infrastructure. To illustrate these challenges, imagine a growing city where construction of a new bridge across a river is being considered. The bridge will provide significant benefits relative to the existing options for crossing the river—for example, taking a ferry or traveling several miles to cross at another point.

One possibility is that a private party will construct the bridge, planning to earn a profit by charging tolls. If the private sector builds a bridge, the market for river crossings at any given point will likely be provided by a single monopolist. This is because providing a bridge involves *economies of scale:* it is cheaper to build a single bridge that serves 20,000 people per day than two bridges that each serve 10,000 people per day. Because of economies of scale, the market for bridge crossings is called a *natural monopoly.* Even if there are no artificial barriers to market entry, a monopoly is likely to emerge simply because a single firm can produce the good more cheaply than multiple firms could.

A monopolistic bridge owner may choose to charge prices that are too high from society's perspective. A monopolist will choose a toll that generates the highest possible profit, even though the cost of allowing an extra person to cross the bridge may be very close to zero. This means lost opportunities: some people will choose not to cross because of the high toll, even though the cost of allowing them to cross is very small. The people who choose not to cross may waste time and fuel traveling to a toll-free bridge, or may choose not to cross, perhaps visiting friends less often or not shopping at stores that would require a bridge crossing. Economists refer to this type of foregone benefit as a *deadweight loss,* and it is a key economic reason for preventing monopoly pricing. To avoid this deadweight loss, government often attempts to prevent monopoly pricing of infrastructure, either by regulating the price or by providing the infrastructure itself. While government involvement can address monopoly concerns, it can create other inefficiencies: regulators may lack the information necessary to make efficient choices and may make decisions based on political considerations rather than on a cost-benefit analysis.

If the government builds and operates the bridge, it must make a number of decisions. First, the government must decide how to pay for the bridge. One approach is simply to charge a toll, for each use of the bridge, that is high enough to cover the average cost of providing the bridge. This approach seems sensible: the bridge will be paid for by those people who use it, and their willingness to pay for the bridge reveals that it passes a cost-benefit test. However, this approach is likely to create some inefficiency, because the average cost of providing the bridge will be higher than the extra cost each person imposes when he or she crosses at uncongested times. Thus, some people will choose not to cross even though it would cost the government little or nothing to allow them to cross. This can create a deadweight loss similar to the loss that occurs when a monopolist chooses the toll, though the deadweight loss will generally be smaller than under monopoly pricing.

One response to this problem would be to charge a *two-part tariff:* a fixed charge for a permit to use the bridge, in addition to a per-use toll that would be low to reflect the small marginal cost of using the bridge. This approach creates efficient incentives for those consumers who obtain permits, because the toll they pay for each crossing reflects only the cost of their use. However, some drivers will choose not to obtain a permit, and their failure to use the bridge is a deadweight loss.

Other issues arise if the bridge becomes congested. Suppose that, at peak hours, so many people attempt to use the bridge that traffic jams develop. At such times, each person who uses the bridge contributes to the delay that everyone on the bridge suffers. Congestion means that, from society's perspective, the marginal cost of bridge trips is no longer small: each additional trip makes traffic slower, adding to the delay costs of everyone using the bridge.

When the bridge becomes congested, users of the bridge may urge the government to invest in expanding its capacity. If people can use the bridge for free, frequent users are likely to insist that greater investment is a good idea, while those who do not use the bridge will object to spending tax dollars on the project. If the bridge is financed by tolls that are the same at all times of day, people who use the bridge at peak times will receive the benefit of extra capacity, even though they do not bear the full cost of the expansion. People who use the bridge at uncongested times will pay more in tolls to finance the expansion, but receive no benefit. Thus, peak-time users may support expansion even if the benefits to society do not outweigh the construction costs.

Setting aside the question of whether the bridge should be expanded, the congestion described above reflects a system that encourages inefficient choices. Each person who uses the bridge decides when to cross without considering the costs this creates for others because of increased congestion. Addressing this inefficiency can help ensure that existing capacity is used as efficiently as possible.

The questions of building the bridge—who should provide it, how it should be paid for, and when new capacity should be constructed—are all present to different degrees in debates about the major infrastructure systems in the United States. The next section gives an overview of some of these systems and some of the specific issues they face.

## Current State of the Nation's Infrastructure

This section discusses aspects of the U.S. transportation, energy, and communications infrastructure. Economic growth has meant increased demand for transportation, raising questions about how best to address congestion. In energy and communications, changes in technology and market structure are transforming the way that infrastructure serves these sectors.

### Roads

Roads play a central role in the U.S. economy. Both firms and consumers depend on cars and trucks in their everyday economic lives. Most U.S. freight shipments take place by road; for example, trucks handle over 70 percent of U.S. freight shipments (by value). On average, drivers travel 29 miles by car each day and spend almost an hour a day behind the wheel. Americans use roads in all parts of their daily lives, from commuting to work to shopping and visiting friends.

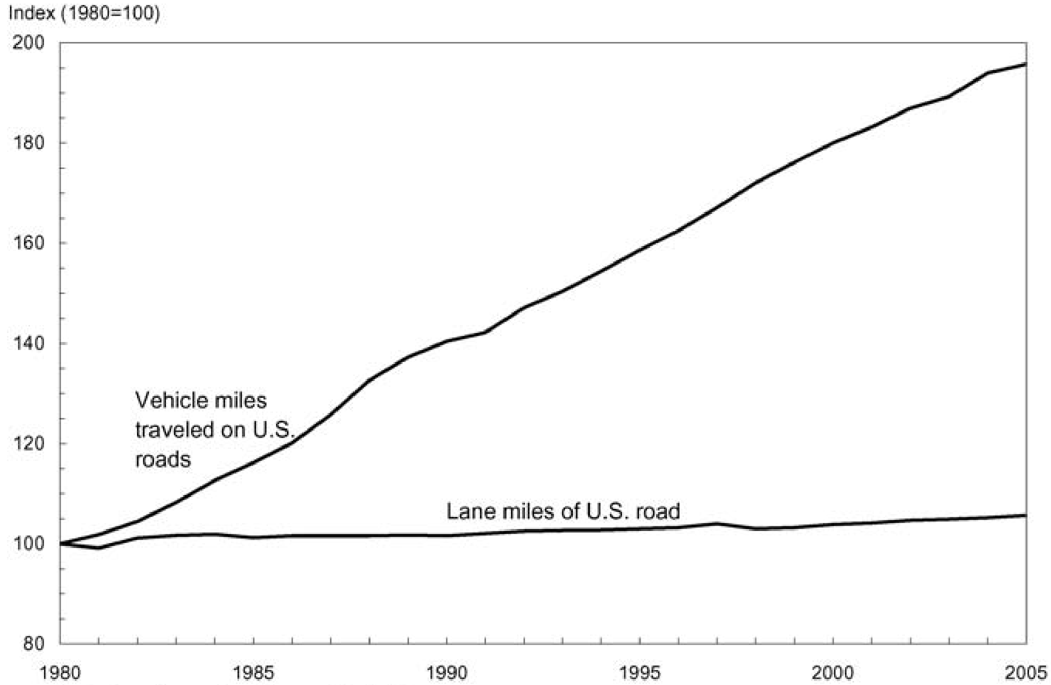
The amount of traffic on U.S. roads has been increasing steadily for decades. As traffic has increased, priorities have shifted from building new connections between places to accommodating growing traffic on existing routes (see Box 6-1). Although Federal, State, and local governments have built new roads and added lanes to existing roads, new construction has not kept up with the increases in traffic. Chart 6-1 shows that vehicle miles traveled in the United States have almost doubled since 1980, whereas total lane-miles of road have expanded by less than 6 percent. Put somewhat differently, each mile of road serves more traffic. For example, on urban highways the average number of vehicles using a given mile of road each day has increased from 3,785 in 1980 to 5,527 in 2005. We would not necessarily expect new road investment to match increases in miles driven, because a mile of road that serves 500 vehicles per day may easily accommodate 1,000 vehicles per day without any new construction. But at peak hours, the number of drivers attempting to use many urban roads approaches or exceeds the roads' maximum capacity. In 2004, almost two-thirds of peak-hour travel on urban interstates took place on roads carrying at least 80 percent of their theoretical maximum number of vehicles. More than a third of travel on urban interstates took place on roads carrying at least 95 percent of their theoretical maximum.

