CHAPTER 1

America's Essential Infrastructure

A Key to Competitiveness

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When most Americans hear the increasingly frequent references to *infrastructure* they summon up only ill-defined images. Some call to mind the hulking gray mass of crumbling bridges and the disruption of leaking water lines; others associate it vaguely with public works jobs and federal stimulus funds; and still others are numbed to the point of disinterest by the bureaucratic jargon. In truth, infrastructure is at the core of one of the most urgent aspects of the United States' well-being: our national competitiveness. The U.S. competiveness determines whether the products our industries create are viable in world markets, whether our economy is strong enough to enhance national income and wealth, and whether our society can sustain a high quality of life.

National competiveness depends on continual improvements in productivity, the value of output we create per unit of resource devoted to its production, usually measured as gross domestic product (GDP) per capita or per job. There are many factors that contribute to steadily improving productivity. Among them are advances in technology and innovation, higher level skills and education, access to capital, vibrant entrepreneurship, and functioning rules for free markets. More and more economic scholars such as Professor Michael Porter of the Harvard Business School include the range of physical and communications support systems—modern infrastructure—as essential components of productivity. It may be helpful to think of infrastructure as the basic systems that bridge distance and bring productive

EXHIBIT 1.1 Types of Infrastructure

Transportation	Communication	Energy and Utilities	Social Infrastructure
Roads	Telephone systems	Electricity distribution and generation	Universities
Bridges	Cell towers	Gas storage and distribution	Schools
Tunnels	Cable networks	Water supply	Hospitals
Airports	WiFi	Wasterwater treatment	Sports stadiums
Rail systems	Satellite	Renewable energy	Community facilities
Seaports	Television		Public housing
Shipping	Radio		Prisons
Cargo	Other systems		Corrections centers
Logistical centers			
Urban mass transit			

inputs together; that bring materials, products, equipment, information, and people together; and that in fundamental ways bring all the critical factors of productivity to bear across time and space.

As Exhibit 1.1 demonstrates, infrastructure includes the systems of transportation that are used to move materials and industrial goods to fabrication and assembly points and then to distribute finished products to merchants and consumers. Similarly, the infrastructure of communications connects producers and purchasers in our economy as well as conveys marketing through advertising, broadcasts entertainment, and transmits personal messages. Infrastructure is also critical in providing the water and power needed for industrial, commercial, and residential purposes. The generation of electricity from coal, nuclear, natural gas, hydro, wind or solar sources and its distribution through the power grid are essential inputs to national production and secure human safety and comfort. The institutions that extend education, health care, civic engagement and jurisprudence, such as universities, schools, civic centers and public buildings of various kinds, constitute the public social infrastructure of the nation.

The realization that the nation's infrastructure is comprised of the assets that connect the productive capacities of the society and that mobilize the physical inputs to our economy is particularly important as we consider the way the modern U.S. economy actually functions. Infrastructure should be regarded as among the most basic and essential dimensions in the workings of U.S. society. Many societal interactions are based on ideas, abstractions,

and symbolic or numerical representations. Many modern processes involve information flows, electronic pulses, higher order cognitive exchanges related to creative thought and quantitative analyses. But it is physical infrastructure that makes possible not only the movement of the materials and products that are quantified in those digital messages but it also makes possible the electronic pulses themselves.

Even the most modern of companies, including those regarded as Information Era breakthroughs such as Amazon.com, rely intensely on efficient and reliable physical infrastructure. Clearly, the communications by which a consumer shops on Amazon.com via the Internet relies on channels of high-speed electronic distribution lines as well as the capacities of massive server facilities in physical locations across the country. Then the consumer goods, which have been ordered via Amazon.com and were manufactured in fabrication plants and stored in warehouses utilizing sophisticated logistical technologies, are rapidly shipped through a network of cargo aircraft and overland trucks with the goal of having products to the consumer within a day or at most several days. Amazon is an example of the interface between the information economy and the physical economy of materials and products that relies so heavily on state-of-the-art infrastructure.

