Global Competitiveness in the Rail and Transit Industry

Michael Renner and Gary Gardner

Worldwatch Institute

Apollo Alliance — Clean Energy Good Jobs

Northeastern University
Kitty and Michael Dukakis Center for Urban and Regional Policy

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About the Authors

Michael Renner is a Senior Researcher at the Worldwatch Institute. His work has focused on a variety of linkages between the environment and other global concerns, with particular focus on transportation issues and the connections between environment and employment. With colleagues at the Global Labor Institute (Cornell University), Michael authored *Green Jobs: Toward Decent Work in a Sustainable, Low-Carbon Economy*, published by the United Nations Environment Programme in 2008. He has also collaborated with a broad variety of other organizations on this topic, including WWF, the Friedrich Ebert Foundation (Germany), Carbon Forum Asia, the Workplace Research Centre at the University of Sydney, and the Political Economy Research Institute (PERI) at the University of Massachusetts.

Gary Gardner is a Senior Researcher at the Worldwatch Institute. He has written on a broad range of sustainability issues, from materials use and water scarcity to malnutrition and bicycle use. Gary's recent work has focused on resource trends analysis and has included the *Rationale for Sustainable Resource Management* report for the government of the Netherlands and the forthcoming *White Paper on Sustainability in the United States*. He also contributes regularly to Worldwatch Institute publications, including *State of the World* and *Vital Signs*.

Both Michael and Gary are contributors to Worldwatch's "Green Economy" blog at http://blogs.worldwatch.org/greeneconomy/.

The Apollo Transportation Manufacturing Initiative

With support from the Rockefeller and Surdna Foundations, the Apollo Alliance partnered with Northeastern University, the Worldwatch Institute, and the Duke University Center on Globalization, Governance & Competitiveness to conduct research, engage stakeholders, and develop policy recommendations to inform the emergence of a comprehensive strategy to create good American jobs by bolstering the domestic manufacture of advanced rail and transit vehicles systems and component parts. Over the course of 2010, the initiative culminated in the release of four separate reports:

U.S. Manufacture of Rail Vehicles for Intercity Passenger Rail and Urban Transit,
Duke University Center on Globalization, Governance & Competitiveness

Modeled on its previous analyses of the hybrid truck and public transit bus supply chains, the Center on Globalization, Governance & Competitiveness mapped the supply chain for the U.S. passenger railcar industry. The study details nearly 250 existing manufacturing locations in 35 states that are currently producing rail vehicles or component parts. While domestic manufacturers exist in many of the industry subsectors, the U.S. supply chain has several gaps, and many higher-value added activities are still performed abroad. The U.S. passenger and transit rail supply chain currently supports between 10,000 and 14,000 employees, numbers that could grow with scaled-up U.S. investments in public transit and intercity rail.

Global Competitiveness in the Rail and Transit Industry,
Worldwatch Institute

To inform ongoing discussions at the U.S. federal, state, and local levels regarding public investments in rail and urban transit, the Worldwatch Institute analyzed global rail industry trends and profiled four countries—Germany, Spain, Japan, and China—that have made major commitments to public transportation and that offer important lessons for the United States. The report finds that at least half a million people in total are directly employed in rail vehicle manufacturing in these countries. The creation of strong rail manufacturing industries has depended to a significant degree on steady domestic markets for these products, driven by substantial and sustained investments in rail and transit infrastructure.

Reviving the U.S. Rail and Transit Industry: Investments and Job Creation,
Northeastern University & Worldwatch Institute

Northeastern University and the Worldwatch Institute estimated potential manufacturing job creation in the transit bus and passenger railcar supply chains under different scenarios of federal investment: the current funding levels, increased domestic investment, and international comparative investment. Building on the supply chain analyses conducted by Duke University, the study finds that the United States could gain over 79,000 jobs in rail and bus manufacturing and related industries if public transit were funded at a level that would double transit ridership in 20 years, and more than 250,000 jobs if the country were to invest as much in transit as China does. Employment gains across both rail and bus supply chains could increase by up to 30 percent if stronger domestic supply chains allowed for greater domestic content. The authors conclude that the United States needs a more coherent industrial policy to link public transportation and manufacturing goals.

Make It in America: The Apollo Clean Transportation Manufacturing Action Plan,
Apollo Alliance

Based on the successful GreenMAP initiative, which developed a comprehensive strategy for expanding the U.S. clean energy manufacturing sector, the Apollo Alliance convened a diverse set of political stakeholders, including labor and business leaders, transportation, economic development, and environmental policy experts, to identify the policy needed to expand the domestic manufacture of advanced bus and rail transit systems, clean freight technologies, and their component parts. The resulting policy recommendations call for expanded investment in clean transportation options and for a comprehensive manufacturing strategy to create good American jobs by providing the supports needed to ensure that expanded demand for an advanced transportation system is met by U.S. manufacturers.

For copies of the reports and more information about the Apollo Transportation Manufacturing Initiative, please visit www.apolloalliance.org/programs/tmap.

Summary

The United States once had a thriving intercity rail and urban transit network. By the 1950s, however, the federal government shifted its infrastructure spending decisively to highways and airports. Public transportation systems atrophied, and America's technological leadership in the manufacture of everything from subway cars to trams to high-speed trains passed to companies in Japan, France, Germany, and a few other European countries. By the 1970s and 1980s, the domestically owned passenger rail manufacturing industry had vanished. Today, the U.S. passenger rail industry remains underdeveloped, with significant gaps in the supply chain for passenger rail equipment.

In the face of challenges such as high gasoline prices, traffic congestion, and greenhouse gas emissions, public transportation offers a range of benefits over private automobile travel. Indeed, rising urban rail and bus ridership, as well as plans for high-speed rail corridors, suggest a rekindling of U.S. interest in these alternative forms of transport. Although still far from adequate, capital funds for these projects have been on the rise for several years, and the 2009 economic stimulus bill provided an important one-time boost. Along with this renewed interest in stronger transit systems, there is an increasing emphasis on capturing the jobs required in manufacturing these vehicles as well.

Global demand for passenger and freight rail equipment, infrastructure, and related services in 2007 was $169 billion and is projected to grow to $214 billion by 2016. Western Europe dominates the market, followed by Asia and the Pacific. North America ranks third, due almost entirely to its large freight rail market. Rail vehicles account for close to one-third of the total rail market. Urban light rail systems and subways are expanding in many regions of the world, and there is growing investment in intercity high-speed rail lines.

This report offers profiles of four countries that have retained significant manufacturing employment in the rail and transit industries: Germany, Spain, Japan, and China. It discusses their national transportation policies, including how much they invest in their rail and transit sectors. For the United States, these experiences offer a mix of commitment and success, but also some cautionary lessons.

Key producer countries such as those listed above employ at least half a million people in total directly in rail vehicle manufacturing, with an unknown number of additional jobs in the supply chain. The construction of tracks, facilities, and other infrastructure; R&D and engineering; as well as the production of communications and signaling equipment provide several hundreds of thousands more jobs. And employment in operating rail and transit systems runs into many millions worldwide.

The country profiles offered in this report underline the importance of policies that create strong and steady domestic markets for rail and transit, driven by substantial and sustained capital investments. Strong domestic markets are also critical for export sales. As the U.S. Congress considers the overdue reauthorization of surface transportation legislation for the next several years, there is little question that much larger investments are needed over several decades to improve and expand U.S. rail and transit systems—and to re-create a viable U.S. rail manufacturing industry. Investments need to go hand-in-hand with policies that lay out clear goals and ensure that urban and intercity lines work together harmoniously to attract large numbers of passengers.

Germany is one of the largest rail and transit markets in the world. Its rail manufacturing industry remains a global technology leader, underpinned by strong internal demand and even larger export sales. Germany's per capita investments in rail and transit are double those of the United States. Direct and indirect jobs in rail manufacturing amount to almost 200,000; if rail construction and operations are included, the number rises to 580,000.

Spain is an up-and-coming rail power, maintaining the largest high-speed rail construction program in Europe. The government's 2004 Strategic Plan for Infrastructures and Transport (PEIT) serves as a visionary planning tool. And the two-year Extraordinary Infrastructure Plan of April 2010 allocates 70 percent of the country's $24 billion in transportation funds to rail. Spanish companies that provide goods and services exclusively to the rail sector employed about 116,000 people in 2008.

Japan has been a pioneer in high-speed rail development and continues to be a global leader. Still, the country's declining population will limit domestic demand for rail services. Thus, Japanese rolling stock manufacturers are looking increasingly to the burgeoning global market; exports accounted for 38 percent of their revenues over the past decade. Some 25,000 people are employed in the production of rail equipment, parts, and signal and safety equipment in Japan, with many times more employed in component parts supply chains.

China's leadership has embraced a highly ambitious plan to expand the country's intercity rail network, possibly reaching 93,000 miles by 2020 (including 16,000 miles of high-speed lines). With mushrooming subway and light rail lines, China is expected to account for more than half of global rail equipment expenditures in coming years. Stiff local-content rules stipulate that 70–90 percent of rail equipment be manufactured domestically. Technology-transfer agreements with foreign suppliers have permitted Chinese manufacturers to reproduce vehicle designs in local factories. The country's two dominant rail manufacturing companies, CSR (China South Locomotive and Rolling Stock) and CNR (China Northern Locomotive and Rolling Stock) together employ more than 200,000 people directly.

Bombardier (Canada), Alstom (France), and Siemens (Germany) have been the leading international manufacturers of rail and transit vehicles, but they are increasingly challenged by China's CSR and CNR. Other companies such as Kawasaki (Japan), CAF and Talgo (Spain), Transmashholding (Russia), Ansaldo-Breda (Italy), and Hyundai Rotem (South Korea) also play important roles internationally. U.S. producers are focused almost exclusively on freight locomotives and wagons.