**Box 6-1: The Interstate Highway System**

The Interstate Highway System began when President Eisenhower signed the Federal-Aid Highway Act of 1956, which authorized $25 billion for the construction of 41,000 miles of interstate highway designed to a common standard. One of the original motivations for construction was to move materials and troops in times of emergency. President Eisenhower originally hoped to finance the system with tolls, but the system was instead financed through a fuel tax because of concern that tolls in less densely populated areas would be insufficient to cover the cost of those roads.

The Interstate System has come to play a central role in our Nation's economic life and has lowered the cost of transporting goods around the United States. The construction of the Interstate System may have made important contributions to economic growth, although there is no consensus among economists regarding highways' economic effects, and it is therefore difficult to say what parts of the Interstate System have benefits that outweigh their costs. Today, the local objective of reducing congestion in urban areas has replaced the National objective of connecting distant markets and providing for National defense. Now that interstates connect the country, the priority is to find ways of using these resources as efficiently as possible, and in particular to address congestion on the most heavily traveled interstate corridors.

Chart 6-1 **Vehicle Miles Traveled and Lane Miles of Road in U.S., 1980–2005**
Growth in vehicle travel has outpaced capacity expansion.



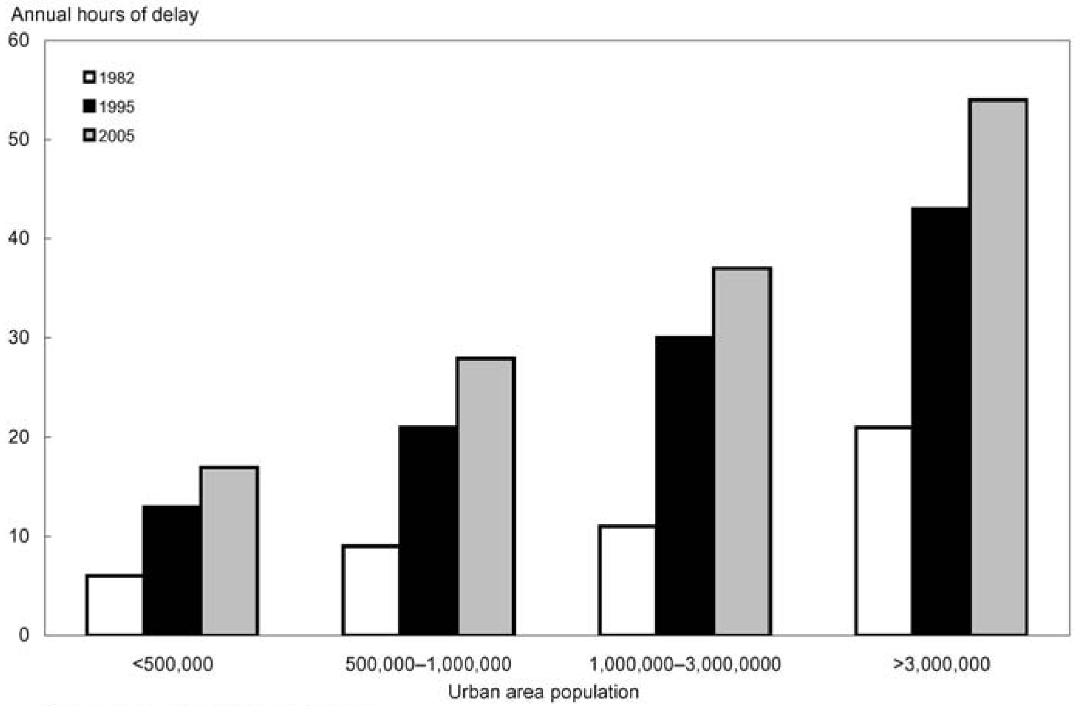

Note: Sampling method changed in 1999.
Source: Department of Transportation (Federal Highway Administration).

When traffic approaches a road's capacity, the road becomes congested, resulting in real costs for drivers and businesses. The extra fuel consumed in all urban areas amounts to 2.87 billion gallons per year—about 2 percent of U.S. gasoline consumption. On average, commuters in urban areas lose almost 38 hours per year due to traffic congestion, and in the largest cities congestion costs the average commuter 54 hours per year. In the largest urban areas, over 40 percent of travel takes place under congested conditions. Congestion is worst in the Nation's largest cities, but is increasing in urbanized areas of every size. Chart 6-2 shows that congestion is increasing even in urbanized areas with fewer than 500,000 residents.

Traffic congestion is the predictable result of a situation in which a scarce resource—road space at rush hour—is made freely available to everyone. Individual drivers choose to travel at the time they find most convenient. When they travel at congested times, however, they contribute to the wasted time, fuel, and increased pollution borne by everyone else on the roadway. Individual drivers do not take this cost into account, so they use the road even though the social costs they create may be greater than the individual benefits they receive. This is the "tragedy of the commons": when a resource is freely available to anyone who wants to use it, it is overused, potentially leaving everyone worse off.

With highway traffic, as with other types of infrastructure, the problem is not simply that so many people use a road, but that they choose to use it at

Chart 6-2 **Annual Delay per Peak-Period Traveler, by Urban Area Size, 1982–2005**
Traffic flows have deteriorated in urban areas of all sizes.




Source: Texas Transportation Institute.

the same time. At hours when many drivers want to travel, a certain amount of delay can be optimal, given the benefits that many drivers receive from traveling at their most preferred time. But as a road becomes very crowded, small increases in the number of cars can cause large decreases in the speed of traffic. When too many people attempt to enter road space at one time, traffic flow "collapses," meaning that a road is able to handle fewer cars in a given amount of time. Spreading out the times at which drivers enter a roadway can permit higher speeds, allowing a road to handle more traffic with the same amount of pavement.

One response to road congestion is to build more roads or widen existing roads. While new construction can be justified in many cases, it is not the solution to all congestion. Road construction is expensive; each additional lane can cost millions of dollars per mile. Furthermore, the tragedy of the commons applies to new capacity as well as to existing capacity. If a new lane makes a road less congested at peak hours, drivers who had previously avoided travel at peak hours will start to use the road at those times. This increase in rush-hour drivers means that the road will again become congested. This phenomenon is often referred to as the "fundamental law of highway congestion": increased capacity induces new traffic at peak times, so that moderate increases in capacity do not eliminate congestion.

A solution that does address the tragedy of the commons is to charge a price for using a road that reflects the extra delay each driver causes. *Congestion* *pricing* refers to a policy of charging tolls that reflect how crowded a road is at particular times. When drivers are required to pay such a toll, some drivers will choose to travel at less crowded times, take less crowded routes, or take alternative means of transportation. Those for whom it is especially important to travel a particular route at a particular time will pay the toll and be able to travel without inefficient levels of delay.

Congestion pricing has proven effective in many areas in reducing congestion and increasing traffic flows. For example, on a busy 10-mile stretch of State Route 91 in Orange County, California, drivers can choose between free lanes and toll lanes, for which prices adjust during the day on a schedule designed to maintain a free flow of traffic. Speeds in the toll lanes exceed 60 miles per hour even at the busiest time of day, with the result that, at the busiest part of the rush hour, each toll lane can produce almost twice as many vehicle trips each hour as the nontoll lanes. Because prices discourage drivers from entering the toll road when it is already crowded, traffic does not become so dense that flows collapse, and the road is able to serve more drivers during any given period of time.

