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Investing To Be Competitive

The New U.S. Industrial Strategy

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Contents

Introduction and summary

The 21st-century U.S. economy has three significant challenges: building manufacturing competitiveness in the United States; reducing carbon emissions in transportation, energy production, and industry; and elevating wages, training, and equity for workers. Solutions to these challenges require long-term action that addresses significant market failures and corrects previous, misguided policy.

Building competitive advantage in advanced manufacturing requires successful translation of scientific discovery into commercially viable products. The complex requirements of this process are under-provided by the private sector because individual private actors cannot capture all the returns of investing in them.

Reducing emissions in carbon-intensive sectors of the economy will reduce the risk of climate change, and making that transition will put the U.S. economy in a competitive position as the world is forced to reduce reliance on fossil fuels. But the external effects of carbon emissions—which include droughts, heat waves, rising sea levels, damage to agriculture, and uninhabitable communities—are not reflected in market prices.

Higher worker wages would deliver measurable social gains and would lead to higher levels of aggregate demand and employment. However, real wage growth has been limited by policy decisions—such as weakening the right to bargain collectively, as well as monetary and fiscal policy that has led to excess unemployment—that have suppressed worker bargaining power and failed to counter race- and gender-based labor market discrimination.

Three major pieces of legislation passed in the 117th Congress include novel provisions designed to overcome these market and policy failures. They support public goods—and create private sector incentives—that will strengthen U.S. manufacturing competitiveness and national security. They also provide large, targeted subsidies to incentivize private sector actions, which will lower carbon emissions:

- **The Infrastructure Investment and Jobs Act** (IIJA) funds the restoring and upgrading of basic public infrastructure in transportation, clean power generation, water, and broadband—important for manufacturing and the economy generally.
- **The Inflation Reduction Act** provides targeted subsidies for clean energy research and development (R&D), production, delivery, and consumption.
- **The CHIPS and Science Act** (CHIPS Act) provides extensive support for R&D and production of advanced semiconductors, which are central to modern economic functioning and have significant security implications.

These policy measures also set important wage and job quality standards for the projects that they will support. All construction supported by the CHIPS Act, and most IIJA projects, must meet prevailing wage standards. To receive maximum investment tax credits under the Inflation Reduction Act, construction of supported projects must also pay prevailing wages and meet a threshold fraction of work performed by registered apprentices for all construction. Priority will be given to funding employers that meet the Good Jobs Principles—published by the departments of Commerce and Labor—which include nondiscriminatory recruitment, family-sustaining benefits, equal workplace opportunity, access to union representation, stable living wages, and other factors.

The novel industrial strategy implemented in this legislation is potentially transformative for key sectors of the economy.

The novel industrial strategy implemented in this legislation is potentially transformative for key sectors of the economy. The $864 billion appropriated in the three bills will upgrade basic infrastructure to meet 21st-century requirements of entire economy, stimulate significant private sector investment, and increase the long-term competitiveness of domestic clean energy, auto, and semiconductor production.[1] As a result, carbon emissions and other greenhouse gas emissions will be reduced significantly, and employment in manufacturing, construction, and other sectors will increase over the next 10 years.[2] Moreover, conditioning subsidies on wage and job quality standards in construction will mean that at least some workers will share in the economic gains created with public support.

Although the effect of these measures will take time to develop, the impact on auto and semiconductor manufacturing and supply chains will be the most immediate. Since the passage of these bills, announced private sector investment in battery, electric vehicles (EVs), and semiconductor production totals more than $386 billion.[3]

This strategy has the scale and significance of the construction of the interstate highway system. That effort, during 1956–1993, cost $614 billion in 2022 dollars, creating a transportation network connecting all regions of the country, which continues to support economic activity.[4] The combined public and private resources allocated toward this strategy are larger, and the economic effects are potentially as important.[5]

The first section of this report sets out the extent of the three challenges—in increasing manufacturing competitiveness, reducing carbon emissions, and raising worker wages—and then describes the market and policy failures that must be overcome to resolve them.

The second section examines how the novel industrial strategy measures included in the IIJA, the Inflation Reduction Act, and the CHIPS Act interact to address these challenges and their causes. The specific goals of this legislation include expanding clean energy production and distribution; transitioning the auto industry from internal combustion to electric; reducing building-related energy consumption; expanding domestic semiconductor design, production, and packaging; and improving worker wages. The tools for reaching these goals include support for basic science, R&D, and demonstration projects; subsidies for private sector investment and production costs; and demand subsidies for products that reduce energy consumption and carbon emissions. Access to certain business subsidies is made conditional on meeting specific wage and job quality provisions.

Although the industrial policies included in these bills set sectoral priorities and provide incentives and labor market requirements, they rely on the actions of profit-maximizing businesses for their execution. The second section also tracks announced private sector investment connected to these policies, which provides some insight into business response and long-term economic effects.

Why industrial strategy is necessary

Manufacturing faces public-goods obstacles to crucial investment. Carbon emissions are excessive because this "external effect" is not included in market prices. Wages are too low because of misguided policy that reduces worker bargaining power.

