12

Strengthening Urban Industry: The Importance of Infrastructure and Location

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This chapter focuses on policies that can strengthen urban manufacturing and associated distribution/logistics activity in the context of shifting trends in industrial infrastructure, conversion pressures on urban industrial land, and attempts to limit low-density residential development. Within urban policy development and planning practice, a little-acknowledged conflict exists: efforts to increase population density and promote more effective use of grey infrastructure to support residential density contribute to industrial sprawl and the need to extend grey infrastructure further out in metropolitan areas. Grey infrastructure consists of human-made systems that support population and economic activity, such as roads, bridges, rail, water, and sewer systems. The continued expansion of grey infrastructure contributes to the growing carbon footprint of metropolitan areas and to associated climate change implications. It also adds to the long-unresolved burden of maintaining the nation's infrastructure.

Urban agglomeration theory, beginning with Alfred Marshall (1961), has long made the case for firm proximity (i.e., industrial density or clustering) as a fundamental feature of innovation and competitiveness. In resolving the conflict between strengthening urban manufacturing and increasing population density (along with associated commercial and service activity), policy makers require a better understanding of which industries are most competitive in central cities, and within these industries, which functions (research and development, production, distribution, remanufacturing, recycling) are most compatible with the surrounding area's activities. This understanding is needed for creating a robust approach to providing urban infrastructure that supports industry in a manner compatible with desired residential, commercial, and service (private and public) activity.

The argument for explicit attention to strengthening urban industry is based on five premises. First, urban industry is essential for two key reasons: to increase U.S. exports and elevate U.S. leadership in advanced manufacturing, which will help the country maintain its global economic position, and to address chronic problems of central city unemployment and poverty, the incidence of which is higher around older industrial areas. Second, the changing landscape of urban industry has shifted the location and purposes of buildings such as warehouses and distribution centers. Third, underinvestment in infrastructure and poor maintenance constrains urban industry and the development of the information economy. Fourth, the public sector is critical in developing policy that promotes urban brownfield development rather than suburban greenfield construction. A distorted land market in metropolitan areas disadvantages efforts to retain an adequate supply of industrial land. Distortions are driven by government subsidization of suburban and exurban development. This subsidization occurs at all levels of government and takes the form of property tax and other incentives and the subsidization of road construction and other infrastructure. Finally, climate change is real, and efforts to strengthen urban industry and maintain central city industrial land play a significant role in climate change mitigation by creating less pressure for expansion and by encouraging lower-impact development.

The Movement to Strengthen Urban Industry and Economic Development

NATIONAL LEVEL

The manufacturing sector creates higher value than any other major sector in the economy. For example, for every dollar of manufacturing output, another $1.35 in economic activity is created, compared to $0.95 for transportation, $0.88 for information, and $0.63 for finance (President's Council of Advisors on Science and Technology 2012). However, the U.S. position as the leading producer of manufactured goods is widely seen to be eroding:

> The loss of U.S. leadership in manufacturing is not limited to low-wage jobs in low-tech industries, nor is it limited to our status relative to low-wage nations. The hard truth is that the United States is lagging behind in innovation in the manufacturing sector relative to high-wage nations such as Germany and Japan, and the United States has relinquished leadership in some medium- and high-tech industries that employ a large proportion of highly skilled workers. In addition, the United States has been losing significant elements of the research and development (R & D) activity linked to manufacturing to other nations, as well as its ability to compete in the manufacturing of many products that were invented and innovated here—from laptop computers to flat panel displays to lithium ion batteries. (President's Council of Advisors on Science and Technology 2012, 2–3)

National-level policy is being directed toward strengthening the U.S. position as a creator of advanced manufacturing because it is viewed as critical for maintaining the nation's leading economic position in the global market.

Ezell and Atkinson identify five reasons why manufacturing is essential to a healthy economy (2011, 2):

1. It will be extremely difficult for the United States to balance its trade account without a healthy manufacturing sector.
2. Manufacturing is a key driver of overall job growth and an important source of middle-class jobs for individuals at many skill levels.
3. Manufacturing is vital to U.S. national security.
4. Manufacturing is the principal source of R & D and innovation activity.
5. The manufacturing and services sectors are inseparable and complementary.

Ezell and Atkinson's call for a national manufacturing strategy stems from three concerns. First, U.S. manufacturers face unfair competition because other countries have explicit manufacturing strategies. Second, market failures and externalities associated with manufacturing cause underperformance. Finally, once a manufacturing sector is lost to international competition, it is very unlikely it can be regained.

In a review of 2009 and 2010 presidential and congressional initiatives and legislation, the U.S. Congress Joint Economic Committee (2010) reported more than a dozen other national economic recovery efforts supporting manufacturing exports and sustainable manufacturing, including the U.S. Manufacturing Enhancement Act, which was signed into law in August 2010. In June 2011, the committee followed up their review, published in *Understanding the Economy: Promising Signs of Recovery in Manufacturing*, with a hearing titled "Manufacturing in the USA: Why We Need a National Manufacturing Strategy." Instead of a manufacturing policy that focuses on certain industry sectors, the panelists supported national manufacturing policies focusing on total exports and innovation and on specific application of knowledge and technology in advanced and sustainable manufacturing processes and products.[1]

As one of the responses to the Great Recession, a strong interest has developed in strengthening manufacturing. Recent national policy efforts focus on

1. In July 2012, the President's Council of Advisors on Science and Technology issued "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing." Advanced manufacturing is defined as a "family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example nanotechnology, chemistry, and biology. This involves both new ways to manufacture existing products, and especially the manufacture of new products emerging from new advanced technologies" (2012, ii).

innovation in manufacturing (especially advanced manufacturing), promoting exports, and supporting manufacturing's transformation to cleaner, more sustainable production. In June 2011, President Obama announced the Advanced Manufacturing Partnership of industry, government, and universities to invent and deploy new manufacturing technology, processes, and products. Earlier, the president promoted the National Export Initiative in his first two State of the Union addresses. The National Export Initiative established a goal of doubling U.S. exports by 2014. To meet this goal, a new federal program, the Renewable Energy and Energy Efficiency Export Initiative, began in late 2010 to focus on increasing U.S. capacity in clean energy manufacturing, promoting exports of renewable energy and energy-efficient manufactured goods and services, and encouraging waste reduction (Trade Promotion Coordinating Committee 2010).