More and more urban areas are becoming interested in using congestion pricing as a way to alleviate clogged roadways. As part of its Congestion Initiative, the Department of Transportation has developed Urban Partnership Agreements with five cities across the country, working with local authorities to mitigate the increasing congestion. In August 2007, the Secretary of Transportation announced the selection of Miami, Minneapolis/St. Paul, New York, San Francisco, and Seattle as the cities chosen from dozens of applicants to receive a share of $850 million in Federal funds to help alleviate highway congestion and the mounting costs it imposes. Each of these cities has developed plans to use some form of congestion pricing to reduce traffic delays. For example, New York City is proposing "cordon pricing," following an approach that has been successfully implemented in London and Stockholm. Between 6:00 a.m. and 6:00 p.m. on weekdays, cars would pay $8 per day to drive in the busiest parts of Manhattan, while trucks would be charged $21. Vehicles driving in the area could be identified by electronic "E-Z Pass" readers or, for vehicles without the readers, through a license plate recognition system using digital cameras.

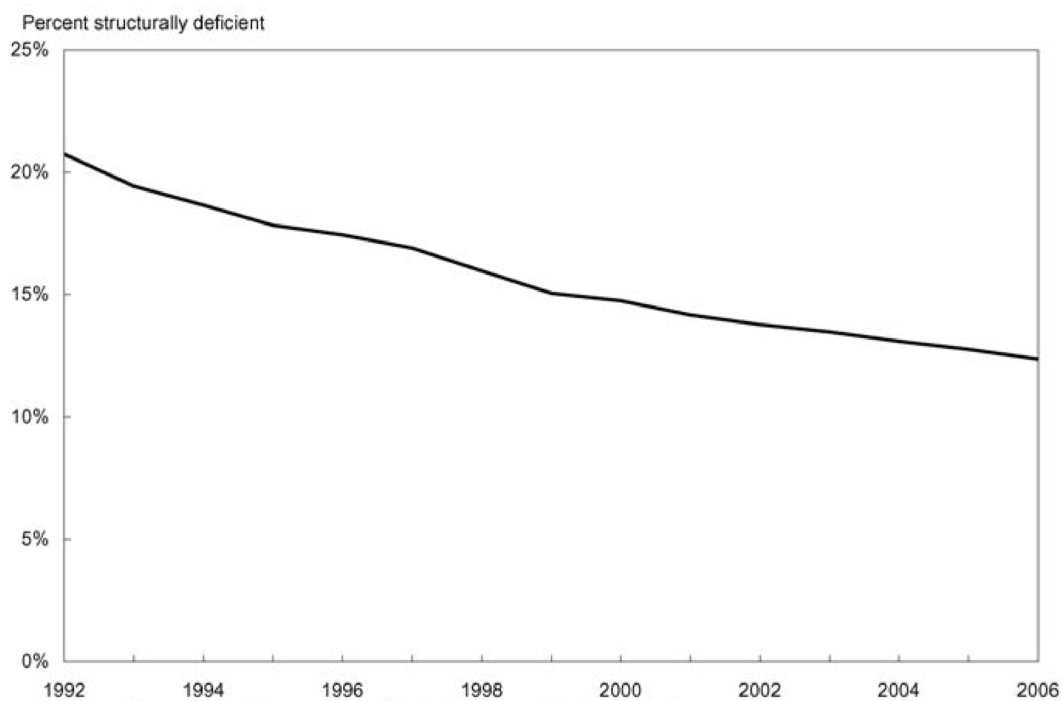
New York's plan is targeted at a heavily congested urban area; other cities have followed different approaches targeted at certain roads or stretches of road that are especially congested. On SR-520 in the Seattle area, regional planners are proposing to use demand-based toll rates both to alleviate peak-hour congestion and to raise funds to replace a high-traffic bridge over Lake Washington. Under the plan, toll rates would be updated in real time to reflect current traffic conditions, and in-vehicle transponders and supplemental cameras would collect the toll while drivers travel at highway speed.

## Bridges

On August 1, 2007, the I-35W Bridge in Minneapolis collapsed, killing 13 people. This was the first collapse of this magnitude since May 2002, when a barge collided with a bridge in Oklahoma, causing the collapse of a section of I-40 and killing 14 people. The recent tragedy focused national attention on the condition of our highway bridges. Bridge repair and maintenance are important for two reasons: to ensure safety and to maintain or increase the capacity of a bridge to carry traffic.

There are nearly 600,000 bridges in the United States. Bridges are inspected using the National Bridge Inspection Standards, in most cases every 2 years. The Department of Transportation collects this information in the National Bridge Inventory, a database of information on bridge conditions. About 12 percent of the bridges in the United States are classified as "structurally deficient" by the Department of Transportation, meaning that the bridge is subject to certain weight or other restrictions due to its condition. This share has been shrinking as States have focused greater resources on bridge maintenance and repair (see Chart 6-3). These numbers suggest that bridges have become a higher priority for States in recent years.

Chart 6-3 **Condition of U.S. Highway Bridges, 1992–2006**
Bridge conditions have improved in recent years.




Source: Department of Transportation (Federal Highway Administration).

Ongoing inspection and maintenance is especially important for bridges. Infrastructure investments should be based on a cost-benefit analysis. In some cases, new projects might seem more appealing to decisionmakers than routine maintenance, but maintenance is essential. One way to encourage investment in projects with the greatest return is to ensure greater transparency in reporting the costs and benefits of different infrastructure projects. For example, by publicly identifying the bridges in greatest need of repair, the National Bridge Inventory may help generate political support for targeting resources where they are most productive.