To expand its domestic rail and transit manufacturing industries, the United States needs a comprehensive strategy that links expanded investments in rail and transit with policies to support domestic manufacturers of the vehicles, equipment, and technologies demanded by this investment. Through a combination of domestic R&D, technology transfer, and learning from global industry leaders, and a process that ensures that a growing share of high value-added manufacturing activity is sourced domestically rather than from abroad, the United States can revitalize its rail and transit manufacturing industries.

U.S. Rail and Transit in Context

On May 26, 1934, a U.S. diesel-powered train christened the *Zephyr* broke the world speed record previously held by Germany, traveling from Denver to Chicago at an average speed of 77 miles per hour.[1*†] In the 1930s and 40s, U.S. intercity passenger trains were the envy of much of the world. Domestic manufacturers of rolling stock—the various vehicles that move on a railway—introduced a host of technological innovations, including the diesel-electric locomotive, lightweight cars with improved wheel sets, and reliable braking systems.[2]

But by the mid-1950s, U.S. intercity passenger travel began to shift to newly constructed—and amply subsidized—highways and airways. Between 1956 and 1969, 59,400 miles of railroad track were taken out of passenger service. By 1971, when the government-owned rail company Amtrak was created, less than a fifth of the 2,500 daily intercity trains (not counting commuter lines) that ran in 1954 remained in service.[3] Today, Amtrak trains travel at slower speeds than their predecessors did in the mid-20th century.[4]

Similar developments took place within U.S. urban areas, where extensive tram and trolley networks were replaced first by bus lines and later by an infrastructure dedicated to the private automobile. Again, this was in large measure the result of changed federal priorities. But it was also driven by actions such as those perpetrated by National City Lines, a bus company controlled by General Motors. With financing from oil and tire companies, National City bought up more than 100 electric streetcar lines in 45 cities between 1938 and 1949 and proceeded to dismantle them and replace them with buses.[5]

As the United States increasingly gave up on rail and transit,[‡] other countries stepped up their investments and research and development (R&D) efforts. Engineers in France and Japan developed electric trains that were capable of running at higher speeds. In 1964, Japan inaugurated its first Shinkansen, dubbed the "bullet train," with service between Tokyo and Osaka. At first, Japan relied on technology developed in the United States by the Budd Manufacturing Co.—the firm that produced the *Zephyr*—and others.[6]

The Pioneer Zephyr *come to rest.*
Scott Brownell, Museum of Science and Industry, Chicago

In the ensuing decades, Europe and Japan have demonstrated strong commitment to rail and transit in their allocations of public funds. Although they, too, became enamored of automobile and air travel, they managed to maintain a more balanced transportation system than the United States. They built world-class rail and transit systems, and their design and manufacturing companies became the unchallenged global leaders in this field—from modern high-speed intercity trains to subways to urban light rail.

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* Endnotes are grouped by section and begin on page 30.

† Units of distance throughout this report are expressed in miles.

‡ Throughout this report, "rail and transit" refers to intercity passenger rail (including high-speed rail) and all forms of urban mass transit. The latter includes trams, light rail systems, subways, and bus lines.

Meanwhile, the United States continued to fall further and further behind as a result of the continued bias in favor of highway and airport spending, the failure of U.S. companies to keep up with innovations, and the lack of policies to support the manufacture of advanced rail and transit technologies.[7] The country maintained a strong presence only in the freight rail sector, whose focus on hauling power is far removed from the convenience and speed that are key to successful passenger service.

The U.S. streetcar manufacturing industry vanished by 1970. And when Pullman-Standard and Budd went out of business in the 1980s, the United States lost its capacity to produce subway cars and intercity rail vehicles as well. It was thanks only to a Congressional "Buy America" requirement that foreign companies such as Canada's Bombardier, Germany's Siemens, Japan's Kawasaki, France's Alstom, and Spain's Talgo subsequently set up assembly plants in the United States, with design and other high-value work being carried out abroad.[8]

Today, plans for high-speed rail corridors in various regions of the United States, rising rail and bus ridership, and a growing desire for more lines and better service suggest a rekindling of interest in these alternative forms of transport, and in reviving the manufacturing industry that underpins them. A variety of factors play a role in this revival. They include a desire to reduce import dependence on the sources of energy that fuel cars and planes; a growing recognition that the environmental and climate crises require a more balanced transportation system; and the broad aspiration to revitalize the U.S. economy with the help of "green jobs."

There is also the hope that rail and bus manufacturing can help address the significant job loss in the U.S. manufacturing sector, including the motor vehicle industry. The U.S. motor vehicle industry—focused heavily on automobile and truck manufacturing—outperformed the overall manufacturing sector in job creation during the 1990s.[9] Since then, however, it has been crisis-ridden, shedding 48 percent of the 1.3 million jobs that existed 10 years ago. The U.S. Bureau of Labor Statistics projects a further 16 percent decline of employment in the period 2008–2018.[10]

Capital funds for public transportation are still far from adequate but have been on the rise for several years. The Obama administration's 2009 economic stimulus bill has provided a one-time boost of $17.7 billion.[11]* And as the U.S. Congress considers the reauthorization of surface transportation legislation for the next several years, hopes for a new beginning are shining through.

There is little question that much larger investments in expanding and improving public transportation networks are needed over several decades to revive the U.S. rail manufacturing industry. Beyond the money, there is a need for smart planning to build attractive systems that will draw passengers away from cars and planes.

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* All dollar amounts are expressed in U.S. dollars.

The Global Rail Industry

The United States currently invests a much smaller amount in rail and transit, relative to the size of its population and territory, than many countries in Europe and parts of Asia. But proponents of expanded rail and transit systems have ambitious plans for the future, and the Obama administration's stimulus program has triggered hopes of substantially larger public investments in coming years. There is so much pent-up demand for federal funding from state and local authorities that the sums that are currently available are but a fraction of what is needed both to bring existing systems to a good state of repair and to expand them to keep up with increasing ridership.

Rising U.S. spending on rail and transit systems is certainly in line with broad global trends. The global passenger rail industry emerged from the recent economic crisis relatively unscathed, and worldwide demand for rail vehicles is projected to grow strongly in coming years.

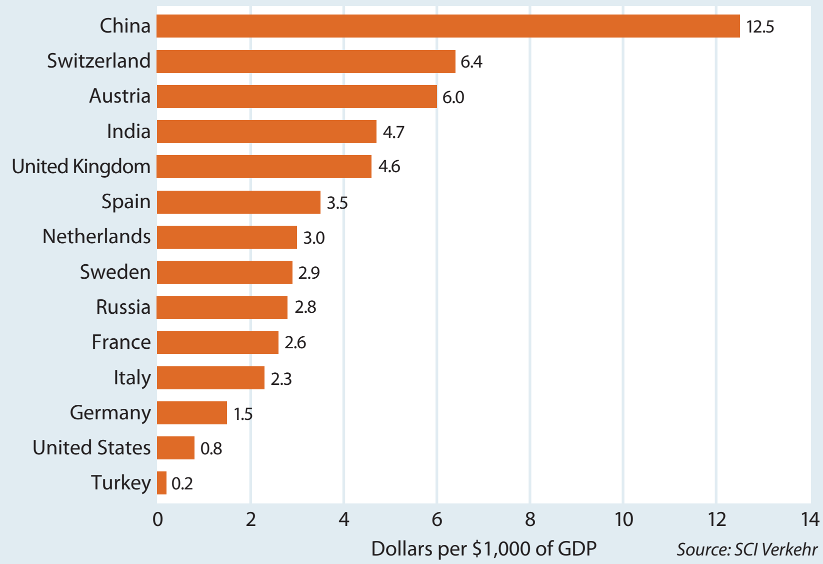
Comparing National Investment Levels

Many countries in Europe and Asia have embraced effective policies and invested significant funds in their rail and transit sectors. Especially for intercity passenger rail, U.S. spending on rail and transit relative to gross domestic product (GDP) and population lags far behind that of these global competitors.

Relative to the size of its economy, China's investments dwarf those of all other countries, at $12.50 per $1,000 of GDP in 2008. Several European countries, including Switzerland, Austria, and the United Kingdom, are also making major commitments.[1] (See Figure 1.) Although Germany has historically had one of the most extensive rail systems in the world, it currently spends a relatively small $1.50 per $1,000 of GDP. In the United States, even combining rail and all other public transit infrastructure, the figure is a comparatively tiny $0.78. If private rail infrastructure (mostly for freight purposes) is included, the number rises to a still modest $1.40.[2]

Similar disparities between the United States and other countries are also evident in comparing combined capital and operations spending. For intercity purposes, China spent $66 per capita in 2009, Germany $156, France $141, the United Kingdom $112, and Italy $87. By contrast, the United States spent only $9, although the stimulus funds under the American Recovery and Reinvestment Act of 2009 (ARRA) temporarily raised this figure to nearly $36.[3] For urban transit infrastructure, Germany has spent $52 per capita in recent years and France plans to spend $57 in the coming decade, compared with a 2010 figure of $40 for the United States. China spends $28 per capita on subway infrastructure alone. For transit vehicle purchases, Germany spends $36, or twice as much as the United States.[4]

Figure 1. National Investment in Rail Infrastructure, Selected Countries, 2008



Source: SCI Verkehr

Global Market Size

Not surprisingly, differing levels of commitment and investment have led to highly diverging market volumes worldwide. Globally, the consulting firm SCI Verkehr reports that operations and capital budgets for passenger and freight rail were a combined $590 billion in 2008.[5]* Another study by Roland Berger consultants put the size of the global market for rail goods and related services in 2007 at $169 billion, up from $129 billion in 2006.[6] Western Europe dominates the market, followed by Asia and the Pacific, although other regions lead in specific industry segments, such as services.[7] (See Table 1.) About two-thirds of the market volume is considered "accessible," meaning that orders are open to bids from international suppliers.