While it was the financial institutions and devastated residential and commercial markets that created the Great Recession and its lingering impacts, exports—particularly manufacturing exports that are dependent on an adequate supply of industrial land and infrastructure—are essential to a full recovery and continued prosperity. As Istrate and Marchio observe:

> In a slow recovery, exports are essential to job creation and the reorientation of the U.S. economy towards productive economic growth. Metropolitan areas are a vital part of this proposition. In 2010, exports were a major driver of the U.S. recovery and the largest metropolitan areas produced the majority of the nation's exports. While the overall economy was still losing jobs, the rapid growth of U.S. export sales translated into 600,000 additional jobs in the first year of recovery. These are jobs not only in the industries producing the exported goods and services, but also in the suppliers to the exporting industries, and in the case of merchandise exports, in the transportation and wholesale trade industries. Manufacturing drove the rapid recovery of U.S. export sales. (2012, 21)

METROPOLITAN LEVEL

A 2010 Brookings study highlights several advantages of metropolitan areas for export activity: a large and diverse pool of workers, strong logistics networks to move cargo, greater capacity (universities, investment in research and development, and basic, science, and venture capital) to support innovative products that can become exports, and proximity to other export-oriented firms. The study calls for greater support to increase the export activity of the nation's metropolitan areas, and it specifically states: "Local metropolitan leaders should be concerned with increasing the export intensity of existing companies rather than simply recruiting new ones" (Istrate, Rothwell, and Katz 2010, 7).

Urban areas actually do play an essential role in the manufacturing economy, as a recent Brookings study on the location of manufacturing illustrates (Helper, Krueger, and Wial 2012). The study found that 80 percent of all manufacturing jobs, including 95 percent of the highest technology jobs, were located in metro areas in 2010. Further, while manufacturing plants are typically thought to be large in size with hundreds of employees, the average manufacturing plant in the nation's metro areas had only 57 employees. This raises the question of whether individual manufacturing plants require less space than is commonly perceived. Data for 2000 to 2010 show that the long-term trend of manufacturing jobs shifting away from metro areas and central metro counties continued. In particular, the location of high-tech firms shifted from central to outlying counties in metro areas between 1980 and 2010. The study's authors state that this trend "should be an important policy concern" given that "firms in higher-density environments are more productive [and therefore] decentralization of manufacturing clusters could undermine the competitiveness of U.S. manufacturing" (Helper, Krueger, and Wial 2012, 31).

The 366 metro areas in the United States generated 84 percent of manufacturing exports in 2010, but most of this activity was concentrated in the top 100 metro areas (based on population). The top 10 manufacturing exports in 2010 were (in rank order): transportation equipment; chemicals; machinery; computer and electronic products; petroleum and coal products; food; primary metal; medical equipment, sporting goods, and miscellaneous; fabricated metal products; and electrical equipment. The top 100 metro areas generated 75 percent of manufacturing exports, 75 percent of national gross domestic product, and two-thirds of all jobs (Istrate and Marchio 2012). Researchers recognize that most U.S. export activity originates in metropolitan areas and that manufacturing constitutes the majority of metropolitan export activity (Atkinson and Gottlieb 2001; Berube 2007; Istrate and Marchio 2012).

Helper, Krueger, and Wial (2012) found that around two-thirds of the nation's metro areas exhibit manufacturing clustering in one of six areas: computers and electronics, transportation equipment (trains, planes, autos, and ships), low-wage manufacturing (textiles, apparel, and furniture), chemicals, machinery, and food. They suggest that the continuation of recent gains in manufacturing employment will be "highly shaped by the local dynamics of regional supply chains and industry clusters" (Helper, Krueger, and Wial 2012, 35). Dense economic activity is vital, but they caution that market forces will not produce the amount of clustering activity the United States needs to remain competitive. They observe, for example, that firms underinvest in research and development and worker training because they take advantage of other firms' investments. Thus, they call for "geographic high road" policies, such as more worker training and R & D, instead of the dominant policies of tax abatements and location subsidies that favor nonmetro and outlying metro counties. These "low road" policies are predicated on the assumption that what makes a location desirable is low wages, "even though such wages typically account for far less than 20 percent of a manufacturer's total costs" (35).

The national-level focus on strengthening manufacturing and exports shores up the efforts undertaken by a small group of forward-thinking U.S. cities to preserve industrial land in their urban cores. These efforts began well before the Great Recession. These cities were bucking the trend of the majority that seemingly accepted the view of a postindustrial economy, one in which supply-side and demand-side economic development strategies focused on real estate, retail, services, and housing development, largely framed within the smart growth movement. The acceptance of this viewpoint led to substantial urban industrial land rezoning in some cities and pressured industrial businesses into leaving urban industrial districts by raising rents and land values. The economic development approaches of the public and private sectors in these cities ignored industrial uses. Essentially, in buying into the postindustrial worldview, many cities allowed themselves to become deindustrialized. The highly influential smart growth movement played a significant role in this process.