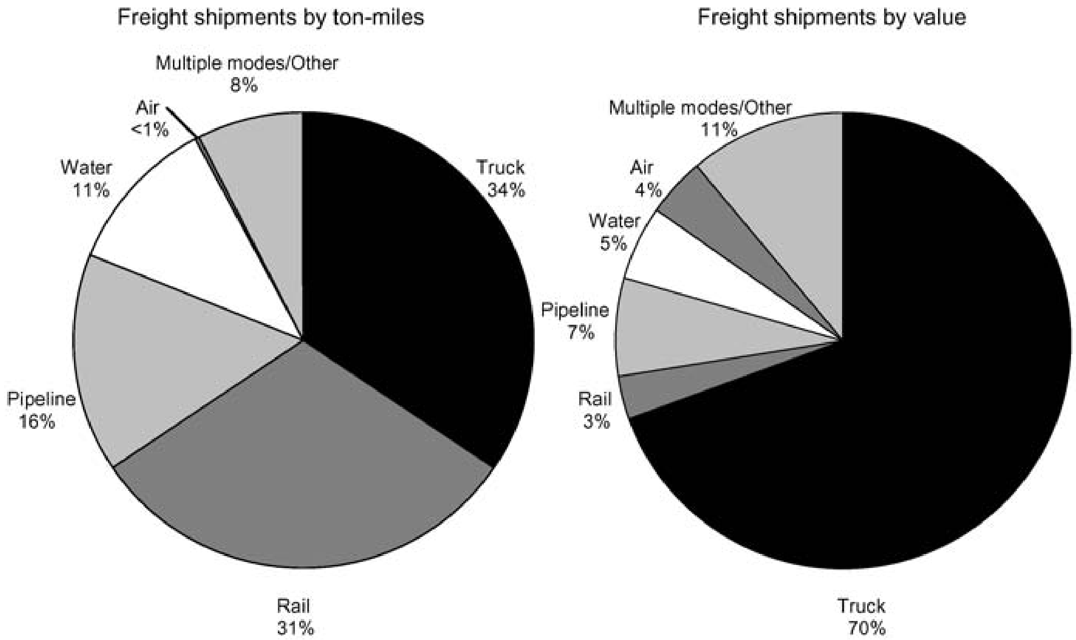
## Railways

Railroads have played a central role in our Nation's history, linking markets over long distances and helping create a national economy. Rail continues to be an important mode of freight transportation, particularly for heavy bulk materials such as coal. Chart 6-4 shows that railroads carry almost one-third of the Nation's freight, measured in terms of ton-miles, but because rail tends to be used for lower-priced goods, this represents a small fraction of the total value of goods shipped. In 1980, the Staggers Rail Act deregulated the freight rail industry. At the time, observers expected prices to increase, but in fact deregulation unleashed significant efficiencies and lower rates. After decades without changes in rates or traffic, shipping rates have fallen substantially in real terms since 1985, while the volume of freight rail traffic has nearly doubled. In the last few years, rising fuel prices have made rail an attractive alternative to trucking, because railways are about three times more fuel efficient than trucks. Increasing highway congestion may also have contributed to increasing demand for rail. As a result of the increased demand for rail shipping, its real price has increased for the first time in many years, and railroads are investing increasing amounts in new capacity.

Railroads serve a variety of customers who face different sets of options for shipping their freight. Some routes are served by only one railroad, while other routes are served by competing railroads. Some products (such as goods in containers) can be economically shipped by road, whereas others (such as coal) may be prohibitively expensive to truck over long distances.

Like roads and other infrastructure, rail systems are very capital intensive, and railroads must pay the cost of maintaining their rail lines and other capital stock regardless of the amount of freight they carry. This creates difficulties for railroads that serve competitive markets. To remain profitable overall, the total revenue from all shipments must cover the railroad's capital costs. But a particular shipment will increase a railroad's profit as long as revenue from that shipment is greater than the marginal cost of that shipment. In markets

Chart 6-4 **Distribution of U.S. Freight Shipments by Mode**
Rail is used disproportionately for heavier, lower-value shipments.




Source: Department of Transportation (Bureau of Transportation Statistics).

where shippers have an alternative to rail, this means that railroads will offer rates to some shippers that do not cover a full share of their capital costs. They make up for this by charging prices that cover more than a shipment's share of capital costs in markets where shippers do not have economical alternatives.

Understandably, many shippers in these markets complain that they pay shipping rates substantially higher than those paid by shippers in more competitive markets. However, the railroads' ability to charge different rates to different shippers plays a vital role in enabling railroads to maintain the large capital investments needed to operate a railroad. If railroads were forced to charge the same price for all freight, many shippers that have alternative shipping options would respond to an increase in rail rates by shifting toward road, water, or other transportation. This reduction in revenue would make railroad capital investments less profitable, and the likely result would be reductions in investment and in rail capacity. In the long run, the result could be even higher shipping rates for those who continued to use rail transportation.

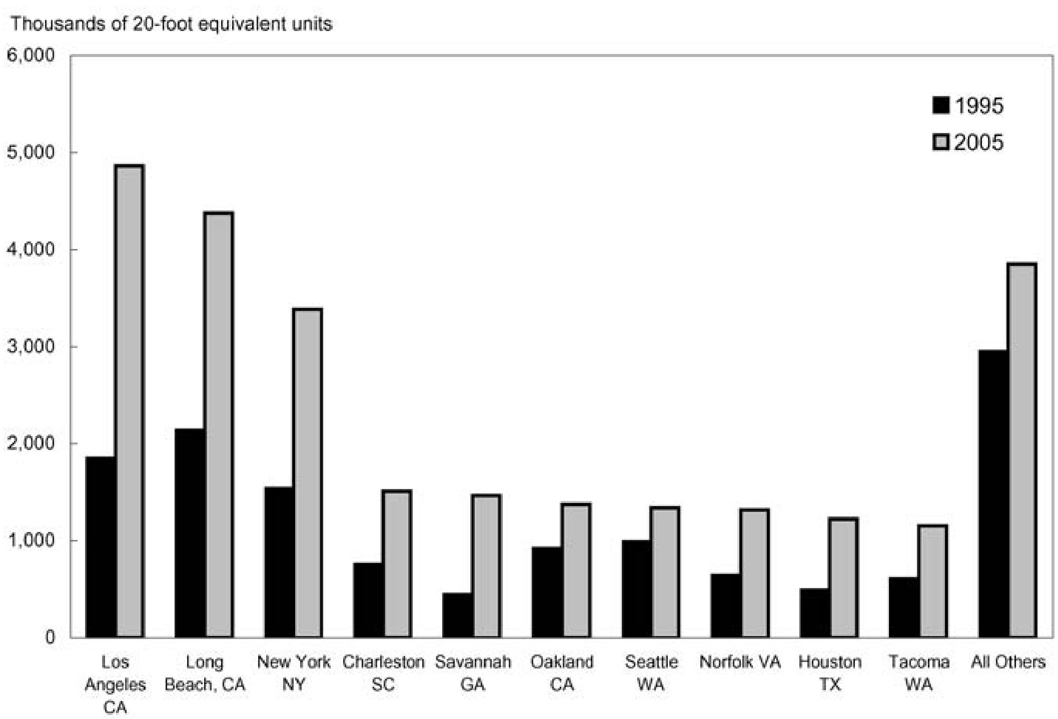
## Container Ports

Over 800 billion dollars worth of goods, representing over 40 percent of U.S. trade, passes through U.S. seaports each year. Container trade—that is, goods packed in containers that can be moved from ships to trucks or trains without being unpacked—continues to grow dramatically, more than doubling in the United States since 1995. All of those goods pass through a relatively small number of facilities. A complex system of cranes, berths, skilled labor, warehouses, and ground transportation facilities is necessary to transfer goods from oceangoing ships to the domestic transportation network.

Increases in global containerized trade have meant an increase in the size of container ships. In the late 1980s, shipping companies introduced the first container ships that were too large to use the Panama Canal, and today such "post-Panamax" ships represent at least 30 percent of container shipping capacity. As ships have gotten bigger, port traffic has become more concentrated among those ports with waterways and port facilities capable of handling such large vessels. Today, the 10 busiest U.S. ports handle 85 percent of U.S. container traffic, up from 78 percent in 1995. Chart 6-5 shows that increased concentration has been most noticeable at the 3 busiest U.S. ports (Los Angeles, Long Beach, and New York), where the share of National container traffic increased from 41 percent in 1995 to 49 percent in 2005.

Chart 6-5 **Container Trade at U.S. Marine Ports**

The largest U.S. ports handle a growing share of container shipments.




Source: Department of Transportation (Bureau of Transportation Statistics).

Freight shipments into and out of the United States will continue to grow along with the growth in U.S. trade. This increase in trade flows will place tremendous demands not only on port facilities, but also on the land-based systems that carry traffic to and from the port. For example, the ports of Los Angeles and Long Beach together handle container traffic representing over 10,000 truckloads each day (not to mention goods shipped in tankers, dry bulk, and other ships). All of this traffic must be accommodated on the roads and railways serving the port.

Increased demands on port facilities are creating opportunities for smaller ports to expand their traffic. For example, the Port of Savannah, Georgia, more than tripled its container traffic between 1995 and 2005. Savannah's growth reflects significant investments in expanding warehouses, docks, and rail yards, as well as the desire of shippers to avoid congestion at the larger ports in New York and Los Angeles. Increased U.S. sea trade also creates opportunities for ports in Mexico and Canada, which can connect by road or rail to U.S. markets. For example, a new container port in the town of Prince Rupert, British Columbia, opened in 2007, offering facilities for the largest container ships and rail connections to Chicago and the Midwest.