Table 1. Global Passenger and Freight Rail Market, by Region and Major Industry Segment, 2005–2007 Average

Region	Infrastructure	Rolling Stock	Rail Control	Services	Accessible Market	Total Market
			billion dollars			
Western Europe	8.1	13.8	5.9	9.9	37	50
Asia/Pacific	3.5	10.7	2.8	6.5	23	39
NAFTA*	7.4	6.8	1.4	11.2	27	31
CIS†	0.8	3.2	0.5	1.6	8	18
Eastern Europe	1.3	2.1	0.8	2.7	7	9
Africa/Middle East	0.8	2.7	0.6	0.4	5	7
Rest of Americas	0.3	1.0	0.3	1.9	4	5
Accessible	22	40	13	35	111	—
Total	28	48	13	68	—	159

Note: Numbers may not add up due to rounding.
** North American Free Trade Agreement*
† Commonwealth of Independent States
Source: See Endnote 7 for this section.

In 2009, the United States was the single largest national rail market (although heavily focused on freight), with 15 percent of the global market. It was followed by China (11 percent), Russia (8 percent), Germany (7 percent), and France and India (5 percent each).[8]

Rail vehicles account for close to one-third of the overall rail market volume. Of these, high-speed vehicles had a 30 percent market share, followed by freight wagons (28 percent), locomotives (26 percent), and metro and light rail vehicles (16 percent).[9] Rail vehicles for passenger transportation purposes (as opposed to freight rail) account for about 40 percent of the global market for rolling stock.[10]

The United States—and more broadly, the Americas—retains a big market share in freight rail but lags far behind in passenger rail compared to many countries, especially in Europe and Asia. In 2002, North and South America together accounted for 31 percent of the world's diesel locomotives and a third of the world's freight wagons, but for only 1.5 percent of the world's passenger rail cars and less than 1 percent of electric locomotives.[11]

For transit rail cars, the United States accounts for about 5 percent of the global fleet and for a correspondingly small portion of global demand for new cars. Canada and Mexico add another 2 percent, bringing the North American total to 7 percent. Japan is home to 11 percent of the global fleet, Europe 35 percent, and the rest of the world 47 percent. Annual U.S. orders for transit cars are erratic, swinging from a range of some 200–400 cars in most years to isolated peak years of about 1,200 in the early 1980s and early 2000s.[12]

Projected Market Growth

Rail and transit ridership are on the rise in many countries. With many new systems under construction or in the planning stages, orders for rail vehicles and buses are expected to show strong growth in the coming years—and these orders will translate into employment growth. Currently, some 400 light rail systems with more than 44,000 rail vehicles are in operation worldwide, another 60 systems or so are under construction, and more than 200 are in the planning stage. Europe has the highest density, with 170 systems and more than 7,900 miles of lines in operation and nearly 100 more in various stages of construction or planning. North America has 30 systems in operation and 10 under construction. Asia and the Pacific is the region with the fastest growth. Globally, the light rail market might reach $7.5 billion by 2015.[13]

Much of the current excitement is directed toward the expansion of high-speed intercity rail (HSR) lines. In 2009, HSR lines totaling some 6,650 miles were operational, including close to 1,490 miles in Japan

* This and other sources offer spending data in Euros. For the purposes of this report, they were converted to U.S. dollars at the average exchange rate of the relevant year, as per European Central Bank, www.ecb.int/stats/exchange/eurofxref/html/eurofxref-graph-usd.en.html. Where no specific time period is indicated, or where values indicate projections into future years, the exchange rate for the last full calendar year, 2009, is used.

Table 2. Annual Rolling Stock Markets by Region, Current and Projections to 2016

Region	2008–10	2011–13	2014–16
	billion dollars		
Europe	12.9	14.0	14.8
China	11.6	11.5	9.2
North America	3.7	3.8	4.6
CIS, including Russia	2.5	3.7	4.7
Latin America	1.8	1.0	1.4
India	1.4	1.9	2.3
Asia-Pacific*	1.8	2.3	2.5

** Excluding China and India.*
Source: See Endnote 23 for this section.

and about 1,180 miles in France—the two early pioneers.[14] In 2008, European Union members had a combined high-speed network of close to 3,600 miles.[15] The same year, the world's HSR fleet consisted of some 2,200 trainsets. The vast majority of these (1,500) were in Western Europe, followed by Asia with 650, most of them in Japan.[16]

These statistics will change rapidly as more countries jump into the fray. By 2015, the number of trainsets in operation worldwide is expected to rise by 70 percent, to 3,725.[17] Listed in order of their track-building ambitions between now and 2025, the front runners include China, Spain, France, Japan, Turkey, Germany, Italy, Poland, Portugal, the United States, Sweden, Morocco, Russia, Saudi Arabia, Brazil, India, Iran, South Korea, Argentina, Belgium, the Netherlands, the United Kingdom, and Switzerland. (In the United States, Amtrak's existing Acela service in the Northeast Corridor is nominally capable of high-speed service, but infrastructure limitations impose effective lower speeds.)[18]

China is in the process of building the most extensive HSR system worldwide, with a total length of more than 15,000 miles.[19] But the densest network is emerging in Spain, which has a goal of 6,200 miles by 2020. If China were to match Spain's effort relative to land size, it would have to build 118,000 miles of lines; in proportion to population, it would have to build 176,000 miles.[20] Likewise, if the United States were to match Spain's commitment, it would have to build 118,000 and 41,000 miles, respectively.

Economic stimulus programs in several countries are providing substantial sums for passenger rail over the next five years. U.S. stimulus funds of $11 billion are dwarfed by $28 billion of funds in Western Europe and a staggering $118 billion in China.[21] In part because of these funds, the global rail market is expected to resume its growth trajectory and may reach $214 billion by 2016. Western Europe is projected to remain the single most important regional rail market, but Asia and the Pacific will surpass the NAFTA region to become the second largest market.[22] For rolling stock orders, Europe is the largest regional market and is expected to retain its lead during the next several years.[23] (See Table 2.)

Leading Rail Manufacturers

Rail manufacturers once were oriented primarily toward their own domestic markets. But since the 1990s, a series of mergers and restructurings in Europe and North America led to the emergence of three dominant global manufacturers: Bombardier of Canada, Alstom of France, and Siemens of Germany. Their Japanese competitors are part of large industrial conglomerates that did not participate in international rail mergers and acquisitions. State-owned companies in China are becoming increasingly important players as well.[24] (See Table 3.)

Smaller, yet important, manufacturers include Ansaldo-Breda of Italy, CAF (Construcciones y Auxiliar de Ferrocarriles) and Talgo of Spain, Stadler of Switzerland, and Hyundai Rotem of South Korea. (Rotem resulted from a 1999 merger of the rail manu-

Moroccan passenger train travels between Nador and Taourirt on a branch line built in 2009.
David Gubler

Table 3. Profiles of Major Rail Vehicle Manufacturers

Company	Profile
Bombardier	Founded in the 1940s, Bombardier entered the rail business in the 1970s and is a Canadian company, although its transportation division is headquartered in Germany. As the world's largest rail manufacturer, Bombardier has 59 production and engineering sites and 20 service centers in 25 countries. More than 100,000 of its rail vehicles are in use worldwide. Altogether, Bombardier has sold more than 2,500 trams and light rail* vehicles to about 100 cities worldwide. It supplied a total of more than 3,000 subway cars to the United Kingdom, China, and India, and is a major supplier of commuter and regional trains in France and Germany. Via various consortia, the company has been involved in the delivery of 850 HSR vehicles worldwide, including the TGV in France, AVE in Spain, ICE in Germany, ETR in Italy, and CRH 1 in China. Bombardier (along with Alstom) built Amtrak's Acela Express.
Alstom	Formed in 1928, Alstom started rail manufacturing in 1932 and is headquartered in France. The company developed France's high-speed TGV in the 1960s and introduced the even faster AGV, with top speeds of 225 miles per hour, in 2008. More than 400 TGVs made by Alstom are in service in France, and 640 worldwide (including in the United Kingdom, the Netherlands, Spain, and South Korea). Alstom leads the $3 billion global very-high-speed market and has built 70 percent of the trains in service worldwide that travel faster than 185 miles per hour. It is the second largest tram manufacturer worldwide, accounting for 22 percent of the $5.3 billion annual world market, and has delivered more than 930 vehicles. Alstom is also the second largest manufacturer of subway vehicles, with more than 2,000 cars sold to 45 cities since 1997.
Siemens	A large German industrial conglomerate, Siemens was set up in 1847 and is currently involved in building Germany's ICE 2 high-speed train, along with Bombardier's Adtranz. It has received large orders for the ICE 3 (and a variant, the Velaro) in Germany, Austria, the Netherlands, Spain, Russia, and China, with China's order of 1,000 cars representing the single largest order of HSR trains ever. Siemens designed and built the Maglev train in Shanghai, the only system in operation to date using this technology. In the United States, Siemens is building its S70 light rail vehicle in Sacramento, California.
Kawasaki and other Japanese firms	The rail manufacturing operations of these firms are part of large Japanese industrial conglomerates. For example, Kawasaki Heavy Industries' rail division has produced more than 90,000 rail vehicles since 1906. Japan's rail manufacturers are designing and building slower-speed trains individually. High-speed trains for domestic use, by contrast, have been built by a variety of consortia, including Nippon Sharyo, Hitachi, Kawasaki, Mitsubishi, Kinki Sharyo, and Tokyu Car Corp. Given a limited market in Japan, rail manufacturers are increasingly pursuing export markets for their HSR trains. Orders have been secured in Taiwan, China, India, and the United Kingdom, and Japanese companies are competing for contracts in Brazil, Vietnam, and the United States.
China South Locomotive and Rolling Stock; China Northern Locomotive and Rolling Stock	CSR and CNR were established in 2001, emerging from the former China National Railway Locomotive & Rolling Stock Industry Corporation (LORIC). Nationally, CSR leads in the production of electric locomotives, high-speed electrical multiple units (EMUs), and some types of subway vehicles. CNR is strong in the production of diesel locomotives, very-high speed EMUs, and certain types of subway cars. Both companies are engaged in HSR manufacturing joint ventures with the leading international rail manufacturers via subsidiaries Changchun, Tangshan, and Sifang.