In "Smart Growth's Blindside," Leigh and Hoelzel (2012) critique the movement for its failure to "recognize connections between urban industrial land and the activities it supports with smart growth goals of limiting sprawl and revitalizing central cities" (87). They review the recent local industrial policies of 14 cities[2] and 10 influential practice-oriented smart growth publications[3] with local economic development components. In the 14 cities initiating local industrial policies, a significant amount of industrial land was converted to other uses as city planners pursued smart growth. (Table 12.1 provides details for eight of these cities.) Leigh and Hoelzel compare elements of the cities' adopted local industrial policies with commonly accepted smart growth principles (table 12.2) to illustrate the contradictions between smart growth policies and efforts to protect and revitalize urban industrial areas.

Further, Leigh and Hoelzel's analysis of the smart growth literature found little to no acknowledgment of the need to coordinate urban industrial development practices with other mainstay smart growth activities. As a consequence, industrial land failed to be protected from conversion pressures. Leigh and Hoelzel conclude that approaches are needed that explicitly safeguard productive urban industrial land and discourage industrial sprawl. Further, policy makers need to avoid treating (whether consciously or not) smart growth and sustainable urban industrial development as conflicting goals.

In addition to the need for industrial land to fulfill the key role that cities have to play in growing manufacturing and exports, industrial land is needed for critical urban services infrastructure, warehouses for goods coming in and out of the city, and private and public sector industry maintenance and repair activity. Taken together with manufacturing, these activities have more recently come to be labeled production, distribution, and repair (PDR) activities. Dempwolf

2. Atlanta, Baltimore, Boston, Chicago, Los Angeles, Minneapolis–St. Paul, New York, Oakland, Philadelphia, Portland, San Francisco, San Jose, Seattle, and Washington, DC.

3. These include American Planning Association (2003, 2009), Congress for the New Urbanism and U.S. Environmental Protection Agency (2002), International City/County Management Association and Smart Growth Network (2002, 2003), International Economic Development Council (2006), National Association of Local Government Environmental Professionals and Smart Growth Leadership Institute (2004), Smart Growth Leadership Institute (2007), Smart Growth Network, International City/County Management Association, and U.S. Environmental Protection Agency (2006, 2009).

Table 12.1
Loss of Industrial Land to Rezoning in Select U.S. Cities

City	Industrial Land Lost (Acres)	% Lost	Years
Atlanta, GA[a]	800	12	2004–2009
Boston, MA[b]	960	38	1962–2001
Minneapolis–St. Paul, MN[c]	1,812	18	1990–2005
New York, NY[d]	1,797	14	2002–2007
Philadelphia, PA[e]	1,645	8	1990–2008
Portland, OR[f]	489	2	1991–2001
San Francisco, CA[g]	1,276	46	1990–2008
San Jose, CA[h]	1,470	9	1990–2009

[a]Leigh et al. (2009).
[b]Boston Redevelopment Authority (2001).
[c]CDC Associates (2008).
[d]Pratt Center (2009).
[e]City of Philadelphia (2011).
[f]City of Portland (2003).
[g]San Francisco (2008).
[h]City of San Jose (2009).

(2009) attributes this renaming of industrial land to efforts to avoid negative reaction to industrial activity as well as efforts to emphasize how industrial land use is connected to the overall land use system. The label also highlights possibilities for finer-grained planning approaches that are "more contextual and integrative" (15).

The central cities of metropolitan regions are also interested in preserving their industrial lands as a means to reduce high poverty and unemployment rates. Despite declining unionization levels, which historically have provided high wages and benefit levels, and despite a recent trend whereby manufacturing productivity increases have not been reflected in employee compensation, manufacturing still pays significantly higher wages for blue-collar workers lacking a college education than other sectors, even when controlling for worker and job characteristics (Helper, Krueger, and Wial 2012). Further, the older working-class neighborhoods that are adjacent to many inner-city industrial areas often have the greatest concentrations of poverty. For example, 20 percent of Atlanta's population but 33 percent of its poverty population live within a one-mile buffer from the center of each of the city's three primary industrial areas (Leigh et al. 2009).

While historical zoning practice established the separation of industrial uses from other uses for health and human safety, most of today's industry does not require such separation. Urban industrial land can be made more attractive for manufacturing and related uses through innovative urban design and the accep-

Table 12.2
Local Industrial Issues, Policies, Smart Growth Planning

Summary of Urban Industrial Development Issues and Priorities in 14 Local Industrial Policies	Summary of Smart Growth Issues and Priorities Affecting Urban Industrial Development
Land Use Planning Issues and Priorities	
• Loss of industrial land and ad hoc zoning conversions threatening productive industrial areas.	• Rezone land for functionality and compatible mixes of use.
• Market-driven overpricing of industrial land and competition from other land use alternatives.	• Facilitate transit-oriented development (TOD) and greater access to jobs.
• Encroachment and compatibility of uses within and surrounding industrial areas.	• Foster compact and dense infill development.
Local Economic Development Planning Issues and Priorities	
• Lack of available productive industrial land for advanced manufacturing and sustainable industrial businesses.	• Balance jobs and housing.
• Link workforce training to high-quality, local industrial jobs.	• Reduce job sprawl and job-resident spatial mismatch.
• Foster supportive and innovative business climates for industry.	• Improve employment diversity, quality, and wages in urban job centers.

Source: Leigh and Hoelzel (2012).

tance of mixed land uses. Urban design can address the need for quality space that is buffered from and complementary to nearby residential uses (including appropriate infrastructure for trucks, autos, bicycles, and pedestrians). This can be accomplished through form-based design codes like the transects or overlay districts that are being-used in the Little River/Little Haiti industrial district of Miami (Miami21 2012).