Faced with growing demands, congested ports have implemented innovative strategies for reducing the attendant strain on local infrastructure. The Ports of Los Angeles and Long Beach developed a program called "PierPass," designed to move traffic to off-peak periods during the nights and weekends. Carriers unloading during peak hours pay a surcharge of $100 for a 40-foot container, and proceeds from the surcharge fund port operations during the weekend and overnight. According to the program, 36 percent of the container volume at the Los Angeles–Long Beach complex is now moved during the off-peak shifts, removing 60,000 trucks from the roads during rush hour each week.

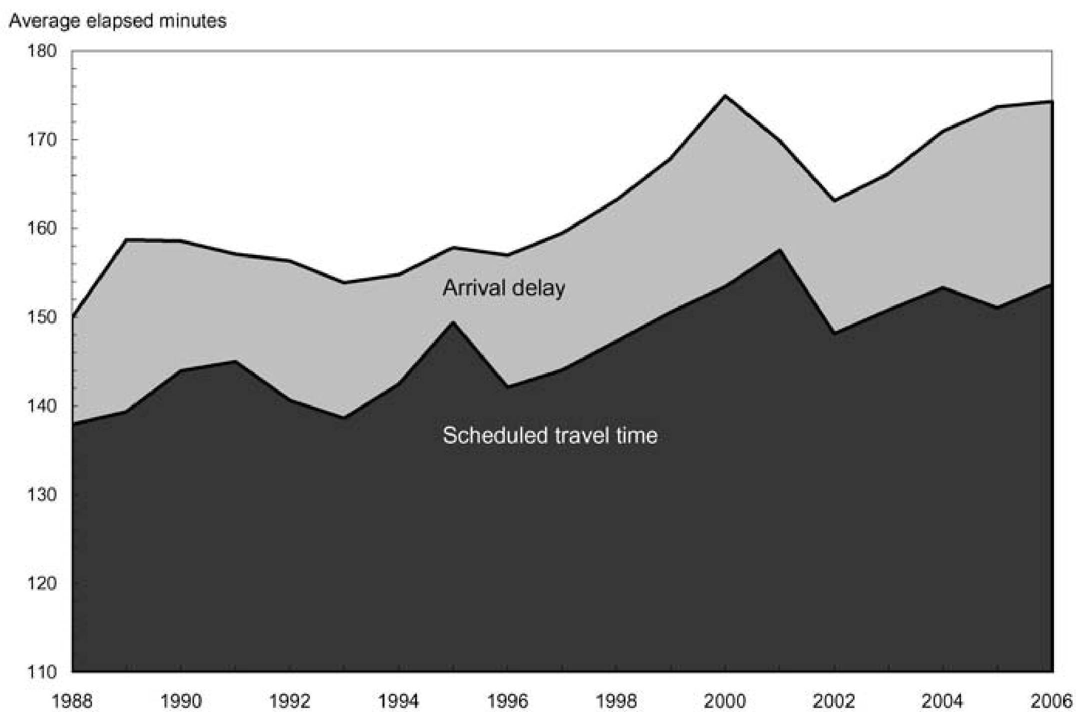
## Aviation

Since 1975, the real price of air transportation has fallen, while the number of miles traveled by air has grown by almost 300 percent. An important part of these changes was the deregulation of the airline industry in 1978. By permitting airlines to introduce new flights and schedules, deregulation introduced competitive forces that have led to entry by discount carriers and reductions in the real price of air travel. In 2006, air travel generated approximately $164 billion in revenue, equivalent to approximately 1.2 percent of GDP.

Air travel requires not only planes, but also runways, terminals, and an air traffic control system to maintain a safe distance between planes. The capacity of these systems has not increased as rapidly as the growth of air traffic. Our air traffic control system is largely based on antiquated technology. New investments in infrastructure have been hampered by several factors, including political opposition from communities near airports and the fact that air traffic control is provided by a government bureaucracy that has no financial incentive to respond efficiently to increased demand for its services.

Growing traffic has created congestion in both the Nation's airspace and its airports. The result has been longer flight times and increased delays. Airlines have accounted for congestion, in part, by building more time into their schedules, although delays have grown despite the longer schedules. Chart 6-6 shows that the average scheduled time for a flight from New York's La Guardia airport to Atlanta's Hartsfield-Jackson International Airport has increased from 2 hours and 18 minutes in 1988 to 2 hours and 34 minutes in 2006. The average delay has also increased from 12 minutes in 1988 to over 20 minutes in 2006. This has been the trend for the busiest routes in the continental United States: for the 10 city pairs with the highest number of airline passengers, scheduled times have increased by an average of 14 minutes, and delay has increased by an average of 6 minutes. Delays have also become more severe: for these same routes, the number of flights that are delayed by more than 60 minutes has increased from 2.7 percent to 7.4 percent. The summer of 2007 saw especially severe flight delays, with particularly acute problems in New York (see Box 6-2).

Chart 6-6 **Average Travel Time, New York (LGA) to Atlanta (ATL) 1988–2006**
Scheduled flight times have increased in addition to growing delays.



Source: Department of Transportation (Bureau of Transportation Statistics).

**Box 6-2: Delays at New York City Airports**

Some of the worst air traffic congestion in the United States occurs in the New York City area. Problems in New York have a large impact on delays nationwide, because a large proportion of U.S. flights travel to, from, or over New York airspace. Delays in New York became especially acute in the summer of 2007, after restrictions were lifted on landings and takeoffs at John F. Kennedy International Airport. With no limitations on how many flights could be scheduled into the airport, the number of scheduled flights increased by 20 percent, and far more flights were scheduled to arrive during peak periods than the airport could handle. The result was long delays: only 56 percent of flights arrived on time during the summer of 2007, with especially severe delays in the peak hours.

In September 2007, the President called on the Secretary of Transportation to seek solutions to mounting air traffic congestion and the frustrations it creates for passengers. The Federal Aviation Administration convened an Aviation Rulemaking Committee to explore ways of relieving congestion, including market-based mechanisms such as congestion pricing or auctions for the right to land or take off at congested times. In December, the Department of Transportation announced that it would limit the number of flights to and from New York airports beginning in spring 2008, while continuing to pursue market-based approaches to reducing congestion in the near term.

History has shown that such market-based solutions can work. In 1968, for example, the Port Authority of New York and New Jersey implemented a congestion-pricing fee on small aircraft by raising the minimum landing fee during peak hours. As expected, travelers responded to the price incentives: general aviation peak hour activity declined by 30 percent, reducing delays at the region's airports.

The Federal Aviation Administration, working with other agencies, has begun an effort to expand capacity by upgrading the air traffic control system. The Next Generation Air Transportation System (NextGen) would use satellites and digital communications to provide both controllers and pilots with a much more accurate picture of where planes are in the airspace. Together with other technologies, these upgrades have the potential to reduce the amount of separation necessary for safe flight, allowing more planes to use a given amount of space and increasing the system's capacity.

Airport congestion reflects capacity constraints and indicates a failure to manage and price that capacity in a way that reflects the costs each plane creates for air traffic control and for other users of congested space. Each plane that lands or takes off at a busy airport takes up roughly the same amount of space and time regardless of size, but the fees paid for using an airport are much higher for larger planes. The airport fees that airlines pay each time they land are based on the weight of a plane, and the national air traffic control system is funded largely by taxes on airline tickets. Both approaches mean that a regional jet carrying 50 passengers pays much less than a large jet carrying 200 passengers, even though each creates roughly the same burden for air traffic control and the same amount of congestion in the airspace. Similarly, fees are the same whether the airport is busy or empty, even though scheduling an arrival at a busy time can generate significant costs for other users. This system creates the wrong incentives, encouraging airlines to use inefficiently small aircraft and to schedule too many flights at the most popular airports and times of day.