This chapter describes in a new way three building-blocks of U.S. competitiveness and the core role of infrastructure in each case. The three are: the global economy's increasing dependence on modern logistics; the power of industry clusters primed to act as linked units of economic competiveness; and the role of metropolitan areas as engines of prosperity for the nation. A fourth building-block is the overarching combination of national population growth, the demand for built space that it will drive and the role of innovation in infrastructure development.

OUR ECONOMY IS INCREASINGLY DEPENDENT ON MODERN LOGISTICS

The U.S. economy has evolved into complex synapses of national and global transactions. Coal mined in Wyoming is essential to the operation of technology firms in Houston; computer software engineered in Silicon Valley is matched with computer hardware manufactured in North Carolina; and materials imported from Indonesia are transferred from ships onto trucks at the Port of Long Beach en route to assembly warehouses in Riverside, California, before being loaded onto rail cars for shipment to big box stores in Kansas City. These kinds of transactions are occurring every moment of every day across the United States and are highly dependent on durable infrastructure. When the infrastructure proves inadequate to the task, the U.S. economy suffers. In his work on U.S. competiveness, Professor Michael

Porter of Harvard has singled out the factors that have "hobbled America's entrepreneurial strength by needlessly driving up the cost and complexity of doing business."[1] Specifically, he writes: "Infrastructure bottlenecks, due to neglect and poorly directed spending, are driving up costs in an economy increasingly dependent on logistics."

International Trade

One area of the U.S. economy where the infrastructure of logistics must flow efficiently is international trade and foreign investment. Global trade has become an increasingly important dimension of the U.S. economy. Imports to and exports from the United States now represent 25 percent of GDP up from 6 percent in 1950.[2] That robust volume of international trade depends heavily on logistical movement of goods by ship into ports, by rail and truck overland, and by air cargo.

Port authorities on both coasts have invested in port infrastructure that is among the best in the world. Los Angeles/Long Beach, Seattle, San Francisco/Oakland, New York/New Jersey, the Chesapeake region, Miami, and Houston—all have made massive investments in the capacity to off-load shipping containers and to transfer them to barges, trains, and trucks. Because so many imports into the United States arrive from Asia, a heavy volume of the container traffic into the United States enters at the Ports of Long Beach and Los Angeles. Those ports handled 15.7 million units of containers in 2007. The Ports of New York/New Jersey handled 5.3 million containers; Seattle/Tacoma, 3.9 million; Savannah, Georgia, 2.9 million; and Oakland, 2.6 million according to the American Association of Port Authorities.[3]

Though the containers arrive at these coastal ports, the products must be moved to warehouses, retail stores, and consumers across the country. Moving cargo by rail from ports has become a dominant channel for moving goods to large distribution centers in the heartland of the nation. There, containers can be off-loaded from trains and moved by trucks to warehouses where goods can be sorted, assembled, and prepared for wholesale and retail sales. Large-scale "inland ports" have been created in cities such as Chicago, Dallas, Kansas City, and Indianapolis. They employ the most modern intermodal technologies to classify merchandise, to package and label products, and to prepare them for marketing.

Rapid Transport of High-Value Goods

The modern economy also places a premium on the rapid movement of certain products. Smaller, higher value and time-sensitive products are flown

directly into air cargo hubs such as those in Memphis via Fed Ex, Louisville with UPS, or to Dallas and Chicago by other carriers. Alliance Airport in Dallas is an example of an air hub built specifically for the handling of cargo. Despite the existence of one the largest and most efficient airports in the country at Dallas/Ft. Worth International, the designers of Alliance Airport recognized the need for a facility in the center of the United States devoted strictly to cargo and equipped with the latest technologies for handling high value freight. Alliance is now home to more than 200 companies utilizing 29 million square feet of processing facilities and includes an intermodal facility that handles more than 600,000 cargo enplanements per year.[4]

Global Communications

Dependence on instantaneous worldwide communications is another important dimension of the interface between the workings of the modern global economy and infrastructure. A report by the Chicago Council on Global Affairs that presented recommendations to guide Chicago's participation in the global economy included the following observation: "Ubiquitous high-bandwidth Internet connectivity is essential for any city to flourish in a global environment. Businesses must be visible on the Web and be able to engage in E-commerce."[5] The Chicago report makes reference to an analysis commissioned by the Communications Workers of America that documents that Internet speed in Japan is 61 megabits per second or more than 30 times faster than the U.S. broadband speed of 1.97 megabits per second. Other countries that have higher broadband speed than the United States include South Korea at 45 megabits, France at 17 megabits, and Canada at 7 megabits.

