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Data and Methods Appendix for America's Advanced Industries: What They Are, Where They Are, Why They Matter

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Defining Advanced Industries

Data Sources

To assess R&D spending per worker by industry, this paper uses the 2009 Business R&D and Innovation Survey (BRDIS) from the National Science Foundation (NSF). Industry R&D per worker was established by calculating the ratio of domestic R&D spending (regardless of sponsor, whether government, university, or private firm) to full-time employees in that industry in 2009. Data on full-time employees was obtained from Moody's Analytics.

BRDIS data offer several advantages in detail and accuracy. The BRDIS survey provides data for almost all industries at a four-digit NAICS code level. For industries where three-digit data were the most detailed available, the research team imputed data at the four-digit level (we have notated where such imputations were made with an asterix in table A-5). The second advantage is that R&D expenditures are assigned to NAICS industries on the basis of a specific establishment's primary line of business, regardless of what the parent company does. This allows for a relatively fine-grained characterization of firms' activities that more accurately situates the diverse R&D activities of large, horizontally integrated firms within particular industries.

To determine the STEM knowledge intensity of four-digit NAICS industries, this study draws on a method developed by one of the coauthors.[1] The method uses O*NET, a rich database created by the Department of Labor's Employment and Training Association. O*NET collects a variety of detailed data from workers on various aspects of their job and the job's requirements. In identifying STEM skills, the study's method relies on the O*NET knowledge survey, which asks workers in specific occupations to rate the level of knowledge in STEM and other domains required to do their job. The level of knowledge required in each STEM domain can thus be quantified for every occupation.

Occupations were deemed STEM-intensive, or to require a high degree of STEM knowledge, if they scored at least 1.5 standard deviations above the mean in one or more of the core STEM fields. For example, computer software programmers score highly on computer knowledge but low on science (consisting of biology, physics, and chemistry). Nonetheless, they are considered STEM workers. Some installation, maintenance, and repair workers score highly on engineering knowledge but low on computer-related knowledge. Using this criterion, in 2013, roughly 21

percent of all U.S. workers were in STEM occupations. The implication is that STEM knowledge is not limited to a small number of occupations officially categorized as engineers or scientists. Rather, STEM knowledge is needed in a variety of occupations, both blue collar and professional.[2]

To link occupations to industries, we use the industry-occupation matrixes provided by the Bureau of Labor Statistics to determine the percentage of workers in STEM occupations for every four-digit NAICS industry at the national level. Table A5 presents the full list of industries, along with R&D per worker information and the industry's share of workers in STEM occupations.

Conceptual Discussion

Industries are not only defined according to their products but also by shared production processes.[3] By advanced industries, this report refers to the set of industries employing specialized labor who draw on scientific and technical knowledge, on the one hand, and deploy that knowledge to research and develop new products and processes, on the other.

As stated in the Methods section of the report, industries are advanced if a greater share of their workforce is STEM oriented than the U.S. average (21 percent) and their R&D spending is at least $450 per worker, which is the 78th percentile of spending per worker. This identifies 50 advanced industries out of the 287 four-digit industries with comparable data.

Both criteria—the STEM labor and R&D orientation—are needed to distinguish a coherent group of industries that meets the conceptual standard laid out above. The raw correlation between the STEM share of employment and R&D spending per worker is just 0.33, suggesting that, although related, they capture different aspects of the production process.[4] As further evidence, in a regression analysis with both variables, each significantly predicts higher rates of industry-level patenting and patenting per worker. However, only the STEM share of employment predicts significantly higher earnings.

Admittedly, these cut-off points are somewhat arbitrary. This section discusses what the definition would have looked like if one or both criteria were altered.

First, there are 132 industries with STEM employment shares of at least 21 percent, and 81 of these do not meet this report's definition of advanced because of inadequate spending on R&D per worker (see Table A-1). The insurance industry has the highest level of R&D spending per worker below $450, with spending at $422. Conceptually, it does not appear to meet the spirit of our definition in that very few insurance companies develop new technologies or products using scientific principles. Only one insurance company is among the top 1,000 patenting companies (and that company's patents seem unrelated to insurance).[5] Patenting per worker in the industry is quite low (just 0.3 patents for every 1,000 workers compared with 0.9 for the United States). Although actuarial science is an important and highly technical STEM field, actuaries constitute only 1 percent of insurance industry workers. A similar case could be made for radio and television broadcasting, which does almost no patenting.