The market-based mechanisms discussed earlier in this chapter can help encourage airlines to use airport infrastructure more efficiently. Different options are available for using market-based mechanisms to manage airport congestion. One is to change the structure of landing fees so that planes pay more to land at more congested times and airports. Similar to congestion pricing on roadways, this would encourage airlines and others to schedule flights at times when the airports and airspace are less crowded. Another approach would be to fix the number of landing and takeoff slots available during the busiest times of day, and auction the right to use those slots. Slots would, in effect, be leased for a fixed period of time, with slots turning over and being reauctioned on a regular basis to accommodate new entrants and promote competition. Assigning slots through a market process would have a similar effect to congestion-based fees, because the price of slots at the most popular times would be greater than those at less popular times. Under either approach, airlines would have an incentive to schedule flights at less busy times, and passengers who attach high value to flying at busy times of day would be able to pay a premium to schedule flights at those times with greater confidence that flights will be able to depart on time.

Market-based mechanisms could also improve efficiency when airport capacity is reduced as a result of bad weather or other temporary problems. For example, airlines could pay a premium for the right to land with higher priority when capacity is reduced. Airlines that pay for higher priority could advertise their higher reliability, whereas other airlines might offer price discounts to travelers who were willing to accept a higher probability of delay.

## The Electrical Grid

Although they transport electricity rather than goods or people, power lines share important characteristics with roads and other infrastructure. Building transmission lines requires a large capital investment. Once this capacity is built, the marginal cost of transmission is low as long as the amount of power being delivered is less than the capacity of the lines.

The transmission of electric power was once primarily a local affair: a utility generated electricity and distributed it on its own power lines to the surrounding area, with rates set by a local regulator. But over time, the United States has moved from this local model to one in which the Nation is covered by grids of high-voltage transmission lines, and power generated in one place may be used hundreds of miles away. While some power plants continue to serve a particular local population, others take advantage of the grid to sell their electricity on a wholesale market.

By permitting power to be generated in low-cost areas and delivered to high-cost areas, the national electrical grid can allow generating capacity to be used much more efficiently. For example, on the West Coast, long-distance transmission lines allow hydroelectric power from Washington State to be transmitted to California to help meet peak summer demand. Long-distance transmission can make alternative energy sources more viable as the United States attempts to reduce its dependence on fossil fuels (see Chapter 7). For example, production of significant amounts of wind power is economically feasible only in certain areas of the country. Similarly, it is easier to site power plants in certain areas. Long-distance power lines mean that electricity can be produced in areas where production is most efficient and delivered to areas where it is most needed.

The legacy of State-regulated local utilities creates obstacles to developing an efficient national electrical grid. One problem is fragmented ownership of power lines. Different parts of the electrical grid are owned and maintained by a large number of investor-owned utilities and other entities, so that power may need to pass through lines belonging to multiple parties before reaching its destination. This can create coordination problems. Each utility must decide independently how much to invest in the capacity of its power lines, even though these decisions will affect many other parts of the network. It may not make sense for one party to invest in greater capacity unless others make similar investments.

Such problems are exacerbated by the fact that different regulators govern different parts of the electrical grid. Utility investments often must be approved by State or local regulators applying rules designed for the model of a local utility. Regulators in one State may not have incentives to account for the benefits of new transmission capacity for residents of other States. In fact, regulators in an area where production costs are low may object to making it easier for local power generators to sell in areas where production costs are high, because more power will flow to the high-cost market, potentially raising wholesale prices in the local market in the short run. In the long run, however, making trade in electricity easier will lead to greater generating capacity in areas where electricity can be generated at lowest cost. The Federal

Government has taken steps to coordinate interstate transmission projects by giving the Department of Energy the authority to designate certain transmission corridors as high priority and to help develop new capacity in those areas.

## Telecommunications

Not long ago, the U.S. telecommunications infrastructure consisted largely of copper wires used to transmit the human voice. Today, information travels any number of ways—satellites, cellular systems, and fiber optic cable, to name some examples—and industry continues to develop new communication technologies. New choices mean consumers and businesses enjoy the benefits of competition among providers. As information technology becomes faster and cheaper, communication infrastructure is allowing workers to telecommute and consumers to shop online.

### *Broadband Internet Service*

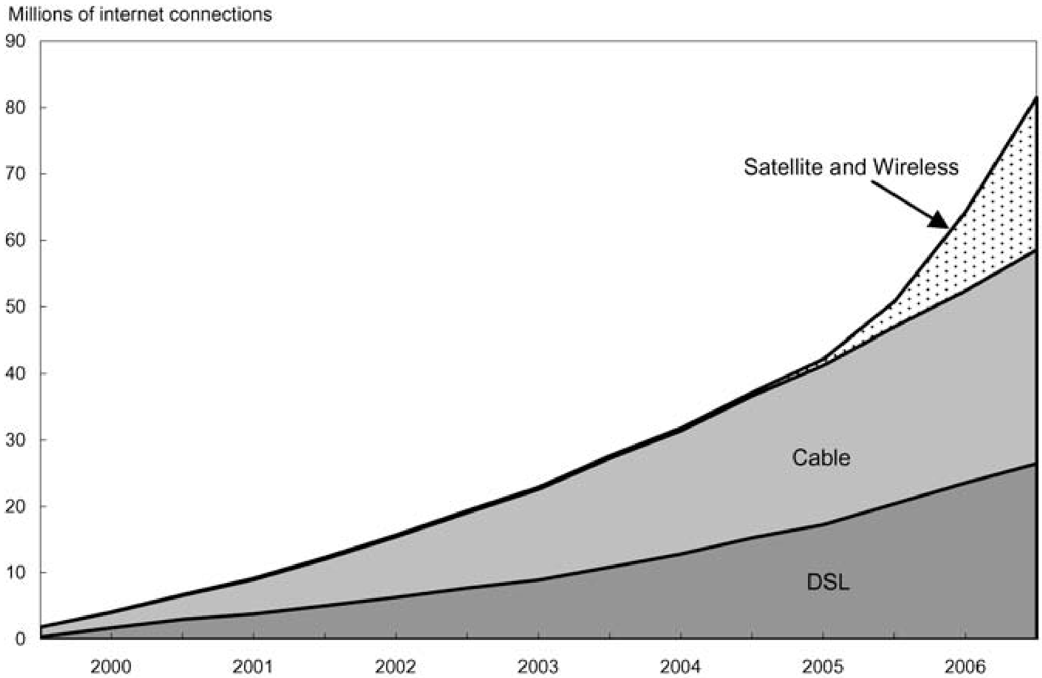
*Broadband* refers to Internet connections that can transmit data at high speeds (the Federal Communications Commission defines a high-speed connection as one that allows transfer rates greater than 200 kilobits per second in at least one direction, but many connections are much faster than this). As recently as 1999, broadband access was very rare, but by 2007 nearly half the country had a broadband connection at home, and the United States had over 80 million high-speed connections. Until 2005, almost all broadband users had either a cable modem or a digital subscriber line (DSL) connection, but recently, mobile wireless subscriptions have increased rapidly (see Chart 6-7).

Like other forms of infrastructure, broadband capacity requires large capital expenditures, and once capacity is installed, the marginal cost of delivering data over a line is close to zero. Telecommunications companies have invested large amounts to expand broadband infrastructure, installing new high-capacity transmission lines and investing in new technology to send data over existing telephone and cable wires.