Mixing industrial activity with appropriate uses that yield higher property taxes can make it more profitable to retrofit industrial properties and can reduce the pressure for the wholesale rezoning of industrial land. The city of San Jose adopted a new development policy for its northern industrial area in January 2012. The area, known as Rincon de los Esteros, the Innovation Triangle, or the Golden Triangle, has been the location of some of the city's well-known high-technology companies. It developed in a uniform and low-intensity manner since the 1980s as a result of city policy that was focused on regional traffic concerns and resulted in a floor area ratio of 0.35. Rincon de los Esteros "is characterized architecturally by low to mid-rise office buildings one or two-story light manufacturing and research & development facilities, surface parking lots and generous amounts of landscaping. . . . The block pattern is large and irregular and access into North San Jose is provided mostly from a limited number of regional freeways or expressways" (City of San Jose 2012, 3).

The updated policy provides for an additional capacity for 20 million square feet of development, and specific sites can be converted from industrial to high-density residential sites based on specific compatibility criteria for industrial activity. The policy adds two land use changes to the area. The first is an industrial Core Area designation to support a "driving industry" corporate center along a primary corridor. The city seeks to

> allow and encourage more intense development for "driving industry" businesses along the North First Street Corridor. Driving industry businesses are businesses that sell goods and/or services outside of the region, bringing in significant revenues that help drive the San Jose economy. The City envisions a very active corridor of mid-rise (4–12 story) industrial office buildings . . . [that] will foster a concentration of high-tech businesses located so as to make best use of existing infrastructure resources. (City of San Jose 2012, 5)

The resulting floor area ratio is expected to be 1.2.

The second land use change is a Transit/Employment Residential District Overlay to expand supporting residential and commercial uses in the industrial area. This land use change

> provides for the development of up to 32,000 new residential units . . . through the conversion of . . . existing industrial lands within a proposed Transit/Employment Residential District Overlay area. New residential units would also be allowed through mixed-use development within the Core Area. . . . This residential development is intended to provide housing in close proximity to jobs to allow employees the opportunity to reduce their commute travel times, to make increased use of transit facilities, and to reduce overall traffic congestion. (City of San Jose 2012, 6)

The policy specifies needed improvements to transportation infrastructure to support the new high-intensity development.

Changing Landscapes of Urban and Suburban Industry

Prior to suburbanization, manufacturing in cities tended to be located in multistory buildings, and warehouse facilities were located along rail spurs. Due to historical pre-auto building density patterns, these properties were more likely to be bounded on all sides, making it impossible to expand them (Fitzgerald and Leigh 2002). Thus, carving out the large industrial sites that would be required of a major distribution center would likely require assembling multiple parcels.

Manufacturing suburbanization after World War II coincided with shifts to mass production layouts in one-story large-footprint buildings that were surrounded by parking lots and adjacent to major road networks with easy on and off access. The predominant production mode was a manufacture-to-stock or just-in-case system generating large product inventories that, in turn, required large warehouses. But the return to manufacture-to-order or just-in-time modes of production associated with lean production can counter the perceived obsolescence of central city industrial facilities that have smaller footprints and multiple stories (Leigh 1996). New emphases on research and development activity, as well as incubators for advanced manufacturing, often coming out of urban universities, can also spur demand for central city industrial facilities. A recent special report by *The Economist* entitled "The Third Industrial Revolution" predicts "there will be millions of small and medium-sized firms that will benefit from new materials, cheaper robots, smarter software, an abundance of online services and 3D printers that can economically produce things in small numbers" (Economist 2012, 20). To realize the significant opportunities for innovation from these new technologies requires proximity between R & D activity and manufacturing.

These trends suggest that urban industrial land can be reused in the advanced economy for industrial activity. When industrial properties need retrofitting, however, reuse presents great challenges. The low rental rates of these properties make it difficult to pay for renovations. If the properties are also brownfields in need of environmental remediation, they are "upside down" even before renovation or modernization activity takes place. (The cost of brownfield versus greenfield development will be explored in a later section of this chapter.)

Beyond the demand for industrial land created by trends such as smart growth or "back to the city" movements, a key reason for the conversion of industrial land has been high vacancy rates. Shifts in the building and infrastructure requirements for manufacturing and distribution are a major factor contributing to the high vacancy rates. Much of the older industrial urban land is considered functionally obsolete. Thus, little has been built in older urban areas for either manufacturing or warehouse activity. Faced with high industrial vacancy rates and pressure to revitalize underperforming property, it is not surprising that the public and private sector have been distracted from considering the implications of declining urban industrial land supplies. Older buildings, whether manufacturing or warehouse, in urban or older suburban locations, may require repositioning to avoid vacancy. For example, Larry Callahan, CEO of Patillo Industrial Real Estate, a firm that has operated in the southeastern United States for over 60 years, suggests they can be useful for subassembly operations that produce components for larger manufacturing operations, incubators, repair operations, and showroom or display activity.

City warehouses have become functionally obsolete for several reasons. The shift in freight transport from rail to air and trucking has decreased the demand for centralized urban warehouse space along rail spurs. The shift to containerization has transformed the way goods are moved to market, along with much of the industrial infrastructure that supports distribution activity. The railroad companies that transport containers to and from port cities and between major regions of the country operate in long-haul mode. It is not cost effective for them to off-load one container at a rail spur in an urban center or even a suburban node. Instead, they move between the ports and multimodal centers. At the multimodal centers, they off-load high volumes of containers, which are then put on trucks and driven to cities. This shift has made older warehouses with smaller loading bays unusable for many industrial businesses, as has the use of larger tractor-trailers (increasing in length from a standard of 40 feet to 53 feet), which have difficulty navigating through central-city streets.