While breakthroughs in the speed of transmission and breadth of content of digital communications over the last decades—particularly the widespread expansion of wireless communications—are breathtaking, it cannot be taken for granted the degree to which the hard infrastructure of transmission towers, satellites, power generators, and antennae farms make the convergence of large volumes of voice, data, and graphic communications possible. Tangible evidence of the infrastructure of instantaneous electronic communications are the massive data centers that are increasingly becoming the nerve centers of the economy and of society. Data centers are critical points of convergence in the generation of ever faster and more robust data transmission, striving to produce more computing power per square foot for the lowest possible expenditure in resources. The technology of computing infrastructure that makes it possible for a Google search to be executed in .15 seconds is financed in large measure by the private sector. But what is easy to miss is the dependence by data centers on the

public power capabilities of the locations in which they are set. Centers such as the 700,000-square-foot facilities built by Microsoft are "a sprawling array of servers, local balancers, routers, fire walls, tape-backup libraries, and database machines, all resting on a raised floor of removable white tiles, beneath which run neatly arrayed bundles of power cabling."[6] And the huge electrical flows required to power the data centers are equaled by the amount of electricity required to cool them. Local utilities are building energy capability in order to prepare for the expectation of more data centers in their service areas. San Antonio, Texas, for example is the site of a Microsoft data center and is now planning future energy capacity in order to support more technology industries. It proposes diversifying its municipally owned power generation from the present base of coal, natural gas, and oil by adding wind and additional nuclear capability. Data centers are an example of the dependence of communications and information technologies on basic infrastructure because the cost of power is so important and interruptions of power are so damaging. Metropolitan areas that have adequate power reserves will have a major advantage in economic development.

The fields of logistics, supply chain management, transportation and global communications are increasingly critical to the functioning of the national economy. Some experts believe that the availability of state-of-the-art logistical capability, supported by massive infrastructure investment, will determine economic development opportunities in the new century. Arnold Perl, Chair of the Memphis Logistics Council, states: "Access is to the 21st century what location was to the 20th."[7] Access to materials, industrial processes, information, electrical power and markets will determine the competitiveness of industries, regions, and nations. Dependence on modern infrastructure could not be clearer.

SUCCESSFUL INDUSTRY LINKAGES CREATE STRONG ECONOMIC CLUSTERS

Michael Porter describes the U.S. economy as composed of thousands of clusters of firms geographically concentrated into poles of sectoral strength across the nation.[8] Linkages between firms and industries create clusters that become the actual platforms for global transactions and are the geographic hot-houses of U.S. productivity. Clusters tend to form bottom-up in different regions of the nation and are characterized by many individual business decisions and investments. Successful clusters of firms, functioning as parts of global chains of companies and developing the knowledge and skills needed to enhance business prowess, define the prospects of regions. This is equally true for manufacturing firms and for enterprises in advanced

services. Principal firms are joined by supplier firms, each making individual investments in the technologies required to participate in the industry cluster. An industry cluster at first forms around infrastructure suited to its specific industries and in time creates the need for more extensive and more advanced infrastructure. By definition, a cluster of industries relies on linkages, such as efficient routes for the movement of raw materials and parts for assembly, cost-effective instantaneous communications, common demands for water or power, or shared manpower needs. These linkages, figuratively the bones and the connecting cartilage and tendons of the cluster, constitute the infrastructure it needs to function and to grow.

Infrastructure Creates Cluster Linkages

An example of how infrastructure links an industry cluster is the supplier concentration that includes 21 automotive supply firms surrounding the Toyota plant in San Antonio. Toyota built a facility capable of producing 200,000 Tundra pick-up trucks and provided space within the footprint of the plant site for supplier firms who wished to locate there. Twenty-one firms have built fabrication and assembly plants on site and avail themselves of the shared rail and truck facilities that serve the complex. The extension of rail lines to the site required public intervention in order to assure that both the Burlington Northern Railroad and the Union Pacific Railroad could ship to the plants. Once the necessary accords were reached and the rail lines built, a cluster of automotive firms formed which now extends to support plants in South Texas and Northern Mexico.