Despite large fixed costs of deployment, there are multiple broadband providers competing for subscribers in most U.S. markets. The Federal Communications Commission (FCC) reports that by the end of 2006, over 80 percent of U.S. ZIP codes were served by at least four broadband service providers. Nationwide, 79 percent of local telephone subscribers had access to DSL, and 96 percent of cable subscribers had access to cable Internet service.

Broadband service provision remains an extremely dynamic area, and telecommunications providers are exploring new models to determine what type of broadband provision can produce the greatest benefits for consumers. For example, last year, the fastest-growing category of high-speed Internet

Chart 6-7 **High-Speed Internet Lines in the United States by Type of Connection, 1999–2006**
Broadband connections have grown rapidly.




Note: Fiber and powerline connections are a small fraction of connections and have been omitted.
Source: Federal Communications Commission.

access was in mobile wireless connections—a category that grew from about 3 million connections at the end of 2005 to over 20 million connections at the end of 2006. Broadband providers are also offering dramatically higher transmission speeds, enabling consumers to access new services such as streaming video and voice-over Internet protocol (VOIP). The tremendous value the Internet creates for consumers has provided strong incentives for the private sector both to invest in building out the Internet infrastructure and to innovate in finding new ways of serving the market.

### *Wireless Communication*

Wireless technology, such as that used in cellular phones, has been one of the most dynamic sectors of the economy in recent years, with considerable growth in both the number of users and the quality of services. Today, the United States has 243 million wireless subscribers, up from 16 million at the end of 1993. Several wireless service providers compete to offer communication features that will attract new customers, such as the opportunity to share pictures, download news and other information, or view a map of their current location and directions to their destination.

Wireless communications systems transmit radio signals using specific frequencies of the radio spectrum. If different signals were to use the same frequency, the result would be interference that prevents communication.

To prevent interference, the Government regulates who can use each part of the spectrum. Private sector users obtain licenses from the FCC that grant exclusive permission to transmit signals in a certain area. Certain frequencies are reserved for use by Government agencies, and use of this spectrum is coordinated through the National Telecommunications and Information Administration in the Department of Commerce.

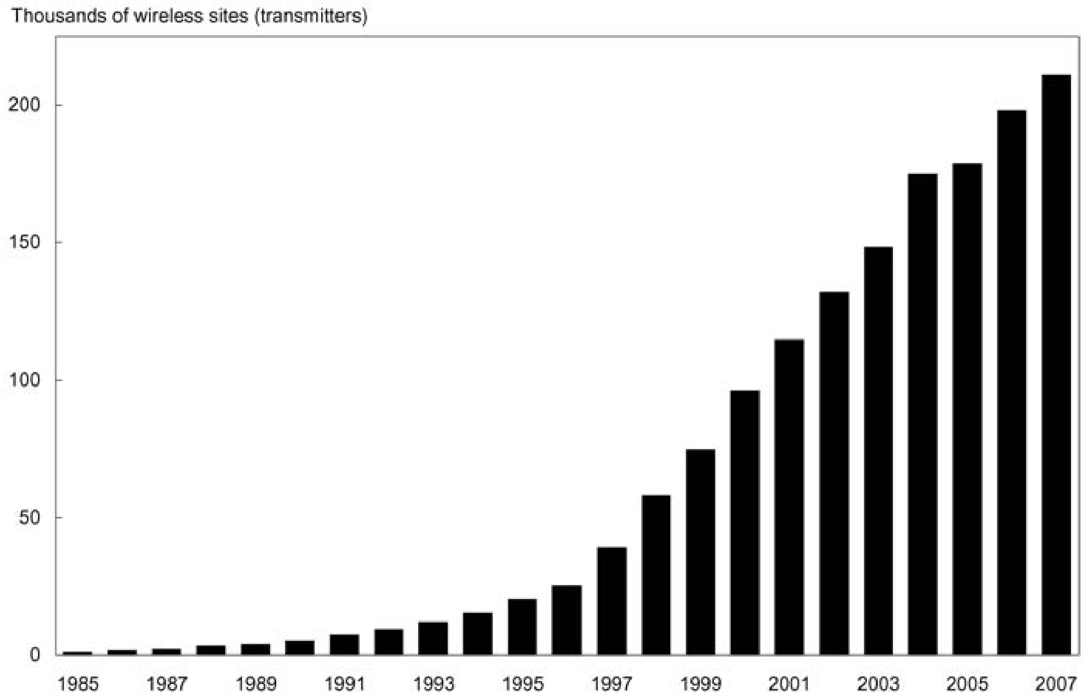
The right to use spectrum is a scarce resource, with many competing demands. Early in the history of radio, the U.S. Government began allocating the right to use spectrum through an administrative process, in which different potential users applied for licenses and the FCC attempted to determine which use would generate the greatest social benefit. This approach requires the Government to evaluate an enormous amount of information about the competing benefits of using resources in different ways. Markets can help solve this problem, because the prices people are willing to pay for a scarce resource reflect all the information they possess about how the resource can be best used.

Recognizing these benefits from market allocation, the U.S. Government has moved to a system in which the right to use spectrum for wireless communication is awarded through auctions. In 1994, the FCC began a series of auctions for the rights to use spectrum for personal communication services. Since then, the FCC has held about 70 spectrum auctions, generating nearly $60 billion in revenue and opening up new opportunities for firms to offer wireless services.

The spectrum auctions have put the right to use spectrum in the hands of those who believe they can use it to generate the greatest value. By creating clear property rights to use particular frequencies, the auctions have given companies the incentives to invest in the resources they have obtained. The result has been a rapid build-out of networks of towers for cellular communication. Chart 6-8 shows that the number of wireless transmitters in the United States has grown from about 20,000 in 1995 to 210,000 in 2007—an increase of 22 percent per year.

Through the President's Spectrum Management Initiative, the Administration has sought ways to ensure that spectrum is used in the way that generates the greatest value. One way to do this is to create incentives for Government users of spectrum to consider the opportunity cost of the spectrum they use. Currently, Government agencies obtain spectrum licenses through an administrative process—in contrast to other valuable resources, such as electricity and labor, for which they must pay. Policies that lead agencies to recognize the cost of using spectrum will encourage them to free up this resource when there are others who could use it more efficiently.

Chart 6-8 **Wireless Communications Infrastructure in the U.S., 1985–2007**
Wireless sites grew rapidly following the first spectrum auctions.




Source: CTIA.

# Infrastructure Policy

Though the U.S. infrastructure systems face a diverse set of issues, they have certain features in common, such as high capital costs and limitations to capacity that create the potential for congestion. This section discusses some of the key policy questions that are common to many forms of infrastructure. First, how should infrastructure be paid for? The price of infrastructure should reflect marginal cost, but this may not be sufficient to cover capital costs. Second, how should policymakers set priorities for infrastructure investment? In many cases, the government can look to markets for ideas as to how to best identify which projects have the greatest return. Third, should infrastructure be provided by the private or public sector? Policymakers can often choose between government provision and private sector provision with some degree of government regulation. Fourth, when should infrastructure be provided at the Federal level, and when is it better provided at the State or local level?

## How Should Infrastructure Be Paid For?

As discussed at the beginning of this chapter, efficient use of any good or service requires that the price people pay for using the good or service equals the extra cost they impose when they use it. If the price is lower than this cost, people will have an incentive to overuse the good or service. For example, if electricity is available for free, consumers may leave lights on when they are not using them. If the price is higher than the extra cost of providing the good, it will be underused, creating a deadweight loss.