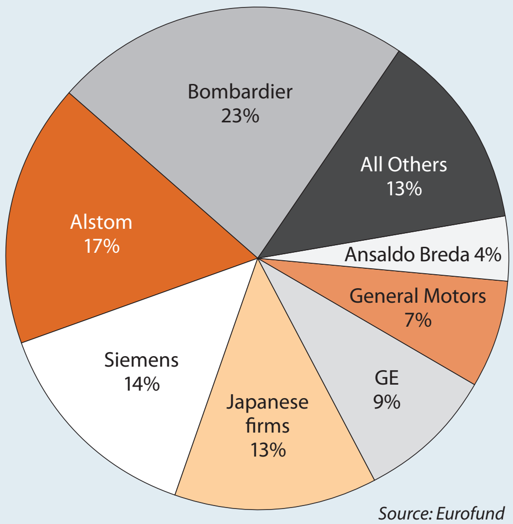
** A tram is a "railway mainly installed on and well integrated into the urban road system. The tramcars are powered either electrically or by diesel engine, particularly for special rail borne road vehicles. Also known as trolley car." Light rail is defined as "a rail line mainly for urban transport of passengers often electrified. . . . It is sometimes difficult to make a precise distinction between light rail and trams; trams are generally not separated from road traffic, whereas light rail may be separated from other systems." Definitions from UN Economic Commission for Europe, International Transport Forum, and Eurostat,* Illustrated Glossary for Transport Statistics *(Geneva, Paris, and Luxembourg, July 2009), pp. 10–11.*
Source: See Endnote 24 for this section.

facturing operations of Daewoo, Hyundai, and Hanjin.[25]) Thousands of small and medium-size companies operate along the supply chain as well, providing critical inputs such as transmissions, brakes, articulation systems, signaling equipment, and services.[26]

As recently as a decade ago, the three leaders accounted for more than half of global sales.[27] (See Figure 2.) Bombardier and Alstom have maintained their leading positions, but two Chinese manufacturers, CSR and CNR, have now moved into third and fourth place, reflecting the huge expansion of China's rail network. The composition of leading companies has changed in other ways as well. Except for Russia's Transmashholding (TMH) and General Electric, which suffered strong sales losses during 2009, the global economic crisis did not affect the leading manufacturers.[28] (See Figure 3.)

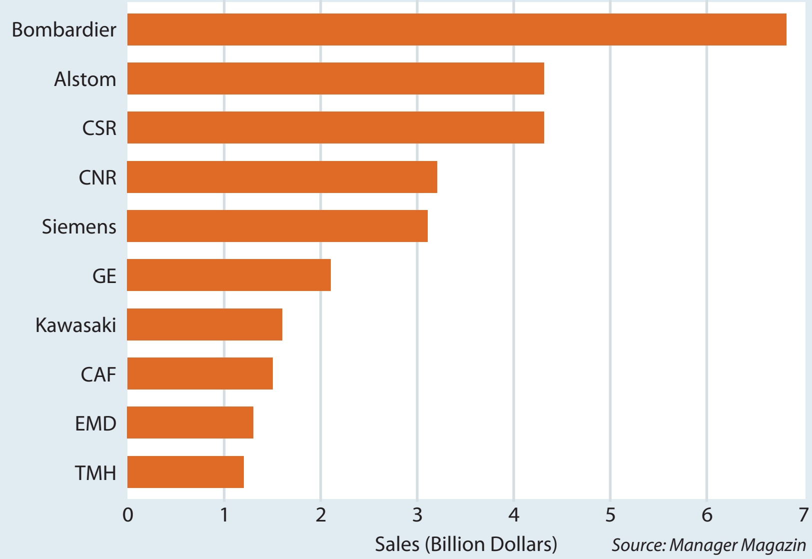
The railway equipment industry in Europe continues to be a global leader, especially in technology development. In early 2009, members of the Union of the European Railway Industries (UNIFE)—which work in design, manufacture, maintenance, and refurbishment of rail transport systems, subsystems, and related equipment—not only controlled an 80 percent market share in Europe itself, but they also accounted for more than half of global production of rail equip-

Figure 2. Leading Global Rail Equipment Manufacturers, Share of World Market, 2001



Source: Eurofund

Figure 3. Leading Global Rail Equipment Manufacturers, by Sales, 2009



Source: Manager Magazin

ment and related services. Yet European companies face growing competition from their counterparts in Asia. UNIFE's 2009 *Annual Report* laments that, "In the next 20 years, European rail suppliers will either be swallowed by Chinese competitors or struggling to find a new business model."[29]

All of the major international rail equipment manufacturers are significant employers.[30] (See Table 4.) In Japan, the government's *Census of Manufactures* tallied a workforce of about 17,500 people in 2007.[31] Among the smaller manufacturers, South Korea's Rotem employs some 3,800 people, but not all are involved in rail-related production. Ansaldo-Breda of Italy employs about 2,400 workers, and Stadler of Switzerland more than 2,200.[32]

Rail employment data by country tend to be somewhat fragmented and incomplete. However, it appears that key rail producer countries—some of which are discussed below—employ at least half a million people directly in manufacturing, with an unknown number of additional jobs in the supply chain. Although this report focuses on the manufacturing of rail equipment, it is worth noting that the construction of tracks, facilities, and other infrastructure; R&D and engineering; as well as the production of communications and signaling equipment provide hundreds of thousands if not millions more jobs. Additional employment in operating rail and transit systems runs into many millions worldwide. In the United States, the number of transit agency employees (engaged primarily in operations) reached some 400,000 in 2008, up from 263,000 a quarter-century earlier.[33]

Table 4. Employment at Leading Rail Vehicle Manufacturing Companies

Company	Employment
Bombardier	33,800 rail-related employees as of early 2010 (out of 64,000 total). 25,600 rail-related employees in Europe; 2,800 in the United States; 2,200 in Canada; and 1,400 (as of 2005) in China.
Alstom	27,000 employees in the transportation division (76,500 employees total). About 70 percent are in Europe and 6 percent in North America.
Siemens	Mobility Division had about 19,000 employees in 2006 (out of 434,000 total).
CSR	China South Locomotive and Rolling Stock has about 112,000 employees.
CNR	China Northern Locomotive and Rolling Stock has more than 100,000 employees.
Kawasaki	Kawasaki Heavy Industries is an industrial conglomerate with about 32,300 employees, including a rail manufacturing division. Rolling stock manufacturing in Hyogo, Japan, employs about 2,300 people; 940 people are employed in the United States.
Other Japanese manufacturers	Nippon Sharyo (since 2008, a subsidiary of rail operator Central Japan Railway Company) employs 18,300 people, although it is unclear what share are working in rail manufacturing; Tokyu Car Co. employs 1,500, and Kinki Sharyo employs 1,000. Rail-related employment at Hitachi (total workforce of 400,000) and Mitsubishi Heavy Industries is not reported separately.
Transmashholding	57,000 employees in 2009 in Russia.

Source: See Endnote 30 for this section.

Selected National Experiences: Europe and East Asia

As the United States tries to catch up to its competitors in Europe and Asia, it has much to learn from their experiences. This report offers profiles of four selected countries—Germany and Spain (in the European Union context), as well as Japan and China (in East Asia)—and discusses their policies, including how much they invest in their rail and transit sectors. These countries vary in terms of their historical public transportation experience, the volumes and dynamics of passenger rail travel, investment levels, and the mix of public and private policies that both shape their rail and transit networks and determine job creation in this sector. They offer a mix of commitment and success, but also some cautionary lessons, from which the United States can and must learn.

A German ICE train in Amsterdam Centraal station.
Michael Renner

At the core, these countries demonstrate the importance of substantial and sustained investments in rail and transit. These investments are critical to building and maintaining a strong domestic market, which in turn is essential for the health of the rail and bus manufacturing industry. Investments need to go hand-in-hand with a visionary public policy that lays out clear goals and ensures that various systems—high-speed and conventional intercity lines, trams, buses, and subways—work together harmoniously so as to attract large numbers of passengers. Passenger demand bolsters and justifies public support for rail and transit expansion and service improvements, thus driving a larger market for the production of vehicles and related equipment.

The European Experience

Compared with the United States, European governments have made a serious commitment to rail and transit investments. This is reflected in the region's more extensive and denser networks, as well as its more balanced modal split. About 16 percent of all European passenger travel is undertaken by bus and rail, compared with a mere 4 percent in the United States.[1]

European high-speed rail travel grew from 9.3 billion passenger miles in 1990 to 61 billion passenger miles in 2008, equaling almost a quarter of total EU intercity rail travel.[2] In France, the HSR share reached an astounding 60 percent in 2008, due to an impressive network and affordable ticket prices.[3] As of 2004, Europe's urban rail network encompassed more than 200 tram, light rail, and subway systems and extended over more than 6,200 miles.[4] By early 2009, an additional 544 miles were under construction and about 1,240 miles more were planned.[5]

European rail car manufacturers will have contracts for years to come. In 2004, Europe had a fleet of about 25,000 light rail vehicles and 19,200 subway cars. The European Rail Research Advisory Council (ERRAC) estimated that 7,500–9,300 new light rail vehicles and 14,000 subway cars will likely be needed for replacement and expansion purposes over a 20-year period. Rolling stock purchases, along with track and infrastructure construction, civil engineering, and R&D,

may add up to a total investment of $222–229 billion.[6] (See Table 5.)