Another example of how transportation infrastructure creates linkages for businesses is the UPS Worldport sorting system at Louisville International Airport. It is a 4 million square foot facility presently being expanded by an additional 1.2 million square feet. Its access to 250 daily flights and to parking facilities for 117 cargo jets has attracted a cluster of firms that rely on transportation solutions.[9] UPS has perfected what it calls "end-of-runway service," to describe the access available to firms that locate in proximity to Worldport in order to be able to fill online orders and ship immediately. Firms are able to take orders and have them in consumers' hands the next day anywhere in the United States because they can insert products into the UPS system within hours. Access to UPS's distribution network has created a cluster of shipping-sensitive firms which include Stride Rite, Johnson & Johnson, Ann Taylor, Zappos, and over 110 other companies.

Transportation infrastructure has also attracted major companies to Memphis. An April 2009 report in *Urban Land* states the following: "Memphis is known as a 'quadrimodal' city. It includes the largest cargo airport in the world, the third-largest rail center (behind Chicago and St. Louis), and the second-largest water port on the Mississippi River, and it is within range

of more cities by overnight truck (600 miles) than any other U.S. city."[10] Memphis has evolved as an inland port serving the entire nation from a central location. The *Urban Land* report continues: "Major companies with headquarters or significant space in Memphis include AutoZone, Williams-Sonoma (more than 5 million square feet), DDN (pharmaceutical logistics), Cummings Diesel, Nissan, Kyocera, Nike, and Technicolor."

The science of analyzing industrial clusters as engines for the American economy is creating greater understanding of both the functioning of clusters and the infrastructure linkages that make them possible. The established clusters across the United States—including the biosciences cluster in the Washington/Baltimore area, telecommunications in Dallas, computer software development in Silicon Valley, biotechnology in the Research Triangle of North Carolina, automotive research and engineering in Michigan, aircraft manufacturing in Seattle, new media in Los Angeles, and finance in New York—are built on historical antecedents, are financed by specialized investment firms, involve specialized legal and accounting capabilities, and are supported by targeted educational and training programs. Each is also served by infrastructure essential to its function, by air routes, road and highway access, specialized communications, water supplies, electrical distribution, and various kinds of public works. When successful, the interwoven character and mutual uplift of firms in multiple industry clusters can grow into economic rationale strong enough to drive another building-block of national competitiveness, the economic engines which are the United States' major metropolitan areas.

STRENGTHENING COMPETITIVE METROPOLITAN ECONOMIES

The Brookings Institution has produced extensive research that describes the role of metropolitan areas in the U.S. economy. While 65 percent of Americans live in just the 100 largest metropolitan areas, more than 75 percent of GDP, 76 percent of knowledge jobs, 78 percent of patent activity, 81 percent of research and development (R&D) employment, and 94 percent of venture capital funding are generated in those metropolitan areas.[11] A report of the Brookings Metropolitan Policy Center states:

> *Today, our nation—and our economy—is metropolitan. U.S. metropolitan areas—complex regions of interwoven cities and suburbs—are home to more than eight in ten Americans and jobs. . . . They concentrate and strengthen the assets that drive our economic*

> *productivity, grow the skills and incomes of our workers, and contribute to our environmental sustainability. Our major metro areas reflect the face of the U.S. in a global economy where, for the first time, more than half of the world's population is metropolitan.*

The major forces that contribute to national competiveness play out in a decentralized pattern in metropolitan areas across the nation: the presence of strong industry clusters, the availability of highly skilled talent, the capacities of entrepreneurs and investors, the existence of constructive regulatory structures, and the strength of regional infrastructure. Porter observes:

> *The federal government has also failed to recognize and support the decentralization and regional specialization that drive our economy. Washington still acts as if the federal level is where the action is. Beltway bureaucrats spend many billions of dollars on top-down, highly fragmented federal economic development programs. Yet these programs are not designed to support regional clusters nor do they send money where it will have the greatest impact in each region.*[12]

National economic strategy must encompass the pragmatic determinants of competitiveness and productivity, which percolate up from the metropolitan institutions where human capital is developed, where on-the-ground environmental challenges are resolved, where investment decisions are made, where states and localities legislate regulatory frameworks, and where the next generation of infrastructure must be built.