Trucking deregulation resulted in transportation costs being minimized when goods were shipped from a national or regional location that minimized distance to all customers. The centralization of warehousing, along with advances in storage and disbursement of products, required much larger warehouse spaces with high ceilings for automated racking systems. The primary new industrial building construction of the last couple of decades has been large warehouses known as distribution centers that take up much larger footprints than typically found in center cities. Callahan observes that the size of warehouse buildings grew from 100,000 square feet (SF) in the mid-1980s to 800,000 SF in the late 1990s, and some are over 1 million SF today (pers. comm.).

An 800,000 SF building occupies 18.3 acres. As a state-of-the-art facility, it requires 30-foot ceiling heights (older space often has half that height) and a truck court with 200 feet depth on both sides of the building to accommodate 120 truck bays. This allows for product to be brought in one side of the building, processed within the building, and then taken out for distribution on the other side. Altogether, the facility consumes 60 or more acres and must be located on land near a freeway exit. Callahan suggests that distribution centers are being built in exurban environments because of the large footprint they require, not because it is the best logistical location (pers. comm.). However, a logistics expert suggests that these decentralized locations may become a significant issue if, as he expects, the need to contain rising fuel costs supersedes the need for cheap land (McCurry 2012).

Essentially, the distribution/warehouse building segment of the industrial real estate market has evolved into a tiered system. At the top end are very large distribution centers located in exurban locations. Demand exists for smaller buildings for sectors that need to provide quick delivery, such as medical products, or that provide support for smaller operations, such as handling product returns. The growing interest in materials reuse, remanufacture, and recycling is also creating demand for less expensive warehouse space in cities.

There is still demand for warehouse space that supports the efficient distribution of products specifically created for inner-city markets. Firms that produce products that are more easily transported on smaller trucks (due to small size or smaller volumes) can also use inner-city warehouse space (Fitzgerald and Leigh 2002). Additionally, industrial space that is obsolete for warehousing could be converted to manufacturing.

Infrastructure Challenges for Urban Industry

KEY TYPES

Traditional infrastructure requirements for industry have expanded with the development of the information economy. While specific requirements vary across industry sectors, in general, the primary determinants of infrastructure requirements fall into five categories:

1. Characteristics of the industrial site: elevation, soil type, storm drainage system.
2. Transportation: access; links to and types of highways; distance from mass transit, airports, and ports to industrial site; bus and rail service availability.
3. Water and sewer: size of water and sewer mains, capacity of treatment plants.
4. Energy: natural gas and electric power quality.
5. Telecommunications: distance to central office, switch (is fiber available?), Points of Presence (distance of point where long-distance carrier hands off service to subscriber).

A fundamental issue for reusing industrial land for new industrial use lies in the issue of financing retrofits as well as maintaining infrastructure. Although it is not within the scope of this chapter to provide case study data on these costs, the next section's accounting of overall finance issues for the maintenance of infrastructure provides some perspective on the challenges.

COST OF PROVISION AND MAINTENANCE

In a series of reports issued under the main title "Failure to Act," the American Society of Civil Engineers (2011a, 2011b, 2011c) explored the economic impact on industry of chronic underinvestment in three of the five key areas of infrastructure: surface transportation, water and sewer, and electricity.

Surface Transportation The report on surface transportation infrastructure (American Society of Civil Engineers 2011b) noted that in 2010 the United States ranked 19th out of the top 20 countries for quality of roads, and 18th out of the top 20 for quality of railroads. In particular, the report quantified the negative impacts to the United States' ability to export if the surface transportation deficiencies are not corrected:

> By 2040 the cost of infrastructure deficiencies is expected to result in the U.S. losing more than $72 billion in foreign exports in comparison with the level of exports from a transportation-sufficient U.S. economy. These exports are lost due to lost productivity and the higher costs of American goods and services, relative to competing product prices from around the globe. (2)

The poor state of surface transportation is expected to cause businesses to divert increasing portions of their earned income to pay for transportation delays and vehicle repairs, income that could be invested in innovation and expansion. The surface transportation infrastructure in urban areas is in worse shape than in rural areas, and thus urban areas—major cities in particular—will experience the greatest negative impacts from the systemic failure to invest in infrastructure maintenance and new infrastructure. The American Society of Civil Engineers (ASCE) report provides calculations of costs to correct the deficiencies at the present time and into the future. Failure to do so poses particular problems for efforts to strengthen urban manufacturing.

Water and Sewer Each year, new water lines are constructed to connect more distant dwellers to centralized systems, continuing to add users to aging systems. Although new pipes are being added to expand service areas, drinking-water systems degrade over time, with the useful life of component parts ranging from 15 to 95 years (American Society of Civil Engineers 2011c).

Water is, of course, essential to human life and to the economy. As the second ASCE "Failure to Act" report observes, farms depend on irrigation to grow crops, while commercial businesses and government offices require clean water. Particularly relevant to urban manufacturing, industries such as food and chemical manufacturing as well as the power plants that supply electricity cannot operate without "clean water that is a component of finished products or that is used for industrial processes or cooling" (American Society of Civil Engineers 2011c, 1). But as the above quote implies, the underfunded and undermaintained U.S. water system is continually taxed by the decentralization of population and industry. The failure to invest in an adequate water and sewer system is estimated to cost businesses in the United States $147 billion between 2011 and 2020; if left unaddressed, the cost will be $1.487 trillion between 2020 and 2040.