Boosting advanced manufacturing competitiveness

Manufacturing has historically been a source of productivity growth and high-wage employment. Much of manufacturing productivity growth has derived from innovation—adopting new technologies rather than merely adding more capital equipment per unit of labor. The ability of many U.S. manufacturers to operate at the technological frontier has made U.S.-manufactured goods competitive internationally, and, until recently, the United States was the world's largest manufacturing exporter.[6]

While in the aggregate, much of U.S. manufacturing productivity remains at frontier levels, the long-standing U.S. competitive lead has been eroded in recent decades. For example, between 1995 and 2004, U.S. manufacturing productivity growth was higher than that of Germany, a major advanced economy manufacturing competitor. But during recent decades, labor productivity growth rates in the German economy have converged with the United States'.[7] In addition, German manufacturing total factor productivity growth—the fraction of output growth that is not attributable to increased inputs to production, commonly used as a measure of innovation[8]—exceeded that of the United States and was more or less evenly distributed across all manufacturing sectors.[9]

U.S. manufacturing has also been challenged by the rise of China as a competitor. China has overtaken the United States as the world's leader in manufacturing value added, and it surpasses the United States in manufacturing exports.[10] Millions of domestic manufacturing jobs were lost to the so-called China shock beginning in 2000, as domestic Chinese firms entered the U.S. market as competitors and as an increasing share of U.S. manufacturing employment was offshored to China and elsewhere by U.S. multinationals.[11]

In addition, in 2015, the Chinese government announced a program called "Made in China 2025," with the goal of rapidly developing capacity in 10 high-tech industries.[12] This includes artificial intelligence, advanced robotics, energy-saving vehicles, and biopharma. The stated goal of the plan is to significantly improve manufacturing quality, productivity, and innovation, and by 2049, have China take the leading global position in advanced manufacturing. The tools used to achieve these goals include subsidies, investments in foreign companies to obtain technology, and technology acquisition via joint venture requirements for foreign firms operating in China. The success of this effort is yet to be determined, but the government commitment and scale of resources available for the effort appear formidable.

While in the aggregate, much of U.S. manufacturing productivity remains at frontier levels, the long-standing U.S. competitive lead has been eroded in recent decades.

These challenges to U.S. leadership in advanced manufacturing create both economic and security risks. Under the existing global division of labor in semiconductor production, both kinds of risk are substantial. The United States is dominant in semiconductor design, but the domestic share of chip fabrication has declined from 37 percent to 12 percent over the past two decades. Taiwan holds the dominant position in fabrication, operating leading-edge chip foundries, or factories, that produce to customer specifications. Assembly, testing, and packaging of semiconductors into finished components are done predominantly by contract manufacturers in Taiwan and China. This means that important elements of the semiconductor supply chain are subject to events in other countries and, in the case of firms located in Taiwan and China, to Chinese government interference.[13]

The reduction in domestic auto production over the past two years, caused by chip shortages, illustrates the economic risks posed by disruptions to semiconductor supply chains. By September 2021, shortages had reduced production to 38 percent of the pre-recession peak in 2020.[14] Security risks are illustrated by the U.S. Department of Defense's (DOD) ongoing reliance on Asian production and assembly of micro-printed circuit boards (micro-PrCBs), which are essential to many national defense electronic systems. Almost all commercial micro-PrCB production is located outside the United States, and foreign producers are developing technical and cost advantages that force the DOD to depend on them.[15]

The geography of semiconductor production has been heavily influenced by foreign government interventions. Taiwan, for example, provides subsidies to private companies for land, construction, and manufacturing equipment that lowers fabrication costs by 25 percent to 30 percent. China has provided a single firm, Yangtze Memory Technologies, with $24 billion in subsidies; has allocated $100 billion in support for 60 new manufacturing facilities; and through its Integrated Circuit Industry Investment Fund, has provided $21 billion in capital to firms producing semiconductor manufacturing equipment, with an additional $29 billion on the way.[16]

Requirements for frontier-level advanced manufacturing

Advanced manufacturing is based on scientific discovery; the translation of discoveries into prototype products and production processes; adequate standards and tests to control quality; and a well-trained workforce. Because private actors cannot capture all the benefits of investing in these prerequisites—it is hard, for example, to keep scientific ideas secret or to prevent well-trained workers from leaving for other employment—the level of investment in each of them is insufficient. That is, these important requirements of manufacturing success have some public-goods characteristics, which means they are under-provided by market mechanisms.[17] In addition, uncertain demand sometimes acts as a barrier to needed manufacturing innovation.

Basic science, proof of concept, and standards

It is widely recognized that public support for basic scientific research contributes significantly to U.S. economic success, in advanced manufacturing and other sectors. However, the recognition of the public-goods benefits of basic science is often linked to a simplified picture, in which the discoveries of basic science are handed off to manufacturers, who do applied R&D to produce commercial products. This schematic misses two intervening steps that have public-goods characteristics, as economist Gregory Tassey explains: (see also the graphical representation of the steps involved in Figure 1)

> *One is "proof-of-concept research" to establish broad "technology platforms" that can then be used as a basis for developing actual products. The second is a technical infrastructure of "infratechnologies" that include the analytical tools and standards needed for measuring and classifying the components of the new technology; metrics and methods for determining the adequacy of the multiple performance attributes of the technology; and the interfaces among hardware and software components that must work together for a complex product to perform as specified.*

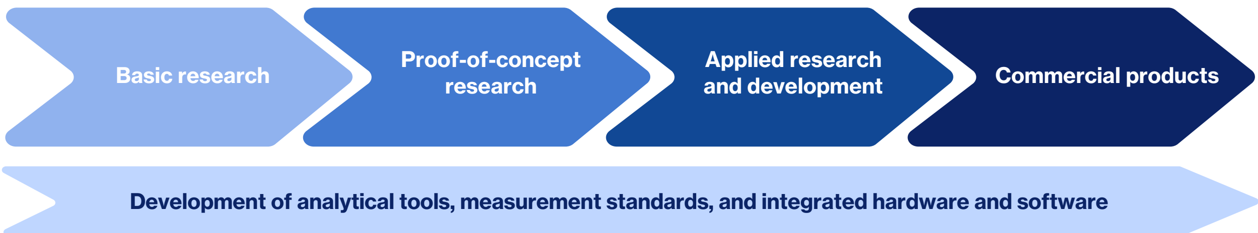
... If the public–private dynamics are not properly aligned to encourage proof-of-concept research and needed infratechnologies, then promising advances in basic science can easily fall into a "valley of death" and fail to evolve into modern advanced manufacturing technologies that are ready for the marketplace. Each major technology has a degree of uniqueness that demands government support sufficiently sophisticated to allow efficient adaptation to the needs of its particular industry, whether semiconductors, pharmaceuticals, computers, communications equipment, medical equipment, and some other technology-based industry.[18]