Metro Economies Need Basic Infrastructure

Like electrical power, water is a basic resource that supports the new economy. Assuring a future water supply for a metropolitan area is one of the most critical imperatives of regional leadership. In water-scarce areas of the western United States, metropolitan strategies to acquire water resources or to conserve water determine growth prospects. Water is a critical resource for industrial processes, for consumer use, for recreational uses, for public amenities, and plays a critical role in business decisions. Metros such as Phoenix have developed compacts for the development of water resources, such as the Central Arizona Project that provides access to water from the Colorado River in order to meet the needs of consumers and industries. The long history of water conflicts between Northern and Southern California's metropolitan areas underscores its significance as basic infrastructure.

Basic transportation infrastructure is central to the historic role of hub metros such as Chicago, the nation's leading rail center and the only city in the country where all six Class One North American railroads intersect.[13] Every day 500 freight trains hauling 37,500 rail cars travel through Chicago. That daily number is expected to grow to 67,000 train cars by 2020, requiring a commitment to expanded rail infrastructure. More containers are transferred in Chicago from train to truck than in another city in the Western Hemisphere and Chicago is the fifth largest intermodal container handler in the world. Intermodal shipments grew by 8 percent in 2006 as increasing imports from Asia are transported to the U.S. heartland. But railroads now must allow more than 30 hours to move rail freight across the city; as a result, many shipments spend more time getting across Chicago then they do in transit from the coasts to Chicago. Metropolitan infrastructure improvements to reduce that congestion would serve not only the economy of the region but of the Midwest and of the nation.

Chicago's role as the transportation hub of the Midwest also depends on expedited passenger traffic through O'Hare International Airport. The report of the Chicago Council on Global Affairs states:

> *As global commerce grows so does global travel. That means that a city with the most international non-stop links is the city most connected to the globe. A city that stands at the center of the global aviation system is like a town on a major highway—it is the place that gets the business.*[14]

The report calls for a $6.6 billion modernization program for O'Hare Airport which, along with the airports serving metropolitan Atlanta, Los Angeles, Dallas/Ft. Worth, and Denver, was among the 10 busiest airports in the world in 2007.

The Future Infrastructure of Metros

The new economy will also require public investment beyond traditional infrastructure. Investment in higher education and worker training will involve not just the physical construction of schools, community colleges, and universities, but investment in technology to extend curricula and broaden access to rigorous skills development. The iron-clad equations of the new U.S. economy are: "High skills = high wages; low skills = low wages." The nation's hopes for a broader middle class require investment in the technology infrastructure of human capital development.

The actual workings of metropolitan areas as engines of the national economy can involve several metropolitan areas in a cohesive network. The

Texas Triangle has Dallas, Houston, and San Antonio as its corners; but within the Triangle are such important university and research centers as Austin and the University of Texas and College Station and Texas A&M University. The highway network that connects this complex of metro areas needs expansion to ensure the rapid movement of goods and people across the region. The IH-35 spine that links San Antonio, Austin, and Dallas-Ft. Worth is known as the NAFTA Corridor because of the volume of cargo it carries from Mexico into the central United States. Texas is now building toll roads as parallel routes in order to allow truck traffic to bypass the congestion on the 60-year-old IH-35 roadway. Planning is accelerating to add rail connections that would allow the Texas Triangle to be connected in the manner of major metropolitan centers in Europe and Japan.

A similar nexus of metropolitan synergy that exists is the Washington-Baltimore complex. The region is home to the most important governmental center in the world, but it also sustains numerous business, research, educational, and biomedical job generators. Mobility is served by road, tunnel, and rail facilities; but the region is linked to the nation and the world by three airports—Reagan National in Washington, Dulles in Virginia, and Baltimore-Washington International in Baltimore—each scheduled for continuous expansion.