As a leading rail manufacturing region, Europe has substantial employment in this industry. Official EU data put the number of direct equipment manufacturing jobs at 164,800 people in 2006 (26,300 in Germany, 23,200 in Romania, 20,600 in Spain, 17,500 in Poland, 13,500 in France, and 11,900 in Italy).[7] These numbers appear to be on the low side, however, judging by German national data (discussed further below). Accounting for the complete supply chain would add many tens of thousands of jobs. (Meanwhile, on the railway operations side, extensive restructuring and partial privatization have led to the shedding of large numbers of jobs in Europe, from about 2.5 million jobs in 1970 to 1.8 million in 2000, and 1.3 million in 2009.[8] Europe's urban mass transit systems (rail and bus) employ about 1 million people.[9])

Since the early 1990s, EU policies have been reshaping the continent's rail landscape in a variety of ways. They prioritize the construction of new cross-continental lines, increase travel speeds and safety, and harmonize national rail systems.[10] These goals are to be achieved with greater modularity for intercity and urban rail equipment, more collaborative R&D efforts, and the introduction of both a European Rail Traffic Management System (ERTMS) and a European Train Control System (ETCS).[11] ERTMS and ETCS are intended to boost the capacity of existing rail networks and improve the safety of operations. In helping to bring about a more integrated and attractive continent-wide rail system that draws passengers away from car and plane travel, these changes will also create additional markets for rolling stock.

On the other hand, a market liberalization push is also having significant impacts on the rail equipment industry. Formerly closed national markets are being opened to international competition, and national rail monopolies are being broken up, which tends to put downward pressure on prices for railway equipment. The need to increase productivity and cut costs has led to a wave of mergers and acquisitions.[12]

Additional impacts on rail manufacturers may be felt as rail operations in European countries are being separated from track and infrastructure management. In the past, national rail companies were able to cross-subsidize less-profitable aspects of their business through profits from more lucrative portions. That is no longer possible under the new system, as developments in France suggest.[13] The new dynamics could undercut the economic viability of national rail operators. This may lead to inferior rail service as operators try to cut costs. If operators pass higher track user fees onto passengers in the form of more expensive tickets, ridership may suffer. Either way, the repercussions may eventually affect rail manufacturers as well in the form of lower or delayed vehicle orders. U.S. policymakers may wish to examine the European experience closely to build on successes and avoid potential pitfalls.

Table 5. Estimate of Needed European Urban Rail Investments over a 20-Year Period

Category	Investment
	(billion dollars)
Tram and Light Rail	
Vehicle purchases	13–19
Track and infrastructure	44
Subways	
Vehicle purchases	29
Track and infrastructure	132
All Urban Rail Systems	
R&D and civil engineering	5
Total	222–229

Source: See Endnote 6 for this section.

GERMANY:
Rail Leader in Danger of Underinvesting

Germany is Europe's largest rail and transit market and one of the largest in the world. Although the United States has almost four times the population of Germany, both countries have about the same number of mass transit (rail and bus) passengers.[14] The number of rail passengers in Germany grew by 50 percent from the mid-1990s to 2008. To some extent, this was the result of a successful regionalization policy that assigned greater responsibility for commuter and regional rail to the Länder (states). A revenue-sharing formula allocates revenues derived from federal crude oil taxes to Germany's regional trains amounting to about $9–10 billion annually.[15]

Deutsche Bahn, the former national monopoly operator, still dominates German intercity rail travel. Many regional lines are still run by its division DB

S-Bahn signage in Munich.
Karl Baron

Regio as well, but there are many other franchises now, with more than 160 companies operating short-distance lines.[16] In addition, more than a dozen commuter rail systems (called S-Bahn) run in Germany's largest metropolitan areas, connecting urban and suburban areas; in some cases, they effectively function as regional trains and offer integrated service with other rail (or bus) lines.[17] German cities pioneered so-called tram-train systems that help to further integrate services. Systems operating in Cologne, Bonn, and Karlsruhe gained recognition beyond Germany, with particular interest in Finland, France, Italy, the Netherlands, and Spain.[18]

Such integration of rail and transit services is critical to drawing travelers away from automobiles and airlines and helping rail capture a greater share of the modal split. This combination of undertaking large-scale investments and offering attractive public transportation systems is key to securing substantial demand for rail and transit vehicles, and thus to a successful rolling stock manufacturing industry.

Germany's rail manufacturing industry—not just Siemens, but companies like Hübner, Knorr-Bremse, Schaeffler, Voith, Vossloh, and others—remains a global technology leader, underpinned by domestic orders of more than $6 billion per year. Backed by this strong home base, the industry has been able to secure growing export sales as well.[19] (See Table 6.)

Germany's annual investments in rail infrastructure are increasing from less than $5 billion in 2008 to $5.6 billion in 2011—substantially more than the United States on a per capita level. Stimulus funds to counter the economic crisis injected another $1.8 billion on a one-time basis.[20] (Together with the regionalization funds, debt service, and other categories, the 2009 federal budget included $23 billion in intercity and urban rail-related spending. Vehicle purchases are not financed via the federal budget.[21]) However, rail advocacy groups argue that the German government is not investing enough in rail infrastructure.[22] A comprehensive joint assessment by rail operators and rail manufacturers likewise concluded that intercity and urban rail investments of about $9.3 billion per year are needed in 2008–2015 to keep pace with ridership.[23]

In recent years, Germany's total capital investments in urban mass transit (infrastructure and vehicles) amounted to $7.3 billion annually. Of that sum, about $3 billion went to the purchase of vehicles, split evenly into bus and rail vehicle purchases.[24] (See Table 7.) U.S. spending on transit vehicles in 2008 was about $5.3 billion, but on a per capita basis, it was less than half of German spending. (A similar disparity can be found in transit operating budgets: Germany's total expenses run to about $24 billion—$10 billion for bus lines and $14 billion for rail lines—compared with U.S. spending of $38 billion. Per capita, that works out to about $300 in Germany, but just $126 for the United States.[25])

Germany's rail and transit investments are critical for keeping the country's rail manufacturing industry at the forefront internationally. Domestic and export

Table 6. German Rail Manufacturing Industry Sales, 2006–2009

Year	Total	Domestic	Export
		(billion dollars)	
2006	11.5	5.7	5.8
2007	13.2	6.2	7.0
2008	14.6	6.5	8.1
2009 (1st half)	6.5	2.7	3.8

Source: See Endnote 19 for this section.

Table 7. Germany's Annual Investments in Urban Mass Transit, 2009

Category	Investment
	(million dollars)
Urban rail vehicles (light rail, trams, subways)	1,508
Buses	1,476
Rail infrastructure (tracks, guideways)	3,652
Rail stations	410
Other buildings and assets	278
Total	7,324

Source: See Endnote 24 for this section.

orders support large numbers of jobs. Rail manufacturing jobs have increased in recent years, to some 45,400 in the first half of 2009 (compared with 45,000 in 2008, 43,900 in 2007, and 38,400 in 2006). Employment in the supply chain is estimated at roughly another 150,000 jobs.[26]

Other statistics paint a similar picture. Germany's urban mass transit-related employment amounts to almost 400,000 direct and indirect jobs (and even more when induced jobs* are added). These figures include the vehicle manufacturing industry, infrastructure companies (tracks, facilities, etc.), and service providers.[27] (See Table 8.)

Combining urban and intercity rail, the advocacy group Allianz pro Schiene reports that rail operating companies, together with rail vehicle producers and their suppliers, as well as rail construction companies, provide a total of 580,000 direct and indirect jobs in Germany.[28] Allianz pro Schiene does not offer estimates for induced jobs, but adding these might push the total to close to 1 million jobs.

Germany has an opportunity to expand its impressive rail and transit systems, raise the share of these in the overall modal mix, and add to already existing manufacturing jobs. Still, the current German government has shown itself reluctant to consider a more fundamental shift away from auto-centered transportation. In 2006–2010, federal highway investments of $33.6 billion exceeded rail infrastructure spending of $23.8 billion by a substantial amount. Among new projects, highways received $18.3 billion, or three times as much as rail.[29]

This is in sharp contrast with France, where a draft plan for transportation infrastructure investments for the next two decades foresees that 52 percent of a total of $236 billion will be allocated to high-speed rail and 32 percent to urban trams, subways, and bus lines. Just 5 percent will go to roads and airports, and the remainder to ports and waterways.[30] The United States, by contrast, remains solidly committed to highway priorities: of $248 billion in federal 2004–2010 surface transportation funds, just 18 percent went to urban transit programs, and intercity rail received mere crumbs.[31]

The overarching lesson from Germany's experience is that sustained investments and well-integrated public transport systems are essential in order to build—and maintain—a world-class rail and transit system and the jobs that are associated with it. The country's domestic market also provides a springboard for Germany's strong export performance.

A double-deck intercity train built by Bombardier, in the German countryside.
© Bombardier

Table 8. Employment in Germany's Urban Mass Transit System

Type of Employment	Number of Jobs
(1) Direct	236,590
(2) Indirect	157,221
Direct & Indirect	393,811
(3) Induced	263,091
Grand Total (1–3)	656,902

Source: See Endnote 27 for this section.

* Induced jobs are those created elsewhere in the economy as incomes earned by employees in transit equipment manufacturing and in the transit sector are spent on goods and services.