The relatively slow development of biopharmaceuticals, after significant National Institutes of Health investment in life science research, has been attributed to the absence of a well-developed proof-of-concept technology platform.[19]

FIGURE 1

Advanced manufacturing requirements

Basic science, proof of concept, analytical tools and standards – all public goods – are essential to advanced manufacturing



Source: Gregory Tassey, "Competing in Advanced Manufacturing: The Need for Improved Growth Models and Policies," Journal of Economic Perspectives 28 (1) (2014): 27–48, available at https://www.aeaweb.org/articles?id=10.1257/jep.28.1.27. See also David Roberts, "What made solar panels so cheap? Thank government policy.", Vox, December 28, 2018, available at https://www.vox.com/energy-and-environment/2018/11/20/18104206/solar-panels-cost-cheap-mit-clean-energy-policy?id= 10.1257/-jep.28.1.27t-cheap-mit-clean-energy-policy.

Workforce development

In addition to needing scientists and engineers, advanced manufacturing requires a well-trained, flexible industrial workforce. A report from the National Research Council, the operating arm of the National Academies of Sciences, Engineering, and Medicine, has recognized this. The report pointed out that the success of German manufacturing relies on the country's "dual system" of vocational training, in which students engage in academic training for practical work while simultaneously receiving training in apprenticeship programs run by firms or public institutes.[20] This commitment to workforce training provides industry with highly skilled workers who can adapt to changing production processes.

It also provides workers with recognized credentials, which give them mobility and bargaining power with their employers. These credentials, together with extensive union representation as well as mandatory works councils and worker representation on corporate boards, help to deliver the high real wages paid to German manufacturing workers.[21] It should be noted that employer-provided training in the United States has declined over time.[22]

Demand certainty

Uncertain demand also can inhibit manufacturing innovation. It is, for example, recognized that the scale of demand is a key limitation of manufacturing innovation in the U.S. defense sector. Although the federal government spends great amounts of money on defense overall, manufacturers outside the defense sector have limited incentive to innovate products that might have defense applications. Relative to commercial products, the defense market can be small.[23]

To address the demand problem, the DOD at times works to find ways to introduce defense-important technology into commercial applications. For example, in the 1990s, the Defense Advanced Research Projects Agency (DARPA) successfully funded R&D in optoelectronics. However, in order to stimulate continued private sector development of the technology, DARPA funded two private-public partnerships that had the goal of establishing commercial fiber-optic networks. These efforts contributed to subsequent broad commercial adoption of fiber optics.[24]

Demand certainty, on the other hand, has facilitated important manufacturing innovation. A salient example is the development of the world solar photovoltaic panel (PV) industry. Until the late 1990s, there was no mass market for PVs, there was limited production capacity for what was a niche product, and the cost of PV power was high. However, the decisions by the governments of Japan, Germany, and Spain to subsidize the adoption of solar power created a surge in demand for solar panels.[25] Because the demand could not be met by existing PV companies, an opening was created for new entrants.

In the early 2000s, several Chinese startup companies entered the PV market, now accounting for significantly more than half of all PVs produced in the world.[26] Because of continuing technical improvements and scale economies in production, the cost of solar power has decreased dramatically, and some solar power is now competitive with other sources of electricity.[27]

With the major exceptions of support for basic scientific research, and defense-related interventions by DARPA and other agencies, domestic policy has not systematically focused on manufacturing in recent decades. Given the challenges facing U.S. industry, and the pervasive public-goods obstacles, this neglect has been anything but benign.

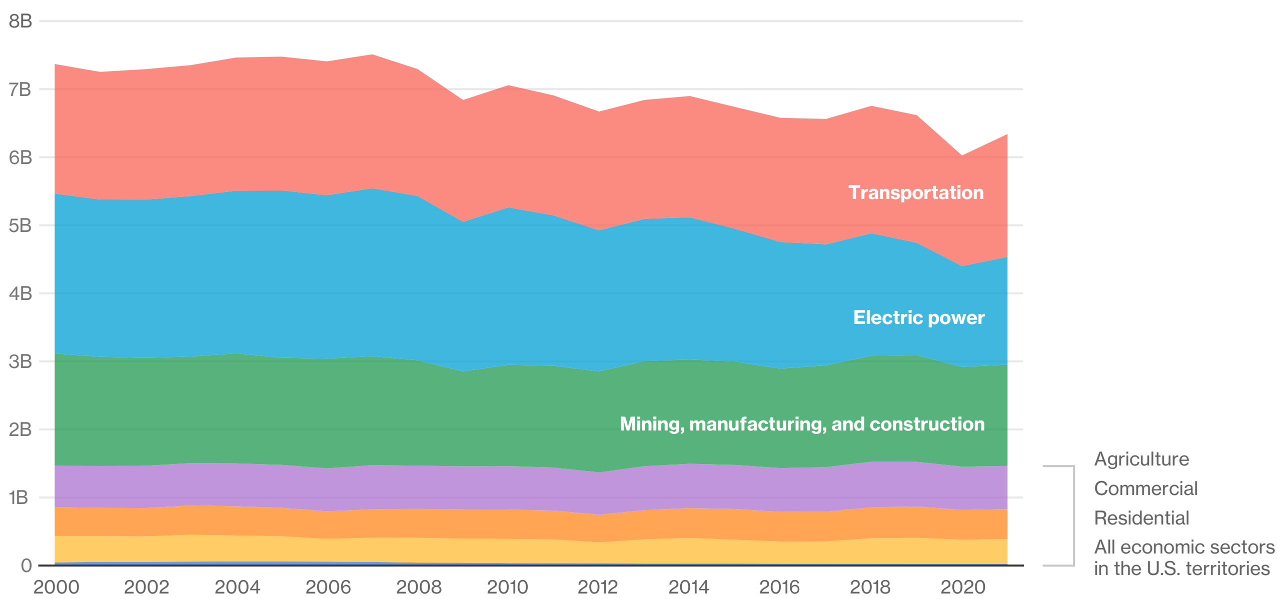
Reducing carbon emissions

The largest contributors to greenhouse gas emissions in the United States are transportation, electric power generation, and industry. (see Figure 2) If the increasingly evident climate-related externalities produced by carbon and other emissions are to be reduced, change needs to be focused on these areas.[28] Doing so will position the economy to transition competitively as the world is forced to reduce reliance on fossil fuels.