POPULATION GROWTH, BUILDING NEEDS, AND INNOVATION IN INFRASTRUCTURE

Among the other major forces that will shape national competiveness and well-being are the growth of national population and its effects on U.S. markets. The nation's population will grow from approximately 306 million people in 2009 to about 395 million by 2050, an increase of about 90 million people in the next 40 years. As evident in Exhibit 1.2, the United States, which is the third most populous nation in the world today behind China and India, will remain the third most populous country in 2050, while the Russian Federation and Japan will decline in population rank among the nations of the world and perhaps even in absolute population.[15]

Exhibit 1.3 describes population changes between 2005 and 2050 among the northern industrial nations and projects population declines in Spain, Germany, Italy, and Japan. Russell Shorto described in the *New York Times* how social scientists Hans-Peter Kohler, Jose Antonio Ortega, and Francesco Billari in a 2002 study found that birthrates in some European nations have dipped below 1.3 percent, the rate at which a country's population would decline by half within 45 years. In the mid 1960s, Europe was 12.5 percent of world population; it is 7.2 percent today and by 2050

EXHIBIT 1.2 Most Populous Countries 2005 and 2050

Country	2005 Population	Rank	Country	2050 Population	Rank
China	1316	1	India	1593	1
India	1103	2	China	1392	2
USA	298	3	USA	395	3
Indonesia	223	4	Pakistan	305	4
Brazil	186	5	Indonesia	285	5
Pakistan	158	6	Nigeria	258	6
Russian Federation	143	7	Brazil	253	7
Bangladesh	142	8	Bangladesh	243	8
Nigeria	132	9	Democratic Republic of Congo	177	9
Japan	128	10	Ethiopia	170	10

Note: Numbers are in millions.
Source: United Nations Population Division.

will drop to 5 percent. Mark Steyn, author of *America Alone: The End of the World as We Know It*, states: "These countries are going out of business."[16]

The United States by contrast will grow, in large part due to the growth of minority populations already within the country, as well as immigrants who will arrive here in the years to come. Minority families tend to be younger than the national average and are larger than average, creating a population trajectory that ensures that the United States will continue to grow in population as well as in markets. The reality of steady population growth and estimates of annual GDP growth of about 3 percent, as shown in Exhibit 1.4, will drive the need for continued development of the physical facilities to support that growth. The growth of population and consumer markets will create a need for new residences, for expanded plants to grow current product lines and for new facilities to provide products and services not yet developed.

Meeting the Need for Built Space

The Brookings Institution has projected levels of demand for expansion of the built environment in the United States. A Brookings study prepared by Professor Arthur Nelson of Virginia Tech estimates that there were 296 billion square feet of built structures in the United States in the year 2000.[17]