SPAIN:
Vaulting into High-Speed Rail Leadership

Spain is enjoying a marked increase in rail ridership. Measured in passenger-miles, rail travel increased 55 percent between 1990 and 2008, far outstripping population growth.[32] This expansion stretched across all markets, from urban metros to regional and long-haul services, and shows no sign of slowing.[33]

A Renfe Cercanías train passing through Avilés, Spain.
Savh

Spain's upward rail trend is the fruit of heavy investments beginning in the late 1980s.[34] Between the end of the 1980s and the mid-1990s, Spain and Germany led the EU in the share of GDP allocated to investment in transport infrastructure, much of it in rail.[35]

Spain has the largest high-speed rail construction program in Europe. Its HSR network has surpassed Germany's in length and at about 1,000 miles in 2009 was second only to France's in all of Europe. It will more than double, to 2,136 miles, by 2012.[36] Government plans call for some 6,200 miles of high-speed track by 2020, with a goal of ensuring that 90 percent of Spaniards live within 30 miles of a station.[37] Ridership grew tenfold in 1992–2008 and now accounts for 23 percent of total rail travel in Spain.[38] HSR is drawing passengers away from air travel, especially on the Madrid-Barcelona route.[39]

Throughout the 1990s and continuing through the present, Spain's rail sector was streamlined, updated with cutting-edge technology including high-speed rail, and reoriented to become a vehicle of national development. This was driven in part by a policy goal of greater integration with Europe and bringing Spain in line with EU transportation directives.[40] The Spanish Ministry of Public Works (Ministerio de Fomento) sets the strategic direction for the rail sector and governs the sector's planning, budgeting, and operations. Most of the players involved in rail operations are state-owned companies, including RENFE (the National Network of the Spanish Railways) and ADIF (the Railway Infrastructure Administrator).[41]

In 2004, the Spanish government adopted a new strategic plan for transportation through 2020 called the PEIT (Strategic Plan for Infrastructures and Transport). The plan grew out of a recognition of the uneven quality of domestic rail infrastructure and service, low levels of traffic on some routes, difficulties harmonizing operations with other European railways, and conflicts between rail and urban development.[42] Remarkably, the plan calls for 44 percent of total transportation investment to be directed toward rail, primarily for expansion of the high-speed network.[43] (See Table 9.)

Table 9. Investment in Spanish Infrastructure and Transportation, 2005–2020

Target	2005–2020*	Annual Average
	(billion dollars)	
New investment in HSR	114.8	7.7
Maintenance and conventional rail	26.4	1.8
Intermodal and fleet	10.7	0.7
Total	152.0	10.1

* Not including stimulus spending for rail in the 2010 PEIT.
Source: See Endnote 43 for this section.

The PEIT is a social, political, environmental, and development plan with transportation at its center. Among other goals, it seeks to integrate rail with other systems of transport (while boosting rail's share of transportation); ensure that traditionally underserved areas of Spain are integrated with the rest of the country; provide a high level of quality of service across the entire system; and adopt the latest railroad technology.

In 2010, with Spain deeply mired in the global recession, the government turned to infrastructure investments, especially in rail, as a way to stimulate the economy while accelerating the modernization plan for the country's transportation system. Its two-year Extraordinary Infrastructure Plan, rolled out in April 2010, promised to invest some $24 billion in transportation. Unlike the prevailing priorities in the United States (where 80 percent of federal transportation funds go to highways and just 17 percent to public transportation), 70 percent of funds will go to rail and 30 percent to highways.[44] Some 65 percent of investments will focus on new construction, with the remainder going to maintenance of existing structures. High-speed rail tracks will see $8.3 billion in new investment in 2010 alone.[45] This is about as much as the American Recovery and Reinvestment Act of 2009 (ARRA) makes available (yet almost seven times as much on a per capita basis).

Given high levels of public debt, initial investments in projects in Spain will be made by the construction companies and financial institutions involved, rather than the government. The government will begin to pay companies for their work starting in 2014, after projects are completed. Government funding will be raised through a new tax on users of the infrastructure.

These investments are a major boon to Spain's manufacturing and construction industries. Some 600 Spanish companies generate products or provide services for the Spanish rail sector, of which 228 do so exclusively. Spanish firms are competitive in every aspect of rail, from design and construction to manufacture of rolling stock to signaling, ticketing, operations, and equipment provision.[46] Talgo and CAF, for example, are rolling stock manufacturers that have pioneered innovations in tilting trains (which enable trains to negotiate curves at high speed), aluminum body trains (which save energy), and variable gauge trains (which allow some trains to transition from Spain's narrow gauge tracks to France's wider gauge tracks).[47]

In the design and construction realm, in particular, Spanish firms stand out. Six of the top ten transportation construction companies in the world are Spanish, and as the government has committed to increased rail construction, these firms have prospered.[48] Spanish companies involved in public works, including transportation infrastructure, have seen a fivefold increase in business since 2004.[49]

A national commitment to building an extensive, modern rail system has propelled the Spanish rail manufacturing sector to world-class status. This has also helped to propel the country's leading rail manufacturers onto the international scene. Spanish exports of rail-related products and services—mostly to European and Latin American countries—have boomed in recent years.[50] (See Table 10.)

Table 10. Spanish Railway Industry Exports, 2009

Export	Amount	Increase over 2006
	(million dollars)	*(percent)*
Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches	467	49
Parts of railway or tramway locomotives or rolling stock	184	53
Railway or tramway track construction material of iron or steel	142	1,289
Diesel-electric locomotives	133	621
Self-propelled railway or tramway coaches, vans, and trucks	54	-7
Assembled or unassembled axles, wheels, and parts thereof	29	45
Switch blades, crossing frogs, point rods, and other crossing pieces	24	52
Compressed air brakes and parts thereof	21	406
Containers specially designed and equipped for carriage by one or more modes of transport	19	n.a.
Other rail locomotives; locomotive tenders	17	199
All other railway exports	107	- 37
Total	1,195	63

Source: See Endnote 50 for this section.

The rail sector is an important source of high-quality jobs in Spain. Published employment figures are often vague, but various sources give a sense of jobs associated with rail:

- The Association of Spanish Manufacturers of Rolling Stock and Railway Equipment reports that direct employment in companies that manufacture rolling stock used in Spain amounts to 9,000 jobs.[51] The Association does not offer employment data for the supply chain, and many other rail-related jobs—in construction, engineering, and signaling equipment, for instance—are beyond this group's purview.
- The Spanish Institute for Foreign Trade reports that the 228 companies that provide goods and services exclusively for the Spanish rail industry employed 115,800 workers in 2008, a 22-percent increase from the 95,000 employed in 2005.[52]
- A much broader employment figure of 600,000 jobs created during the last five years has been put forward by ADIF, Spain's rail network managing agency. This figure apparently includes rail manufacturing, construction, engineering and related services, and

presumably supply-chain jobs. But the precise parameters of the estimate are unclear, as is the question whether induced employment is included.[53]

It is beyond doubt that Spanish rail employment is growing significantly. Spain's experience shows the importance of a long-term vision. Backed up by large-scale investments, it will help the country counter the effects of the recent economic crisis and create a more balanced transportation system. As the U.S. Federal Railroad Administration develops a national plan for the United States, Spain's PEIT offers a vision and planning tool worth emulating.[54]

Talgo rolling stock factory, Spain.
Talgo

The East Asian Experience

The significance of East Asian rail and transit markets is rising. Both urban and intercity rail systems are expanding, and, as in Europe, there is growing excitement over high-speed rail.[55] Although only Japan and China are profiled below, it is worth noting that South Korea also has made rolling stock manufacturing a cornerstone of its industrial policy, eager for technology transfer via domestic-content requirements. A 2009 report, *Rising Tigers, Sleeping Giant*, notes: "Like China, South Korea licensed technology for use on its Korea Rail eXpress (KTX) HSR line from foreign companies…but quickly localized production through a technology transfer arrangement. While the first twelve train sets in use on the KTX were manufactured by Alstom, the next 34 were produced in South Korea by Hyundai Rotem using 58 percent domestic technology."

By 2008, Hyundai Rotem unveiled the KTX-II, the result of a decade-long government-led R&D effort, and a train that is based on 87 percent South Korean technology.[56] Even though the United States once had a passenger rail industry and is thus not a latecomer per se, the approach taken by East Asian nations holds important lessons for how to link transportation policy to resurrecting its rail manufacturing industry and create much-needed jobs.