FIGURE 2

Transportation, electric power transmission, and industry were the biggest contributors to greenhouse gas emissions in the United States from 2000 to 2021

Emissions by economic sector, in metric tons (MT) of carbon dioxide equivalent



Source: Data from U.S. Environmental Protection Agency, "Greenhouse Gas Inventory Data Explorer," available at https://cfpub.epa.gov/ghgdata/inventoryexplorer/ (last accessed April 2023).

Raising wages, aggregate demand, and job quality

Higher worker wages would reduce income inequality, which has profoundly negative effects such as reduced social mobility and life expectancy. Higher wages also would lead to higher levels of aggregate demand and employment. However, as economists Lawrence Mishel and Josh Bivens have shown, real wage growth for workers has been limited by policy decisions that have suppressed worker bargaining power—including the erosion of collective bargaining rights; monetary and fiscal policy that has led to excess unemployment; the failure to manage the effects of international competition on workers; and the failure to counter race- and gender-based labor market discrimination. [29]

The relative stagnation in worker wages has produced a long-term shift of income shares to upper-income households over the past 40 years.[30] This has led to measurable declines in intergenerational economic mobility and increased differences in life expectancy between high- and low-income individuals.[31]

It also has resulted in a surge in upper-income savings [32] The "saving glut of the rich" has not been matched by an increase in U.S. corporate investment expenditure. This contributes to the problem of "secular stagnation," which requires fiscal and monetary policy to keep aggregate demand at full employment levels.[33] At the same time, race- and gender-based differences in wages and bargaining power have been entrenched.[34]

Achieving higher and more equitable worker wages depends in large measure on policy change to counteract reductions in worker bargaining power.

How the new industrial strategy is structured

The strategy updates critical basic infrastructure and will transform auto production, energy production and consumption, and the domestic semiconductor industry, while taking steps to support worker wages.

Scale of the policy effort

Appropriations for the industrial strategy implemented by the three laws are summarized in Figure 2. The IIJA appropriates $415 billion, above the existing baseline, to basic infrastructure projects essential to economic activity in general.[35] Many of these expenditures—including those for clean power production, electrical grid infrastructure, battery material production and manufacture ($65 billion), railroads ($66 billion), public transit ($39 billion), and EV charging infrastructure ($7.5 billion)—will reduce carbon emissions by supporting mass transit, rail transport, and EV usage.

The Inflation Reduction Act appropriates $370 billion to support renewable energy production and transmission; EV purchases and charging; and reduced energy consumption in residential and commercial buildings.[36]

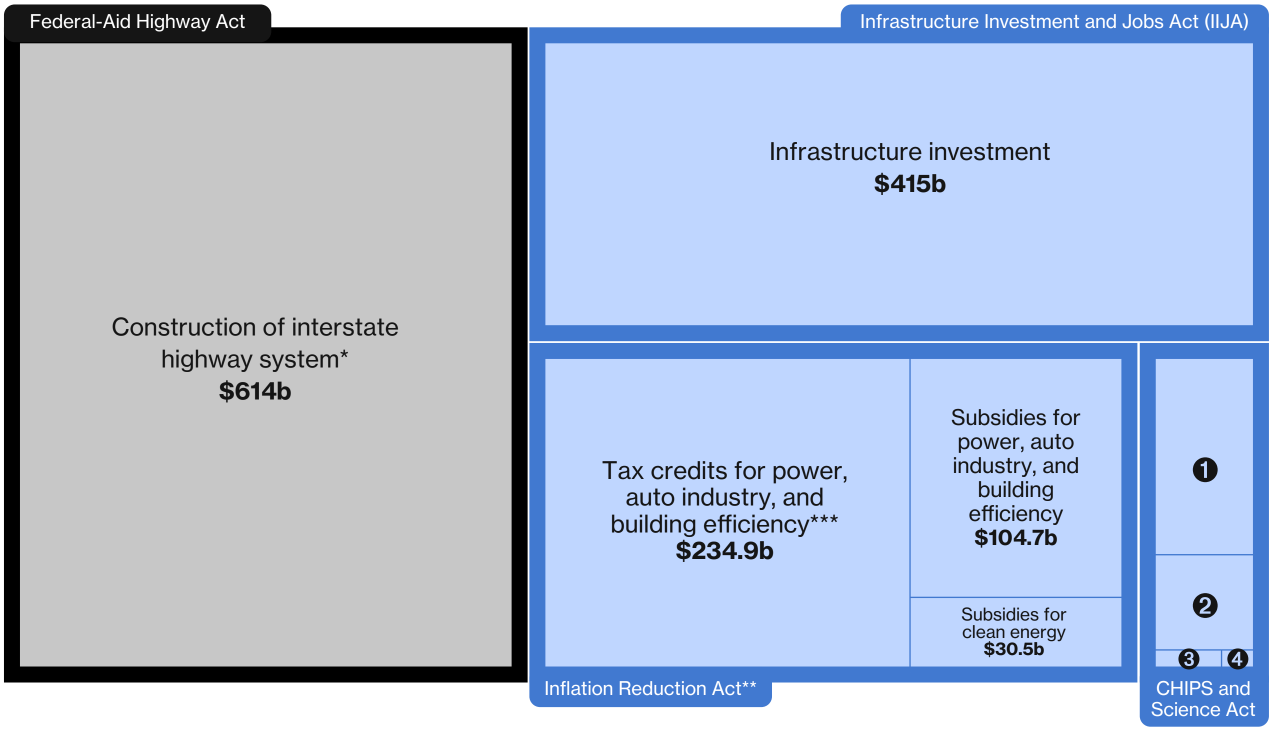
The CHIPS Act appropriates $79 billion to support R&D and the fabrication, assembly, advanced packaging, and testing of semiconductors.[37] The support it provides is intended to guarantee uninterrupted access to inputs, which are crucial to frontier-level economic performance and to national security.