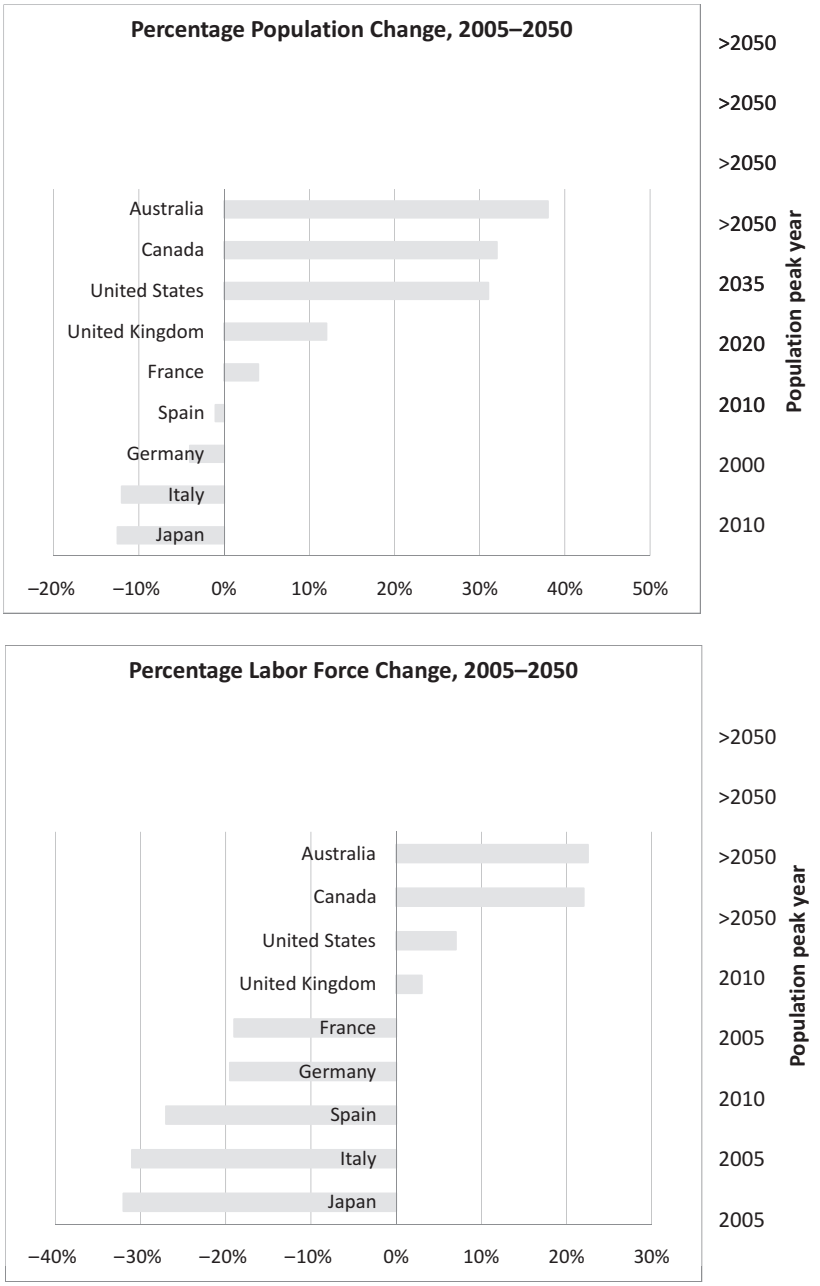

EXHIBIT 1.3 Population and labor force change in selected mature economies (percent), 2005–2050

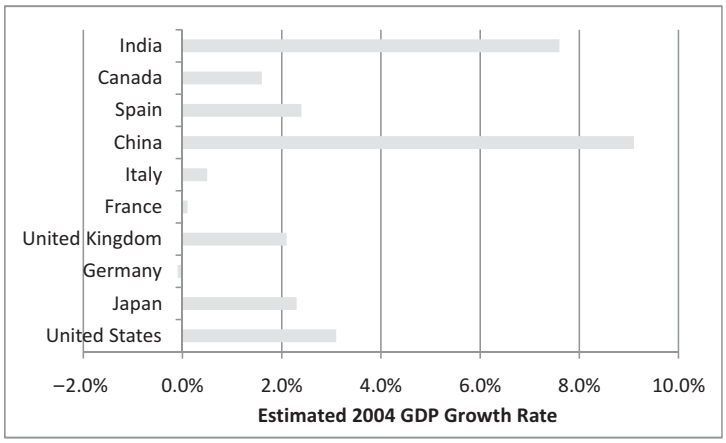

EXHIBIT 1.4 World's top 10 economic countries, 2004

As Exhibit 1.5 describes, by 2030 the nation will need 426 billion square feet of space for residential, commercial, and industrial purposes. That is an increase of 131 billion square feet, which when added to the 82 billion square feet of estimated replacement needs, means that the nation must build more than 213 billion square feet of additional space. That is about two-thirds the volume of the existing built stock in the U.S., a massive amount of construction.

EXHIBIT 1.5 Summary of U.S. Built Space: Existing and Needed, 2005 and 2030

	2000	Needed to Be Built	2005	2030
Total built space[a]	295.9	New:	131.4	426.3
		Replacement:	82.0	
		Total:	13.4	
Residential units[b]	115.9	New:	38.8	154.8
		Replacement:	20.1	
Residential units[a]	176.7	New and Replacement:	108.7	254.7
Commercial and institutional space[a]	106.7	New and Replacement:	96.4	159.3
Industrial facilities[a]	12.3	New and Replacement:	8.2	13.2

Notes:
[a]in billions of square feet
[b]in millions of units

Professor Nelson's calculation for total building needs is equally impressive in its component parts. The nation, for example, had 116 million housing units in the year 2000. It is estimated by 2030 that 59 million additional units will be needed, including 39 million for growth and 20 million to replace aged or deteriorated stock. By that calculation, a volume of housing units roughly equivalent to 50 percent of the nation's existing housing stock will have to be built over the first half of the 21st century.