Electricity Of the three infrastructure types, electricity is distinguished by the fact that it is largely privately owned. However, it is publicly regulated. The infrastructure of the industry is divided into three segments that are connected and interdependent: (1) generation plants; (2) transmission lines; and (3) local distribution equipment (American Society of Civil Engineers 2011a). Also distinct from the other two infrastructure types, electricity infrastructure has experienced substantial investment in recent years. However, ASCE's "Failure to Invest" report on this topic indicates there will still be a cumulative electricity infrastructure funding gap of $107 billion by 2020 that will cost businesses and households $197 billion (in 2010 dollars). In particular, substantial losses in the manufacturing sectors are projected from less reliable electricity service due to the failure to invest. By 2020, this could result in a $10 billion loss in exports; this loss will grow to $40 billion by 2040 if not addressed, countering national efforts to maintain global competitiveness.

A fundamental question is whether our major cities have adequate electricity infrastructure to support the desired increases in manufacturing and export activity at the national and local levels. Congress has mandated congestion studies of the electricity grid. In 2009, four megaregions were identified as significant areas of concern. On the East Coast, this included New York down to Washington, DC. On the West Coast, the Seattle-Portland region, San Francisco region, and greater Los Angeles region were all identified (U.S. Department of Energy 2009). Areas of concern are more likely to experience higher electricity costs as users compete for inadequate supply as well as experience reduced grid reliability. These four megaregions encompass cities that Leigh and Hoelzel (2012) have identified as actively seeking to protect industrial lands.

An additional reason to be concerned about the state of the electricity infrastructure across the country is because green infrastructure systems and predictions of a third industrial revolution that will advance economies and civilization are dependent on electricity. These will be discussed in the final section of this chapter.

Urban Brownfield Versus Suburban Greenfield Development

Redeveloping brownfield industrial sites is another fundamental challenge that contributes to high urban industrial vacancy rates as well as the suburbanization of industry. Brownfield industrial sites are those that were previously developed and are known or suspected to have some form of environmental contamination. The U.S. Environmental Protection Agency and state-level environmental protection agencies regulate the cleanup of brownfield sites. Different standards of cleanup are applied, based on the proposed reuse of the site. For example, a brownfield redevelopment site that is being proposed for residential use will have higher standards of cleanup than one proposed for commercial or industrial use. The standard of cleanup will greatly affect the cost of redevelopment, as will the overall size of the site and the type and extent of the contamination.

Cleaning up a brownfield site for industrial reuse is generally considered to be less expensive than for residential use. However, central city industrial land is already less desirable for much of the industrial real estate market and has low rental values due to obsolescent building structures, lower road network accessibility, aging infrastructure, and other factors. Thus, the costs (in dollars and time) of remediation create an additional disincentive to locate on previously developed urban industrial land.

While government environmental regulation can be said to have instigated the brownfield problem, in response, all levels of government have created support for brownfield redevelopment. Over the last quarter of a century, governments have offered grant and loan programs, financial incentives, technical expertise, and regulatory clarity. At the same time, private sector development expertise and support (e.g., finance, insurance, cleanup technology) have evolved, making brownfield redevelopment more feasible and attractive (Leigh 2008, 2009).

Published data comparing the actual costs of brownfield redevelopment and greenfield development for industrial use are scarce. De Sousa's 2002 study of the Toronto metro area constructed prototypical development scenarios for brownfield and greenfield industrial sites from an examination of actual development projects. The brownfield site was located on city of Toronto port land that had mid-level contamination. The greenfield site was located in a business park in a pro-growth suburban community that had attracted significant development. The brownfield site's estimated tax revenues were nearly three times that of the greenfield site, while development charges were only 16 percent and transportation externalities were less than 80 percent of those of the greenfield site (calculated from De Sousa 2002, table 9). De Sousa's research focused on public sector benefits and costs. His earlier work (2000) focusing on the private sector found that "the perception that brownfield redevelopment is less cost-effective and entails greater risks than greenfield development, on the part of the private sector, is true for industrial projects" (1).

In Portland, Oregon, a consortium of public agencies sponsored a study that compared the costs and issues associated with industrial sites in greenfields and brownfields (Port of Portland 2004). The study focused on four industrial uses considered appropriate for the Portland metropolitan area: high-tech manufacturing, industrial park, warehouse/distribution, and general manufacturing. The report detailed the uses and specifications for the sites under comparison as follows:

- *High Tech Manufacturing* includes high technology industries that are primarily related to manufacturing and processing. In this study, a 350,000 SF high-tech facility is tested that includes two 125,000 SF fabrication plants, one 40,000 SF central utility building, one 60,000 SF office building and 725 parking spaces.
- *Industrial Park* is a series of larger individual buildings whose uses could include light industrial manufacturing, distribution or industrial services. For this project, 630,000 SF of industrial park space, divided into multiple buildings, was tested on both sites.
- *Warehouse/Distribution* includes industries primarily engaged in the warehousing, storage and distribution of goods. For this project, 400,000 SF of distribution space in a single building with 200 parking spaces and 300 trailer spaces was tested on both sites.
- *General Manufacturing* includes industries utilizing manufacturing processes. For this project, three single-user general manufacturing facilities were tested on each site. These facilities totaled 450,000 SF in three buildings—a 100,000 SF user, a 150,000 SF user, and a 200,000 SF user—and 1,100 parking stalls to serve all three facilities. (2)

Greenfield and brownfield sites appropriate for the four uses were identified in the Portland metro area. The costs of development were classified into four categories: on-site construction costs, system development charges and credits, off-site construction costs, and environmental remediation costs for the brownfield sites.