All three bills include long-term incentives for private sector investment and production, which will amplify expenditure effects significantly.

FIGURE 3

The scale of the new industrial strategy is larger than construction of the interstate highway system

Cost estimates, 2021–2031



❶ **$50.5b:** Subsidies for semiconductor fabrication, assembly, advanced packaging, testing, R&D, legacy and defense; semiconductor center, National Institute of Standards and Technology, Manufacturing USA (MUSA)

❷ **$24.3b:** Tax credits for advanced semiconductor manufacturing

❸ **$3.1b:** Subsidies for science and applied labs

❹ **$1.4b:** Subsidies for wireless supply chain innovation

** Interstate highway costs are in 2022 dollars.*

*** This subtotal omits Inflation Reduction Act appropriations and tax credits related to the Affordable Care Act (12001), conservation (20001 and 20002), rural development (22005–22008), forestry (23001–23005), coastal communications and the National Oceanic and Atmospheric Administration (40001–40006), natural resources (50221–50303), hazardous materials (60201), fish and wildlife (60301–60302), the Council on Environmental Quality (60401–60403), homeland security and governmental affairs (70001 and 70003–70007), and climate resilience (80001–80004).*

**** Tax credits are Congressional Budget Office estimates of amounts that will be used for capital investment and production.*

Sources: Congressional Budget Office, "Senate Amendment 2137 to H.R. 3684, the Infrastructure Investment and Jobs Act, as Proposed on August 1, 2021" (Washington), available at https://www.cbo.gov/system/files/2021-08/hr3684_infrastructure.pdf (last accessed April 2023); Congressional Budget Office, "Estimated Budgetary Effects of Public Law 117-169, to Provide for Reconciliation Pursuant to Title II of S. Con. Res. 14" (Washington: 2022), available at https://www.cbo.gov/publication/58455; Congressional Budget Office, "Estimated Budgetary Effects of H.R. 4346" (Washington: 2022), available at https://www.cbo.gov/publication/58319. Interstate cost data from Leah Brooks and Zachary Liscow, "How high are infrastructure costs? Analyzing Interstate construction spending" (Washington: Brookings Institution, 2019), available at https://www.brookings.edu/research/how-high-are-infrastructure-costs/. Author updated data to 2022 dollars using the Consumer Price Index for All Urban Consumers. FRED Economic Data, "Consumer Price Index for All Urban Consumers: All Items in U.S. City Average," available at https://fred.stlouisfed.org/series/CPI-AUCSL (last accessed April 2023).

Support for R&D, production, and demand in key economic sectors

Autos

A higher-resolution examination of these policies shows that Congress was conscious of the requirements of advanced manufacturing and the need to provide incentives to overcome carbon emission externalities. Consider, for example, the approach to auto production, summarized in the Appendix. It starts from a recognition that auto and truck transport is a major source of carbon emissions and that switching to EVs, or other zero-emissions vehicles, will, at least in the intermediate run, require subsidies to bring down production costs and to ensure sufficient consumer demand to realize economies of scale. The Department of Energy receives support via the IIJA to help with producing advanced batteries, which can account for as much as 40 percent of EV component costs, depending on the model of the car and the type of battery used.[38] The Energy Department will engage in mapping and R&D on critical materials—such as lithium and cobalt, which are necessary to produce advanced batteries. It will also map and set up a research and demonstration facility for rare earths, which are essential to the permanent magnets in EV motors.

See Appendix:

For information on R&D, costs, and demand supports associated with policy integration across the IIJA, Inflation Reduction Act, and CHIPS and Science Act, see the Appendix on p. 21.

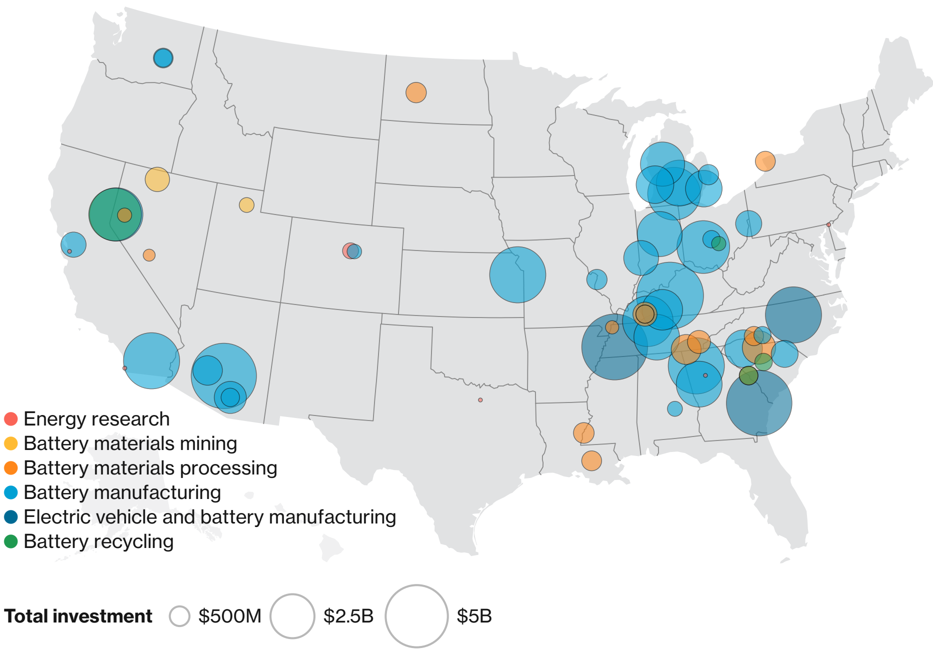
To date, the Energy Department has used IIJA funding for 21 projects to support domestic production and processing of battery materials, along with battery recycling and manufacturing demonstration projects, with announced private investment totaling $90.6 billion to date.[39] (see Figure 4)