JAPAN: High-Speed Pioneer with Growing Export Orientation

Long a world leader, Japan's rail sector faces opportunities and challenges in the coming decades. As the most experienced high-speed rail nation in the world, with service dating back to 1964, Japan has developed a strong technological and managerial capacity for manufacture and operation of high-quality rail service. While the rail sector has been challenged by the automobile since the 1960s, rail ridership remains relatively high. Total rail passenger-miles increased by 29 percent between 1980 and 2007, while population expanded by just 9.1 percent.[57]

The Japanese government's commitment to reducing carbon emissions will likely give rail a fresh boost in coming decades. At the same time, however, the country's declining population will soften demand for rail services. Limited domestic growth is likely to lead many Japanese manufacturers of rolling stock and infrastructure to look to the burgeoning global market (including the U.S. market) for new rail contracts.[58]

High-speed rail has been an important dimension of Japanese rail since 1964. In 2009, HSR in Japan totaled 1,483 miles in length, with 729 more miles under construction and planned for completion over the next 10 years. Shinkansen trains carry more than 300 million passengers annually, the greatest ridership of any HSR system in the world. The high volume is generated by several factors, among them the use of high-capacity trains; an integrated system of track, vehicles, and signaling; extensive geographic coverage; departures at frequent and regular intervals; and an impeccable safety record and on-time arrival performance. In terms of travel time, Shinkansen trains are competitive with air travel for trips of up to 560 miles, about a four-hour ride.[59]

Japan continues to be a global leader in HSR. In

2007, the JR Central railway company announced that it would develop an ultra-high speed technology known as maglev into commercial service by 2025, running from Tokyo to Nagoya.[60] Using the power of magnets to "levitate" a train, which eliminates train-to-track friction, the Japanese maglev prototype was clocked at 361 miles per hour on a test run in 2003.[61]

Japan's national railway system was state owned until 1987, when it was largely privatized into six regionally based passenger rail companies and one nationwide freight company that operate under the Japan Railways (JR) domain. In addition, some two-dozen private regional companies remain entirely independent of Japan Railways.[62] Operating railways in Japan own the lines, trains, and stations, a strategy designed to ensure that a company takes responsibility for an entire railway operation.[63]

High-speed rail is handled somewhat differently. Lines built after the 1987 reform are constructed and owned by the governmental Japan Railway Construction, Transportation, and Technology Agency, and are leased to the JR companies.[64] In addition, profits from the Shinkansen lines are shared across the operating companies to help subsidize less-profitable rural lines.[65]

The national government once underwrote all rail construction spending. Since 1987, however, it covers only two-thirds of the cost, while local governments fund one-third.[66] Funds are generated from the sale of the railroads to private companies, from annual operating assessments on the private companies (in effect for 60 years), and from the national public works budget. HSR lines built after 1987 are funded through lease payments to the Japan Railway Construction, Transportation, and Technology Agency, which are assessed based on projected ridership. No government subsidies are used to fund operations of the HSR passenger network.[67]

Japan has long been self-sufficient in providing all dimensions of rail service, including manufacture of rolling stock. The national rolling stock fleet today consists of some 67,000 units. By far the biggest portion, close to 45,000 cars, comprise the conventional passenger rail fleet; some 4,200 units are in the Shinkansen fleet, and more than 13,000 are freight wagons.[68]

Industry and government statistics differ in their estimates of rolling stock produced. But it appears that total production peaked in the mid-1960s, when Japan's HSR infrastructure was set in place. The decline since then has occurred principally in the production of freight wagons (which has almost disappeared from a peak of more than 9,200 units as shipping by truck has surged), and has been much more moderate for passenger rail vehicles.[69]

In the yard of Fukuoka's main train station, Hakata, an array of high-speed trains.
Rsa

Numerous Japanese manufacturers have a stake in the country's rail sector. Companies tend to compete with one another for work on standard infrastructure and rolling stock, but collaborate extensively on HSR projects. The new N700 series of trains, for example, which can accelerate to 170 mph in just three minutes, is a collaborative effort among Nippon Sharyo, Hitachi, Kawasaki, and Kinki Sharyo. For HSR overall, some 14 companies are involved, with Kawasaki Heavy Industries, Mitsubishi Heavy Industries, and Hitachi dominating manufacture of rolling stock.[70] The Japan Association of Rolling Stock Industries groups major producers of cars, electrical equipment, non-electric equipment, and materials suppliers.[71] (See Table 11.)

Japan's rolling stock manufacturers belong to several large industrial conglomerates that typically employ hundreds of thousands of people. The country's *Census of Manufactures*, which offers employment data for the rail equipment and parts industry for the years 1998 to 2007, reports that the workforce ranged from about 14,300 to 17,500 during this period. In 2007, some 7,200 people were employed in the production

Table 11. Japan's Rolling Stock Manufacturers

Industry Group	Number of Companies
Rolling stock equipment and parts	7
Electric equipment and parts	13
Non-electric equipment and parts	21
Suppliers to rolling stock industries	61
Railway operating companies	33

Source: See Endnote 71 for this section.

The train maintenance factory of Shikoku Railway Company in Tadotsu, Japan.
misijp

of railway coaches and cars, and about 10,300 in parts production. The value of production rose from $5 billion to $6.3 billion in the same period. Another 7,200 people were employed in the production of rail signal and safety equipment in 2007.[72] The *Census* does not offer indirect employment data.

Although Japan continues to invest in rail, opportunities to further expand the domestic rail market are limited given the country's declining population and increasingly saturated market. For this reason, many manufacturers are looking abroad to boost sales. Like Germany, Japan is now increasingly working to parlay the know-how developed for its domestic market into a growing export presence, looking to license its HSR technology and components worldwide. Some 38 percent of revenues from the manufacture of rolling stock were earned in the export sector over the past decade.[73] As in Germany and Spain, a key lesson that emerges is the importance of steadfast investment and planning.

CHINA'S RAIL NETWORK: From Overburdened to Audacious

According to the World Bank, China's intercity rail system carries a quarter of the world's traffic on just 6 percent of the world's track length.[74] It is the largest conveyer of rail passengers and the second largest carrier of rail freight. During the past decade, Chinese rail traffic grew at an average annual rate of about 8 percent, putting growing strain on the network.[75] Relative to population, the density of China's network is much lower than that of Japan, Europe, or even the United States. But the existing system is already used much more intensively than in those other countries.[76] The Chinese government has been acutely aware of these problems and is investing unprecedented sums into the country's rail network.

In 2004, the State Council (China's parliament) approved a new Railway Development Plan to 2020. Its goals were subsequently made more ambitious in 2007.[77] (See Table 12.) In the wake of the recent global economic crisis, investments were accelerated further when rail, with a 17 percent share, became the single largest component of the country's stimulus plan.[78] (In the United States, rail and transit account for just 2 percent of stimulus funds.) China's 2020 rail network target of 75,000 miles may be reached as soon as 2015 and might even be raised to 93,000 miles.[79]

Internationally, most attention has gone to China's audacious investment in HSR. Typical high-speed trains traveling at 125–155 miles per hour are to share tracks with regular passenger and freight trains, while very high-speed trains traveling at 220 mph are to run on separate tracks.[80] The 2007 development plan pro-

Table 12. China's Rail Development Goals, 2007, 2010, and 2020

Goal	2007	2010	2020
		length (miles)	
Total rail network	48,466	57,000	75,000
Electric track	15,824	25,000	45,000
High-speed lines	252	3,000	7,500

Note: The source for these data expressed data for 2010 and 2020 goals in kilometers rounded to the nearest thousand. Except for the 2020 HSR goal, the data here follow the same rule.
Source: See Endnote 77 for this section.

jected 7,500 miles of separate HSR lines, but the goal has now grown to an even-more ambitious 16,000 miles. As of early 2010, some 4,000 miles had already been constructed.[81] HSR lines are to connect all Chinese cities with more than 500,000 inhabitants, providing access for a stunning 90 percent of the country's population.[82]

Although China developed a domestically designed high-speed train in 2002 (dubbed the *China Star*), the country's leadership preferred bringing in the best technology available worldwide. To that end, Chinese companies CNR and CSR have been working since 2004 with international leaders Bombardier, Kawasaki, Siemens, and Alstom. Four train designs—China Railway High-speed (CRH) 1, 2, 3, and 5—were introduced.[83] (See Table 13.) China's approach offers valuable policy lessons for the United States—in particularly the manner in which China has linked its domestic transportation goals to manufacturing policy, and its ability to strike tough deals with foreign suppliers, which has allowed it to join the ranks of leading rail producers.

Table 13. Chinese High-Speed Rail Joint Ventures

Design	Partners	Observation
CRH 1	Bombardier – Sifang (CSR)	First-generation train with top speed of 155 miles per hour; second generation (2009) with top speed of 236 mph. Built in Qingdao, Shandong Province; engineered in Europe.
CRH 2	Kawasaki – Sifang (CSR)	First-generation with top speed of 155 mph; second-generation (2009) with top speed of 217 mph. First nine trainsets were produced in Japan, based on E2 Shinkansen; now entirely in China. Joint venture ended in 2007.
CRH 3	Siemens – Tangshan (CNR)	Derivative of the Siemens Velaro train also used in Germany, Spain, and Russia. First three trainsets were produced in Germany; now in China with Siemens supplying some components. Top speed of 217 mph.
CRH 5	Alstom – Changchun (CNR)	Closely related to Alstom's Pendolino design, with top speed of 155 mph.

Source: See Endnote 83 for this section.

The initial trainsets were produced by the manufacturers in facilities in their home countries. But China has stiff local-content requirements that stipulate that 70–90 percent of rail equipment be manufactured domestically. Technology-transfer agreements have permitted Chinese manufacturers to reproduce the vehicle designs in local factories.[84] As an article on *The Infrastructurist* blog explains, "in many ways, this process is no different than that required for many American transit vehicle acquisitions [under the Buy America Act], in which a majority of parts must be made in the United States to meet federal guidelines. Yet China's willingness to demand that foreign manufacturers abandon their patented technology to Chinese industrial concerns is taking the situation a full step further."[85]

China has used its lucrative market as a lure for securing a high degree of technology transfer. Without doubt, foreign companies are attracted by China's huge market. By 2009, they had won some $10 billion worth of contracts.[86] In 2009, Siemens agreed to a deal that left it with only an 18 percent share of a $1 billion order for 100 trains; the bulk of the order will be filled by CNR subsidiary Tangshan. Bombardier's 2009 contract to deliver 80 of its Zefiro vehicles gives the company less than 50 percent of total revenues. Alstom, however, has been more resistant to such deals, refusing to give China access to its latest technologies.[87] French and Japanese rail industry executives have criticized China, accusing it of forced technology transfer and even technology theft, while a senior German manager said his company, Siemens, was "very comfortable" with China's requirements.[88]