The results of the analysis, depicted in table 12.3, show that brownfield remediation costs were greater than greenfield infrastructure development costs when viewed from the perspective of a private developer doing a speculative development. For example, in the industrial park row of the table, brownfield remediation costs exceeding $8.7 million have to be incurred before redeveloping the potential site compared to $5.2 million that must be spent providing infrastructure to the potential greenfield site. (In the cases examined, the warehouse infrastructure costs for the potential greenfield were less than those for the potential brownfield site.) The study concluded:

> There is an economic challenge to maintaining industrial zoned brownfields as industrial properties after they are cleaned up. The remediation costs of bringing an "upside down" brownfield site "right side up" often cannot be recovered when the site can be developed only for industrial land values. Industrial land values in the Portland metropolitan area tend to range from $3.50 to $6.50 per square foot, the lowest value of any major land use. For comparison, office and residential land ranges from $7.50 to $10.00 per square foot, while commercially zoned land is valued at significantly higher levels. As remediation costs must be deducted from land value, industrially zoned property has the most limited ability to absorb clean-up costs while still maintaining a positive residual land value. (10)

Because the private sector has little incentive to redevelop industrial-zoned brownfields as industrial properties, the role of the public sector is critical for strengthening urban manufacturing and export activity. The Portland study reiterates calls elsewhere for the public sector to help the private sector by reducing

Table 12.3
Comparing the Costs Associated with Greenfield and Brownfield Development in Portland, OR

Use	Brownfield Remediation Costs		Greenfield Differential Costs		Overall Cost Differential	
	Total	PSF[a] Bldg.	Total	PSF Bldg.	Total	PSF Bldg.
Industrial Park	$8,748,863	$13.89	($5,181,167)	($8.22)	$1,319,162	$2.09
General Manufacturing	$22,980,475	$51.07	($1,323,000)	($2.94)	$21,581,081	$47.96
High-tech Manufacturing	$28,027,465	$80.08	($1,428,500)	($4.08)	$27,030,361	$77.23
Warehouse/ Distribution	$7,821,799	$19.55	$444,500	$1.11	$8,553,079	$21.38

[a] PSF = per square foot.
Source: Port of Portland (2004).

the cost of capital and assisting with the initial characterization of contaminated sites.

Transforming Infrastructure for Greener, Lower-Carbon, Evolving Industries

Industry is the most intensive infrastructure user of the economy's sectors. Industry uses all forms of surface, air, and water transportation. It is an intensive user of land and built structures (the latter of which are some of the largest constructed). And it is an intensive user of utilities: power, water, sewer, and telecommunications. The suburbanization and exurbanization of industry has directly contributed to the expansion of grey infrastructure. While the creation of this industrial sprawl is presented as an inevitability of the evolving competitive economy, it is worth considering whether this is really true. Are there alternative industrial development patterns and infrastructure systems that can foster greater sustainability and still be competitive in advancing development?

At the level of the industrial site and from the perspective of the firm, there may be cost efficiencies in the green retrofitting of buildings and site-specific infrastructure. Callahan of Patillo Industrial Real Estate states that lighting should always be the first retrofit to make as new fixtures provide better illumination and reduce electricity costs; therefore, it pays for itself. Plumbing often has to be retrofitted because of changes in code requirements, but doing so saves on water and sewer fees. Callahan notes that over the last 10 years, roofs have been increasingly retrofitted with white thermoplastic olefin (TPO) tiles that improve energy efficiency and last longer than conventional roofing (pers. comm.).

Installing energy-saving green roofs help lower the urban heat island effect. The best-known industrial green roof, and also the largest in the world, is on the Ford Rouge truck manufacturing plant in Dearborn, Michigan. The 454,000 SF, or 10.4 acre, roof is planted with a drought-resistant groundcover known as sedum that weighs less than 15 pounds per square foot. The sedum traps airborne dust and dirt, absorbs carbon dioxide, and creates oxygen, all of which improve air quality. However, the roof's primary function is to collect and filter rainfall as a key part of a natural storm water management system (The Henry Ford n.d.).

Ford is an example of a private company that voluntarily adopted a low-impact infrastructure system. Low-impact development is typically focused on water and sewer infrastructure. Local governments seeking to lower the cost of providing infrastructure are beginning to mandate low-impact development practices for industrial and other forms of developments. Los Angeles implemented its Low Impact Development Ordinance in May 2012 because it is seen as a cost-efficient means of managing storm water and decreasing water pollution. The ordinance applies to new industrial development and any existing industrial development where more than 500 square feet of hardscape is added. The ordinance requires that rainwater from a rainstorm of three-quarters of an inch or more must be captured, infiltrated, or used on site (City of Los Angeles n.d.).

NEW INDUSTRY FROM MORE SUSTAINABLE INFRASTRUCTURE

Jeremy Rifkin (2012), the principal architect of the EU's Third Industrial Revolution economic sustainability plan, argues that as infrastructure transforms to support lower carbon emissions, new industries may emerge. Rifkin identifies what he calls five pillars of the infrastructure of a third industrial revolution:

1. Shifting to renewable energy.
2. Transforming the building stock of every continent into micro–power plants to collect renewable energies on-site.
3. Deploying hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies.
4. Using Internet technology to transform the power grid of every continent into an energy-sharing intergrid that acts just like the Internet. When millions of buildings are generating a small amount of energy locally, on-site, they can sell surplus back to the grid and share electricity with their continental neighbors.
5. Transitioning the transport fleet to electric plug-in and fuel cell vehicles that can buy and sell electricity on a smart, continental, interactive power grid.

From these pillars, Rifkin predicts, will grow an "energy internet" in which green energy will be produced in homes, offices, and factories and shared the same way that information is now shared online.