Direct EV manufacturing costs will be reduced by advanced technology manufacturing loans and facility conversion subsidies. Their cost also will be cut by IIJA and Inflation Reduction Act support for charging station infrastructure, which will lower costs that might otherwise be borne by the auto companies. The reduction in costs should decrease the market price of EVs. Demand for EVs and their battery components will be supported by clean vehicle purchase credits.

FIGURE 4

Battery supply chain investments

Grant funding and private investment across all steps of the battery supply chain



Notes: Locations are approximate and for illustrative purposes only. Jobs are self-reported by companies and are primarily permanent jobs, although some estimates include related temporary construction jobs.

Source: For local data sources, see https://www.americanprogress.org/article/investing-to-be-competitive-the-new-u-s-industrial-strategy/.

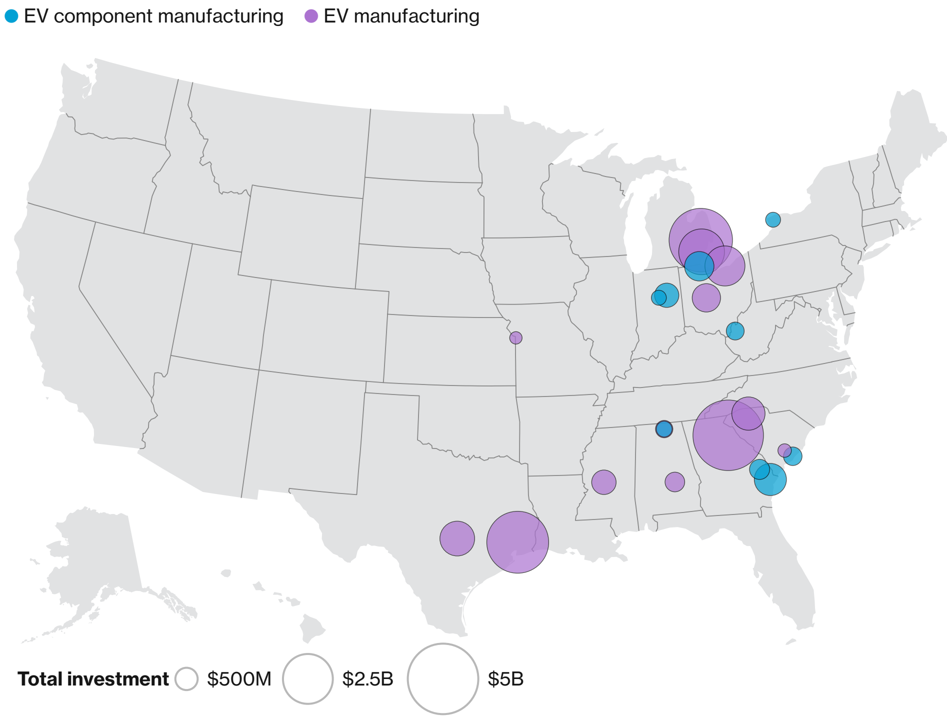
Eligibility for EV purchase credits requires that a percentage of the value of critical minerals contained in the battery be extracted or processed in the United States or a country with which the United States has a free trade agreement, or be recycled in North America; it also requires that a percentage of the value of battery components be manufactured or assembled in North America.[40] The aim of these requirements is to advantage mineral and battery production in the specified locations.

The number of battery and EV manufacturing projects announced so far is substantial. The total of private capital investment amounts to $23.8 billion to date. Figure 4 shows the locations and project descriptions.

FIGURE 5

Electric vehicle (EV) supply chain investments

Announced private investments in EV manufacturing



Notes: Locations are approximate and for illustrative purposes only. Jobs are self-reported by companies and are primarily permanent jobs, although some estimates include related temporary construction jobs.

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Electric power generation

Clean energy receives R&D support via targeted expansion of national laboratories; a planning and modeling effort for offshore wind electricity transmission; and both demonstration projects and deployment of clean hydrogen production via the IIJA and the Inflation Reduction Act. The production and storage of clean energy is supported through Inflation Reduction Act investment and production tax credits, and the IIJA provides support for the transmission grid. (see Appendix)

The National Renewable Energy Laboratory (NREL) has modeled the joint effects of the IIJA and the Inflation Reduction Act on investment in and operation of utility-scale generation, storage, and transmission of electricity. The principal effects come from investment and production tax credits for generation and storage, tax credits for carbon dioxide capture and storage, and the tax credit for existing nuclear power plants. The NREL concludes that the share of clean energy production could increase from 41 percent in 2022 to a range of 71 percent to 90 percent by 2030 and that annual power sector emissions could decline to 72 percent to 91 percent below 2005 levels, across a range of policy scenarios.[41]

The Inflation Reduction Act also supports demand for production of clean energy technology such as solar panels through tax credits for household solar panels and battery storage; residential efficiency and electrification rebates; and grants and loans to Tribes, states, local governments, community organizations, and others to cut greenhouse gas emissions that impose a disproportionate burden on underserved and vulnerable communities.