CNR and CSR are growing into formidable global competitors. They are already selling light rail, commuter, and subway vehicles to a broad range of countries, and are increasingly active in bidding for high-speed projects.[89] (This includes planned projects in the United States, where the Chinese railway ministry has signed a framework agreement to license its technology to GE; China is offering not just to build California's high-speed line but also to help finance it.[90]) Although Chinese companies still lag behind world leaders technologically, they are able to compete internationally on price, and the national government plays a key role in providing low-cost financing to help these companies scale up. Foreign companies are encouraged to join Chinese consortia by the prospect of gaining greater access to China's enormous market.[91]

Even as China's intercity rail network is expanding massively, its urban networks are also growing rapidly. At the end of 2009, metro and light rail lines had a combined length of 617 miles. Shanghai (186 miles) and Beijing (155 miles) had by far the longest networks in 2009. Shanghai was planning to put another

A China Railways CRH 2.
Frank Chan

75 miles into operation for the May-October 2010 World Expo.[92] Beijing will extend the length of its 12 lines to 229 miles by 2010 and 349 miles by 2015.[93]

More than 30 Chinese cities, all with populations exceeding 1 million, have started construction on or submitted proposals for new urban rail systems.[94] Some 870 miles of rail transit lines are currently under construction and another 1,622 miles are planned.[95] With all this activity, China has become the world's largest urban rail construction market. The country's annual demand will likely exceed 3,000 rail vehicles for years to come.[96]

During the 10th and 11th Five-Year Plan periods (2001–2010), China's total investment in urban mass transit was about $59 billion.[97] There are varying figures for the investments planned for the next several years. *China Daily* reported in March 2010 that China would invest about $100 billion during the five years to 2015, or $20 billion annually.[98] But *People's Daily Online* said in July 2009 that investments could exceed $146 billion.[99]

China is expected to account for more than half of the total global expenditure on rail equipment. Its market for trains, components, signaling systems, etc. will likely quintuple from an average of $10 billion a year in 2004–2008 to more than $50 billion a year in 2009–2013.[100]

Meanwhile, rail construction investment grew just as rapidly. The *New York Times* reported investment of $14 billion in 2004, growing to $26 billion in 2007, $49 billion in 2008, and $88 billion in 2009.[101] Half of the 2009 funds went to intercity and high-speed rail.[102] Hong Kong's *South China Morning Post* said that China will spend $88 billion on railway infrastructure, $37 billion on subway infrastructure, and $24 billion on rolling stock each year from 2011 to 2015.[103]

There seem to be no complete numbers for employment in China's rail and transit manufacturing sector. However, as noted earlier, the country's two dominant rail manufacturing companies, CSR and CNR, together employ more than 200,000 people directly. Presumably a few hundred thousand additional people are employed in the supply chain. On the operations side, streamlining efforts by the Ministry of Railways cut total staff from nearly 4 million to 2.2 million during the last two decades.[104] Yet the country's ongoing massive rail expansion has led to the creation of as many as 6 million construction jobs.[105]

Rail analyst and TransportPolitic blogger Yonah Freemark commented in 2009 that, "China is staking much of its economy in the construction of this [high-speed] rail system."[106] The leadership in Beijing has recognized that there are substantial economic and employment benefits in building an extensive public transportation network. Beyond technology acquisition lessons, this is the central message that China's experience offers the United States: large-scale rail and transit investments create substantial numbers of jobs—a critical goal at a time of considerable economic distress.

Implications for the United States

In all of the countries profiled in this report, the creation of a strong rail manufacturing industry has depended to a significant degree on a large and steady stream of investments in rail and public transit, which has created substantial domestic markets. Japan and Germany have done just that for many decades—essentially since they re-emerged from the ashes of World War II. Spain and China have begun more recently to shift their transportation investments dramatically from road to rail. In the process, they are creating world-class industries and positioning themselves for continued domestic growth and export opportunities, and creating rising numbers of rail manufacturing jobs—close to 200,000 in Germany, 116,000 in Spain, and rapidly rising numbers in China. These positive experiences should persuade the United States to follow similar strategies.

So far, spending levels on rail and transit in the United States are not anywhere near adequate. Although the stimulus funds contained in the American Recovery and Reinvestment Act of 2009 (ARRA) are a welcome source of financing, they can be considered no more than an initial down payment. Investments need to be ratcheted up and sustained at a high level, providing a clear signal of long-term commitment to building a modern, attractive U.S. public transportation system. A short-term injection of funds will not work, because rail manufacturing companies will not see sufficient reason to build facilities without clear evidence of a sustained commitment and steady orders for rolling stock.

As critical as generous funding is, investments need to be undertaken intelligently; that is, they need to drive at building public transport systems that work well, provide easy-to-use alternatives to automobile or plane travel, and attract and retain growing ridership—thus translating into a continuous stream of orders for rail and bus manufacturers. By contrast, lack of proper investment in maintaining vehicle fleets and infrastructure, as well as poorly planned and run systems, run the risk of losing customers. Sooner or later, this translates into diminished public support for government investment in rail and transit and declining ticket revenues, which ultimately reduce orders for new or replacement vehicles.

Amtrak's Acela and a MARC commuter train at Union Station in Washington, D.C.
DB King

Intercity rail needs to be connected with urban transit systems, so that passengers do not end up traveling from one city to another only to be stranded at their destination. High-speed rail can play an important role (especially in displacing short-distance air travel), but such lines need to form a coherent whole together with conventional rail lines. Within cities, different bus and rail lines also need to be well-coordinated with each other. This includes a high degree of frequency and reliability of service, and well-designed, easy-to-understand passenger information systems. The United States has much to learn from Japan and Europe—and increasingly China—in terms of what modern non-automobile mobility entails, and thus how to ensure that a revived rail and bus manufacturing industry will succeed in the long run.

The U.S. federal government needs to play a strong guiding role in targeting investments, selecting key corridors, and creating a well-integrated passenger transportation system (as well as ensuring sufficient separation of passenger and freight tracks). While there is a role to play for state and local governments (especially with regard to urban and commuter rail lines), leaving policy decisions to a multitude of authorities and agencies without clear performance goals is unlikely to bring about a system that works well. Smart coordination is a must, not just with regard to route and network planning, but also with regard to funding and revenue-sharing among different layers of government.

Monorail in Las Vegas, train built by Bombardier.
© Bombardier

As the country profiles suggest, a variety of funding and organizational models exist, and countries such as Germany, Spain, and Japan have lessons to offer. (China's political and economic system is probably too different to offer much in the way of applicable models, although the scale of the country's rail and transit investments is worth emulating.) Germany's regionalization policy has led to a successful revenue-sharing model. Japan is showing how a degree of privatization can be combined with a continued guiding role for the public sector. Spain is an example of how investment funds can be secured even in tight economic times.

The European and Japanese experiences also bring up questions regarding the proper balance between public and private decision-making. For many decades, these countries have been well served by strong and competent national intercity rail monopolies. More recently, they have experimented with different forms of breaking up these monopolies. It is clear that while a degree of competition can inject new dynamism, there are also pitfalls if the outcome is fragmentation, socialization of losses, and market anarchy. Ultimately, this affects orders for rail equipment, and thus the fortunes of the manufacturing companies. For the United States, the lesson is not so much abandoning a beleaguered Amtrak as ensuring that—unlike for most of the company's four-decade history—it is properly funded.

When it comes to rail and transit, the United States has not had a coordinated infrastructure investment and industry development policy for several decades. A U.S. investment advisor recently offered a plea for just such a policy to (re-)build a U.S. rail manufacturing industry:

> The strategy starts with creating massive domestic demand and protecting that domestic market—using anything from technology standards to taxes to trade rules—from foreign competition. That lets young, domestic companies build up economies of scale so they can compete on price and, eventually, product quality and technology. (At the same time, the size of the domestic market attracts overseas companies, who, in their eagerness to get into the game, trade technology for (what is usually limited) access. As domestic companies mature, the home government helps arrange cheap financing so that these companies start to win international business. At the same time, the government coordinates the entry of these companies into the international market so that domestic companies don't bid against each other and drive down prices unnecessarily.[158]

In short, the United States has a lot to learn from Chinese policy. China's focus on appropriating and absorbing foreign technology has been spectacularly successful to date. The country's decision-makers have not been shy about using their huge market as a lure for foreign companies. The United States is in a comparable situation, in that it offers a potentially huge market—assuming that, like China, it is willing to prioritize rail and transit investments.

While domestic content requirements such as those contained in the Buy America Act are an important tool, there is a need to step up domestic R&D and to set the stage for a broader process of technology acquisition and learning from the experiences of the global leaders. U.S. domestic manufacturers are focused on producing heavy-duty diesel locomotives with impressive freight hauling power. To transition to producing electric trainsets that concentrate on speed and passenger comfort, they need to undergo a learning and adapting process with proper investment and regulatory support from the federal government. It is likely that subsidiaries of foreign manufacturers, rather than *bona fide* domestic companies, will play a key role for some years to come.

The test for federal policy will be whether it can kick off a process that, over time, encourages both domestic and international companies to carry out a greater share of high value-added manufacturing activity within the United States rather than abroad. A February 2010 report by the U.S. Public Interest Research Group rightly notes:

> Federal policy should seek to expand the capacity of American companies to produce high-speed rail systems and components by negotiating technology transfer agreements and investing in research and development. High-speed rail funding should also be used to help support a strong domestic supply chain for high-speed rail components. Lastly, the government should explore ways to encourage conversion of idle domestic manufacturing capacity and retrain idled manufacturing workers for jobs in the passenger rail industry.[159]

Undoubtedly, history, political culture, and systems of governance make for very different situations in individual countries. There is no blueprint by which the positive experiences of countries like Germany, Spain, Japan, or China can simply be transferred to the United States. But it is to be hoped that growing attention can be directed to some of the key lessons that emerge from them, as the United States ventures to rebuild and modernize its rail and transit systems, and to recreate a manufacturing industry that serves these markets.

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Light rail system in downtown Houston, Texas..

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