For much infrastructure, the marginal cost of extra use may be very low or close to zero when use is well below capacity. This creates a dilemma in financing infrastructure because encouraging efficient use means setting the price equal to marginal cost. If this price is at or near zero, revenue will not cover the cost of providing infrastructure, requiring either a higher price or some other source of revenue. For some forms of infrastructure, firms address this problem with a *two-part tariff:* a fixed fee for access to the infrastructure, in addition to a per-use fee that reflects the marginal cost of providing the infrastructure. For example, telecommunications providers typically charge users a monthly subscription fee but allow users to transmit as much data as they like at little or no extra charge, reflecting the fact that once a user is connected to the network, extra data transmission involves little or no extra costs. This approach creates efficient incentives for those consumers who subscribe, while still allowing telecommunications providers to finance the cost of their investment.

When roads or other infrastructure become congested, the efficient response is to charge fees that reflect the cost each additional user imposes on others. Congestion prices can lead to efficient decisions about whether and when to use infrastructure and yield information about where additional capacity would be most valuable.

Efficient tolls can also generate revenue that can help pay for infrastructure. Fees collected through congestion pricing can be used to fund expansion of existing infrastructure and reduce current indirect taxes and fees. Under the right circumstances, efficient tolls will be sufficient to completely fund new infrastructure construction—meaning that congestion is reduced, while at the same time roads are financed almost entirely by the drivers who use them during the busiest periods.

## How Should Government Set Priorities for Infrastructure Projects?

In competitive markets, firms decide whether to invest in new capacity based on the value that capacity creates for consumers. For example, imagine a coffee shop that has long lines during the morning rush. The shop's owner could shorten the wait by adding an extra cashier. This would cost money, but would please her customers, potentially leading to greater sales. The owner will add a cashier if the extra coffee she can sell will generate enough revenue to justify the extra expense.

In areas in which infrastructure investment is made by private parties, such as broadband or wireless communications, companies undertake exactly this type of analysis. Similarly, when the government decides whether to undertake new infrastructure investment, it should conduct an analysis similar to that of the coffee shop owner, comparing the costs of a new project to the benefits it generates for users. Rigorous cost-benefit analysis should be used to determine whether the benefits of a particular project outweigh its cost and whether the benefits of dollars spent are greater than the social benefits from spending money in other areas.

Private sector firms use the prices consumers are willing to pay to measure the benefits of extra investment. When the government makes investment decisions, however, there is frequently no market price that reflects how much consumers are willing to pay for greater capacity or for a particular new project. When infrastructure is provided for free, one cannot infer from heavy use that users attach a high value to using certain infrastructure. Free access also makes it difficult to evaluate users' stated preferences. For example, residents of a particular area may be strong supporters of expanding a freeway serving their community, given that they are able to use that freeway at no additional charge. But this support is not responsive to the real question that a policymaker would want to answer, which is whether those residents would support the construction project if they had to bear all of its associated costs, in addition to receiving the benefits.

The problem of determining the value users receive from infrastructure projects is another argument on behalf of user fees that reflect marginal cost. When users pay for the infrastructure they use, we can be more confident that the infrastructure produces benefits that reflect the cost.

## When Should the Government Regulate or Provide Infrastructure?

As discussed earlier in this chapter, infrastructure is often a *natural monopoly,* meaning that one firm can serve the market more cheaply than multiple firms could. This may create a role for the government to prevent the distortions that result from monopoly pricing. However, large capital costs by themselves do not necessarily imply natural monopoly; when a market is large, it may support multiple firms even though the costs of participating in the market are high. When several firms compete to provide a service, government regulation is not needed to prevent monopoly prices.

Technological innovation has the potential to fundamentally alter the makeup of markets, and government regulation should adapt to changes in market structure. Markets once dominated by monopolies can become competitive over time due to innovation. Regulations should be eliminated as markets become more competitive.

A good example of this phenomenon is telecommunications. Although the industry was once dominated by a single firm or by a few large firms, today numerous providers compete to provide customers with voice, Internet, and video over numerous platforms, including telephone (DSL), cable, fiber-optic, satellite, wireless, and even the electric grid. In the face of such innovation and digital convergence, the government must reassess legacy regulatory regimes and replace regulation with competition wherever possible to most efficiently maximize consumer welfare.

When infrastructure provision is a natural monopoly, economic theory provides no clear answer to the question of whether infrastructure is better provided directly by the government or by a regulated monopolist. In both cases, decisions will be insulated from market discipline. Government regulation of a private firm involves some duplication of effort, because the regulator must examine firm decisions to prevent abuses of monopoly power. But a government agency may not have incentives to produce efficiently, because it does not have the profit motive of the private sector. Private firms may also be able to provide management with stronger incentives to increase efficiency.

Empirical studies of privatization around the world have shown that, in general, private firms in various industries produce and invest more efficiently than state-owned enterprises. Although these privatizations have occurred in a wide variety of different countries and industries, privately run enterprises on average produce more efficiently and invest more in their industry. Recent U.S. experiences have also demonstrated that, in some cases, there can be benefits to greater private sector involvement in provision of transportation infrastructure.

Some urban areas, wanting to improve congested roads in the face of tight budgets, have turned to private investors to build and operate toll roads. In 1990, for example, Virginia authorized a private investment partnership to construct the Dulles Greenway, a 14-mile stretch of highway in a congested part of the Washington, D.C., metropolitan area. The partnership was authorized to collect tolls that would provide no more than a reasonable return on the invested funds. Since construction in the mid-1990s, the road has become an integral part of the region's transportation network, carrying over 50,000 vehicles each day in 2006.

In 2005, the Federal Aviation Administration contracted with Lockheed Martin to take over operation of the FAA's Automated Flight Service Stations. These stations provide general aviation pilots with weather briefings, updates on airport closings, flight plan assistance and emergency communications. The contractor has successfully consolidated operations and reduced costs, and the FAA projects that it will save $2.2 billion over the contract's first 5-year period. The FAA continues to monitor the stations to ensure quality and service levels.

Although private firms have strong incentives to produce efficiently, some argue that they will tend to provide a lower quality of service than the government, because higher quality may yield lower profits. This concern suggests that when government contracts with a private firm to provide public infrastructure, it should pay careful attention to the terms of the contract to ensure that the firm can be held accountable for the quality of the infrastructure.

## What Are the Proper Roles for State and Federal Government?

Both the Federal and State Governments provide and regulate infrastructure. For example, most funding for road construction and maintenance is provided by the States, although substantial funds are also raised through Federal taxes on fuel and other transportation goods and then distributed to the States. Similarly, electricity transmission is regulated both by the Federal Energy Regulatory Commission and by State utility regulators.

There are advantages to making decisions about infrastructure policy at the State level. State Governments can tailor infrastructure decisions to local preferences and conditions, rather than providing a single one-size-fits-all policy for the entire country. States that implement policies that their citizens dislike will fail to attract new people and businesses.

Federal provision or regulation can be important when infrastructure in one State provides benefits to residents of other States. For example, power lines transmit electricity across State borders, but State electricity regulators may think only about how regulation affects their own citizens. Federal regulation may be more appropriate when State infrastructure produces national benefits. Similarly, State Governments make decisions about infrastructure investment based on the benefits to their own citizens, and will be reluctant to make investments with their own taxpayers' money if a large share of the benefits goes to out-of-state residents. The Federal Government should take into account the total benefits to the Nation, so when infrastructure projects provide significant cross-state benefits, it may be best to set infrastructure policy at the Federal level.

# Conclusion

Infrastructure policy is not simply an engineering problem of how best to build the systems to meet the country's needs. Although Government may play an important role because infrastructure provision is often a natural monopoly, economic incentives matter and must be taken into account. There are two central questions of infrastructure policy. First, what investments in new capacity generate benefits that exceed their costs? Second, how can we ensure that the capacity we invest in is used in the most efficient way possible? By subjecting infrastructure policy decisions to these threshold questions and using market-based solutions where action is taken, Government—at the local, State and Federal levels—will increase certainty that future investments in infrastructure are socially worthwhile and allocated appropriately.