Related to Rifkin's vision and advising of the EU is Coutard and Rutherford's (2011) observation that "we are witnessing an unprecedented critique of the extensive networked infrastructures built over the past 150 years for the provision of essential services such as water, sanitation, electricity, and heating" (106). In response to this critique, alternative, smaller-scale technological systems are developing that many view as more sustainable. The authors label this movement "post-networked urbanism." Table 12.4 presents Coutard and Rutherford's characterizations of features of large centralized networks of infrastructure and those of the alternative "sustainable techno-ecocycle approach" to infrastructure. The sustainable techno-ecocycle approach emphasizes local provision of infrastructure: that is, autonomy from large-scale infrastructure such as electricity and water and sewer.

Coutard and Rutherford suggest four forms of organization for the sustainable techno-ecocycle approach: (1) off-grid, whereby homes, businesses, and even municipalities provide their own utility infrastructure needs; (2) feed-into-grid, whereby locally generated electricity must be purchased by the large centralized power generator; (3) loop-closing, whereby locally produced water and energy is also treated, recycled, and reused; and (4) "beyond net" (beyond

Table 12.4
Contrasted (Opposed) Paradigms: Large Technical Networked System Versus Sustainable "Techno-ecocycle"

Large Centralized Network	Sustainable Techno-ecocycle
Linear metabolism: tapping, supply, disposal	Circular metabolism: recycling, reuse, retrieval
Decoupling between local resource availability and use	(Re)coupling between local resource availability and use
Territorial solidarity	Territorial autonomy
Technical systems	Ecological systems
Flows, imperviousness, kinetics	Stocks, porosity, stasis
Hydraulics-based model	Resource-based model
Supply-side model	Demand-side model
Economics of expansion and growth (scale, scope, club)	Economics of preservation
Unbounded, ever-growing consumption	Bounded consumption
Sector-based, sequential management	Cross-sector, integrated management
Irreversibility, obduracy, "momentum"	Reversibility, adaptability
Carbon dependent	Carbon neutral

Source: Coutard and Rutherford (2011), table 8.1. Reprinted by permission of the publisher.

the network), whereby users have their own wells and septic/treatment systems. Post-networked infrastructure systems may divert financial resources from incumbent systems and may lead to increasing reluctance to finance large systems. This could set up a vicious cycle of declining support, quality, and reliability of large infrastructure systems that, in turn, raises concerns for "the financial sustainability of the incumbent infrastructure, which in most cases will remain of crucial importance, if only as a last-resort supply system, if we are to avoid a 'tragedy of the infrastructural common' " (122).

Conclusions

The efforts to strengthen urban manufacturing and associated distribution/logistics activity coincide with shifting trends in industrial infrastructure and conversion pressures on urban industrial land. These efforts also coincide with the predicted looming crisis in infrastructure and with predictions of revolutionary shifts in how manufacturing occurs and how infrastructure systems are deployed. Thus, the relationship between urban development patterns, industrial land, and strengthening urban manufacturing is complex and evolving. However, urban policy development and planning practice efforts to decipher this relationship must acknowledge the conflict that exists today: present-day efforts to increase population density and promote more effective use of infrastructure to support that density contribute to industrial sprawl by displacing industry and extending grey infrastructure further out in metropolitan areas. We must begin with this little-acknowledged fact to ensure that future transitions in industrial activity and the provision of infrastructure are effective in containing sprawl and lowering urban carbon footprints.

In the United States, due to the failure to finance maintenance needs, older infrastructure systems are deteriorating and failing. States and localities pay more than 90 percent of government non-defense capital outlays. Even before the Great Recession shrank the public revenue sources for making capital improvements, experts observed that elected officials were reluctant to either raise taxes or create new user fees to pay for infrastructure maintenance. With high unemployment rates and declining income for most U.S. households, that reluctance is likely to be even stronger.

In the near to medium term, urban manufacturing and the economy overall are faced with looming problems for productivity and competiveness due to the failure to invest in all forms of critical infrastructure. Further, the economy continues to experience a very weak recovery from the Great Recession. Job creation numbers continue to fall significantly below expectations. While overall unemployment was around 8 percent in late 2012, unemployment for construction workers exceeded 14 percent.

Construction workers would primarily be engaged in rebuilding the nation's infrastructure. While state and local governments typically pay more than 90 percent of the cost of this infrastructure, their ability to do so has been severely hampered by declining tax revenues. A federal government Keynesian response would seriously increase public investment in national building programs, make a significant contribution to solving the national infrastructure crisis, and help strengthen urban manufacturing.

Although not proposing a substitute for a stronger federal government response to the infrastructure crisis, this chapter has highlighted local government efforts that make better use of existing infrastructure and foster new forms of lower-impact infrastructure. These efforts show promise for the retention and intensification of urban manufacturing and other industrial activity, along with supportive residential and commercial uses. This chapter began by noting the premises on which is based the need to give explicit attention to strengthening urban industry and retaining urban industrial land. It should be clear that these premises flow from the reality that the urban land market suffers from many distortions. Government subsidizes suburban and exurban development by providing reduced property tax and other incentives and by subsidizing new roads and other new infrastructure. The historic bias of funding new infrastructure rather than repairing and maintaining infrastructure is undisputed. Additionally, the urban land market does not reflect the full cost of converting agricultural or greenfield land to developed land.

Hence, compensating efforts to strengthen urban industry and maintain central city industrial land are needed. These efforts offer multiple benefits. They will help mitigate climate change by reducing urban expansion pressures and by incorporating low-impact infrastructure standards that can reduce long-run costs of infrastructure provision. They can help address the chronic problems of unemployment and poverty that frequently prevail near central city industrial areas. And finally, strengthening urban industry is essential for raising the United States' level of exports and its leadership in advanced manufacturing in the global economy.

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