The Brookings report estimates that the nation has about 107 million square feet of commercial and institutional space that must grow to 159 million square feet by 2030, a total of 96 million square feet to be constructed new and for replacement. That figure represents about 90 percent of the square footage in existence in 2000. With respect to industrial facilities, the Brookings report estimates that there were 12.3 million square feet in existence 2000 which must grow by 8.2 million square feet of new and replacement facilities by 2030, representing about 67 percent of the total in existence in 2000. By any account, such a scale of projected physical structures to be built is immense and underscores not only the growth challenges before the country but the infrastructure challenges as well. The very act of constructing that amount of built space will require additional transportation, water, power, communications, and social infrastructure. To the challenge of building infrastructure to support such growth must be added the replacement of today's aging and obsolete infrastructure as well as the emplacement of new generations of infrastructure yet to be developed in the communications, energy, and transportation arenas.

Next Infrastructure

Some of the infrastructure to be constructed will incorporate new technologies and assume new forms and functions. One of the most likely areas of infrastructure progress is alternative energy. In the short run, alternative energy innovation means modernizing the electric grid, investing in large-scale public transit, incorporation of smart technologies in homes and buildings, and investment in more efficient automobiles and roadway systems.[18] Developments in renewable energy—including wind, solar, and biomass power—are being funded by traditional financial sources, as electrical utilities replace traditional power generation with renewable energy technologies. The American Public Power Association and the Large Public Power Council have undertaken a joint initiative to promote energy efficiency and clean energy by publicly owned utilities.[19] In Arizona, the world's largest solar plant, capable of generating 280 megawatts, is now under construction and in California, Pacific Gas and Electric and Southern California Edison are embarking on massive solar energy projects. X-Cel Energy is building

the nation's first "Smart-Grid" city installing more than 15,000 advanced residential meters in Boulder and more than 100 miles of cable over power lines for broadband transmission.

State-level public investments in energy infrastructure are also underway, such as Michigan's investment in a clean energy transmission network that would bring wind power from the Dakotas, Iowa, and Minnesota to population centers in the Midwest. The plan calls for 3,000 miles of power lines and would cost $12 billion. Maine is already New England's largest wind energy producer and has plans to produce an additional 503 megawatts from wind power over the next few years. And the State of New Jersey inaugurated the Atlantic City Convention Center's Solar System, which makes it the largest single-roof solar panel in the nation.

Parallel innovations in every dimension of infrastructure development and of infrastructure finance suggest that the field is poised for major breakthroughs. The challenges of sustaining the United States' competitiveness requires heightened levels of innovation, investment, and public and private sector commitment to the next generation of infrastructure.

CONCLUSION

The United States faces challenges in a world that is rapidly changing. The most basic facets of national well-being—international security, domestic prosperity, measures of quality of life, the values of inclusion and opportunity—depend on sustaining competitiveness and productivity in the United States. This chapter has attempted to make a straightforward case: that as the global economy has evolved, critical new building-blocks of national competitiveness have emerged. Modern logistics must be able to move the contents of global production rapidly and continuously to points of convergence. That effective confluence of inputs enables mutually supportive clusters of firms to compete globally and to create jobs. When multiple clusters grow to scale, metropolitan areas become strong enough to be vibrant platforms for national prosperity. And propelling these progressions are continuous fuel injections of population growth, of building needs, and of innovation.

In this context, infrastructure must be understood as the assets and systems that enable these building-blocks to be arrayed together. Americans must move beyond thinking of our infrastructure challenge as only replacing the massive hulks of 19th century public works. The nation must imagine infrastructure that is not just more of the same, just expanded for greater capacity. Our public and private leaders must commit to infrastructure that is new not only in the date of its construction, but is new in the creativity of

how it applies new technologies, how it gets more for less, how it protects the environment, and how it advances national competitiveness. At stake is nothing less than the well-being of the American people.

ENDNOTES

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