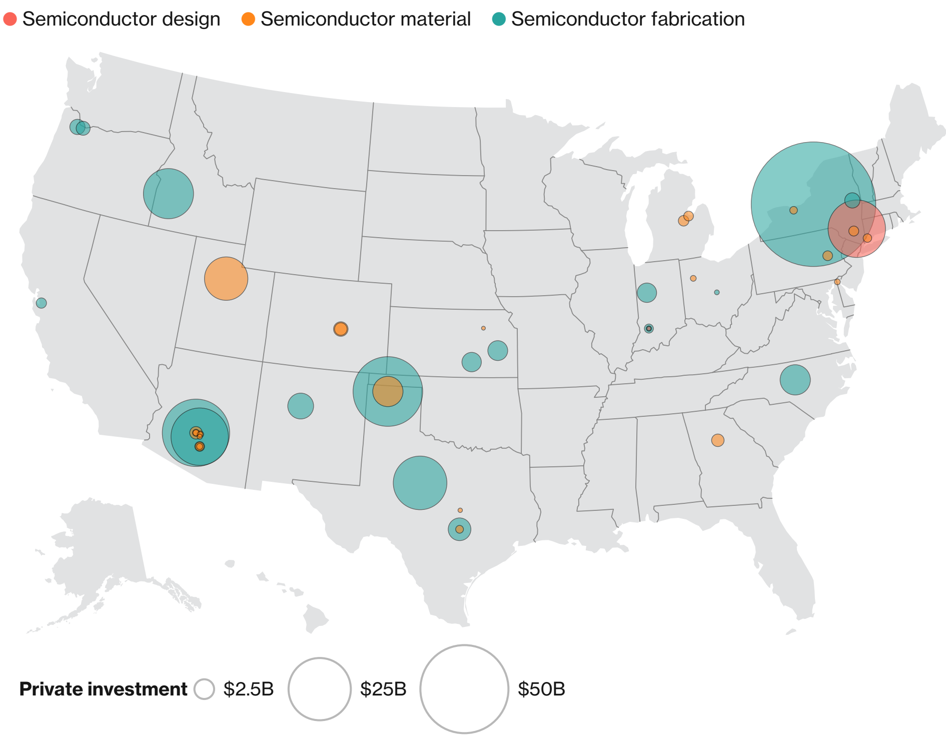
Semiconductors

The CHIPS Act creates a National Semiconductor Technology Center, which will conduct research and prototyping of advanced semiconductor technology. It also creates a National Advanced Packaging Manufacturing Program to develop techniques to test, assemble, and package semiconductors. In addition, the legislation will create up to three Manufacturing USA institutes—public-private partnerships designed to support the translation of basic science into production. There are subsidies and investment tax credits for chip fabrication and advanced packaging, with subsidy preference given to projects with significant private capital. The goal is to create, by 2030, at least two new large-scale clusters of leading-edge logic fabrication plants; multiple advanced semiconductor packaging facilities; and production of high-volume leading-edge dynamic random-access memory chips on economically competitive terms.[42] Figure 6 shows the locations and descriptions for projects announced since the passage of the act. Total announced private sector capital investment totals $271.8 billion to date.

FIGURE 6

Semiconductor supply chain investments

Announced private investments in semiconductor manufacturing



Notes: Locations are approximate and for illustrative purposes only. Jobs are self-reported by companies and are primarily permanent jobs, although some estimates include related temporary construction jobs.

Source: For local data sources, see https://www.americanprogress.org/article/investing-to-be-competitive-the-new-u-s-industrial-strategy/.

Increased employment, wages, worker training, and labor market equity

While one obvious benefit of this policy effort is increased employment opportunities in manufacturing, construction, and related fields, the legislation also sets important wage and job quality standards for the projects that will be supported. All construction supported by the CHIPS Act, and most IIJA projects, must meet prevailing wage standards.[43] To receive maximum investment tax credits under the Inflation Reduction Act, construction on supported projects must also pay prevailing wages and meet a threshold fraction of work performed by registered apprentices.[44]

Priority will be given to funding employment that meets job quality standards related to recruitment, retention, training, diversity, and other factors included in the Good Jobs Principles.[45] These labor-related conditions are illustrated in the recently opened funding opportunity from the CHIPS Program Office. Applications for semiconductor fabrication support must include workforce development plans for those facilities that contain:

> (1) *a workforce needs assessment, including an assessment of job types, skills, and workers required over time;* (2) *strategies for worker recruitment and retention, including plans to address well-known workplace barriers;* (3) *the applicant's approach to meeting the Good Jobs Principles published by the Departments of Commerce and Labor;* (4) *commitments to provide workforce training and wraparound services, including programming for training and job placement for economically disadvantaged individuals; and* (5) *the core milestones the program aspires to achieve, as well as metrics and processes to measure, track, and report publicly on these goals and commitments. The plan should also detail the applicant's engagement with strategic partners.*[46]

The increases in wages and training, which are part of this overall effort, should be substantial. There should also be spillover effects in adjacent labor markets where firms not subject to these conditions are competing for workers. Aside from the material benefits to these workers, rising wages will contribute to higher levels of aggregate demand and to increased output and employment.

Conclusion

The supports and incentives embedded in the Infrastructure Investment and Jobs Act, the Inflation Reduction Act, and the CHIPS and Science Act are designed to overcome well-understood market failures and the effects of past misguided policies to enable significant structural change in the U.S. economy. These include growth of advanced manufacturing capacity in key sectors; reduction in carbon emissions from power generation, transportation, and buildings; and improved wages and job quality for workers.

Many of these goals will take time to fully achieve. Infrastructure improvements and private sector capital investment often require detailed planning and engineering before they begin, and scientific research and product development are often time intensive.

Moreover, important aspects of this new strategy do not rely on new government effort or direct government expenditures. While there is provision for organized government research and development efforts—in, for example, semiconductor design, offshore wind electricity transmission, and clean hydrogen production—most of the work will be done by profit-maximizing businesses. These businesses will receive partial support in the form of grants, loans, investment tax credits, and production tax credits; the expansion of complementary infrastructure such as EV charging networks or a supply of high-assay low-enriched uranium; and, in some instances, such as EVs, through incentives for household and business demand. The connection between the incentives created by the new strategy and the changed behavior of so many businesses will not always be immediately clear.

Nonetheless, the effects of this new wave of industrial strategy are already visible, with major private sector capital investment projects announced or begun in battery materials and manufacturing, EVs, solar panel, and semiconductor manufacturing. Continued implementation of the policy changes contained in this legislation has the potential to transform key sectors of the U.S. economy and deliver significant gains to workers.

Acknowledgments

The author would like to thank David Correa, Emily Gee, David Madland, Jean Ross, Crystal Weise, and Christian Weller for their help with this report.

Appendix

Policy integration across the Infrastructure Investment and Jobs Act (IIJA), Inflation Reduction Act (IRA), and CHIPS and Science Act

Research and development (R&D), cost, and demand supports for key industries[47]

Note: Numbers in parentheses identify sections of the respective bills.

Clean energy: R&D, production, and distribution

R&D

- **IIJA** Hydrogen R&D, demonstration, and deployment (40314); carbon capture utilization, storage, and infrastructure R&D (40301-40303)
- **IRA** Interregional and offshore wind electricity transmission planning, modeling, and analysis (50153)
- **IRA** National laboratory infrastructure, Department of Energy (DOE) oversight (50171, 50172)

Capital goods; variable production costs

- **IIJA** Grid infrastructure resilience and reliability subsidies (4101-40113)
- **IIJA** Subsidies for nuclear power generation (40323), hydropower (40331-40334), carbon capture (40304-40308), urban carbon reduction (11403)
- **IRA** Transmission facilities financing (50151)
- **IRA** Grants to facilitate the siting of interstate electricity transmission lines (50152)
- **IRA** Clean energy investment tax credit (ITC) and production tax credit (PTC): nuclear, hydrogen, solar, wind, storage (13101-13105, 13204,13701, 13702, 13704)

IRA Advanced energy production ITC: (1) Production, recycling of clean energy equipment and vehicles; (2) re-equips an industrial or manufacturing facility with equipment designed to reduce greenhouse gas emissions by at least 20 percent; or (3) re-equips, expands, or establishes an industrial facility for the processing, refining, or recycling of critical materials. (13501)

IRA Advanced manufacturing PTC: domestic manufacturing of components for solar and wind energy, inverters, battery components, and critical minerals. (13502)

IRA Rural electrical production: subsidies (22001, 22002, 22004)

IRA DOE loan program for clean energy technology (50141)

IRA Domestic manufacturing conversion grants: cost-shared grants for domestic production of efficient hybrid, plug-in electric hybrid, plug-in electric drive, and hydrogen fuel cell electric vehicles (50143)

IRA Energy infrastructure reinvestment financing: guarantee loans to projects that retool, repower, repurpose, or replace energy infrastructure that has ceased operations or that enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases (50144)

IRA Tribal energy loan guarantee program (50145)

IRA Tribal electrification program (80003) IRAAvailability of high-assay, low-enriched uranium: support demonstration and deployment of advanced reactors (50173)

IRA Alternative aviation fuel (40007)

Employment rules

IIJA Davis-Bacon

IRA Davis-Bacon; registered apprentice requirements

Auto production and demand

R&D

IIJA Critical materials mapping, research facility; rare earth demonstration facility (40201-40206)

Capital goods; variable production costs

IIJA Advanced battery processing, manufacturing, and recycling subsidies (40206-40210)

IIJA Electric vehicle charging infrastructure grants (11401)

IRA Advanced technology vehicle manufacturing loans: loans to support advanced medium- and heavy-duty vehicles, locomotives, and maritime vessels, including offshore wind vessels, aviation, and hyperloop (50142)

IRA Domestic manufacturing conversion grants: cost-shared grants for domestic production of efficient hybrid, plug-in electric hybrid, plug-in electric drive, and hydrogen fuel cell electric vehicles (50143)

Demand support

IRA Clean vehicle purchase tax credit (13401-13403) IRAAlternative fuel vehicle refueling property credit: tax credit for alternative fuel vehicle refueling and charging property in low-income and rural areas

Employment rules

IIJA Davis-Bacon

IRA Davis-Bacon; registered apprentice requirements

Semiconductor production

R&D

CHIPS National semiconductor technology center, national advanced packaging program (102)

Capital goods; variable production costs

CHIPS Manufacturing subsidies and ITC: fabrication, assembly, testing packaging, legacy and national defense chips (102, 107)

Employment rules

CHIPS Workforce development authorized in National Defense Authorization Act Sections 9902, 9906 for subsidies and ITC authorized in National Defense Authorization Act sections 9902, 9906 for subsidies and ITC

Energy consumption: residential and commercial buildings

Demand support

IRA Tax credits for heat pumps, solar, battery storage (13301-13304)

IRA Residential efficiency and electrification rebates, building efficiency and resilience (50121-50123, 50131, 30001-30002)

Air pollution reduction

Demand support

IRA Grants to Tribes, states, local governments, community organizations, and others to cut greenhouse gas emissions and other harmful air pollutants that impose a disproportionate burden on underserved and vulnerable communities. (60101-60166)

Employment rules

IRA Davis-Bacon; registered apprentice requirements

Endnotes

1 See data in Figure 1. To roughly approximate the current dollar value of expenditures that will take place over time, assume that the $864 billion in government expenditures take place in equal increments over 10 years, and allow for inflation of 4 percent per year. The current value of these expenditures would then be slightly more than $700 billion. Planned private sector capital investment will add significantly to the resources allocated to this effort.

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