Among the group of industries with less R&D per worker than the insurance industry are some that would seem to meet the spirit of our definition. Intuitively, for example, plastics product manufacturing and paint, coating, and adhesive manufacturing could have been included, given that they patent at high rates and meet the STEM criterion. Including them, however, would have necessitated an arbitrary relaxing of the criteria that would have captured insurance and radio and television broadcasting as well, and so diluted the conceptual integrity of the sector.

A more natural cut-off point might have been the 80th percentile, or $700 of R&D spending per worker. Yet, this would exclude petroleum and coal products manufacturing, oil and gas extraction, and wireless telecommunications carriers. In each of these industries more than 40 percent of workers are employed in STEM occupations and patenting rates run above average. Moreover, petroleum and coal products manufacturing and wireless telecommunications carriers have truly extraordinary rates of patenting—roughly 18 and 19 patents for every 1,000 workers. For these reasons, a cut-off point of $450 created a logical break between industries that strongly reflect the spirit of the definition and those that do not.

Only nine companies exhibit high levels of R&D spending per worker but fail to meet the STEM definition. One of these industries—specialized design services—just missed the cut-off by less than 1 percentage point. It includes interior, industrial, and graphic design. The industry "other professional, scientific, and technical services" also barely missed the cut-off, but it includes marketing, translation services, photographic services, and veterinary services, which do not strongly cohere to the concept of advanced industries. Moreover, these two industries had only moderately high rates of patenting per worker, at 2.3 and 2.0, respectively.

Among the group with high R&D but low STEM employment shares was electronic shopping and mail-order houses, which could be seen as a natural fit with 4.7 patents per worker. Yet, including this and the two industries mentioned above would mean lowering the STEM cut-off below the national average and also including industries such as other support services (packaging services and trade show organization), which does no patenting, and credit intermediation, which includes credit card companies not known for innovation. On the other hand, keeping the STEM cut-off just above the average includes innovation-rich motor vehicle manufacturing and "other miscellaneous manufacturing," which patents at a rate of 20 patents per worker and clearly fits conceptually into advanced industries.

In light of these considerations, the cut-offs used here force imperfect groupings but serve to create a meaningfully coherent set of 50 industries that substantially embody the concept of advanced industries, while excluding those that rely on less scientifically informed processes to develop and deploy their business. Making slight adjustments to the cut-offs would have very little effect on the aggregate findings presented in this report and would only serve to dilute or overly concentrate the balance we have striven to obtain in our classification.

Table A-1. Industry groups that just miss being considered "advanced industries" using the report's criteria

	Domestic R&D Spending per Worker, 2009	STEM Share of Employment, 2012
Industries with high rates of STEM employment but low R&D spending per worker		
Insurance Carriers	$422	25.7%
Rubber Product Manufacturing	$349	24.1%
Plastics Product Manufacturing	$349	27.5%
Radio and Television Broadcasting	$316	32.9%
Wired Telecommunications Carriers	$290	52.7%
Soap, Cleaning Compound, and Toilet Preparation Manufacturing	$265	23.8%
Paint, Coating, and Adhesive Manufacturing	$265	23.8%
Water, Sewage and Other Systems	$233	46.5%
Grain and Oilseed Milling	$229	23.1%
Pulp, Paper, and Paperboard Mills	$203	28.1%
Industries with high R&D spending but low shares of STEM employment		
Specialized Design Services	$607	20.9%
Other Professional, Scientific, and Technical Services	$1,705	18.8%
Activities Related to Credit Intermediation	$1,317	17.6%
Other Support Services	$658	16.7%
Advertising, Public Relations, and Related Services	$6,882	15.0%
Electronic Shopping and Mail-Order Houses	$2,401	14.1%
Beverage Manufacturing	$2,075	13.5%
Newspaper, Periodical, Book, and Directory Publishers	$1,286	13.5%
Consumer Goods Rental	$1,172	6.3%

Calculating Multiplier Effects

To calculate the broader impact of the advanced industries sector on the national economy and those of its regions, the team employed the Bureau of Economic Analysis's (BEA) 2007 Input-Output (I-O) Use tables and data sets on employment by industry, consumer expenditures, and IRS tax return data. The BEA I-O Use table describes the flow of inputs in industry production, calculated in terms of gross domestic product (GDP). We matched these GDP figures with Moody's employment data by industry to determine the differences between advanced industries and the rest of the economy, on a per-worker basis for intermediate value, gross value added, compensation, tax revenue, and profit.

To control for the leakage advanced industry worker consumption expenditures on foreign goods and services through imports, we used the Consumer Expenditure Survey (CES) available from the BLS and adjusted worker spending according the share of U.S. GDP spent on imports. To determine local spending, we used our best judgment to categorize spending categories as

primarily local (housing and some services) or traded (the purchase of goods). The following categories of spending were deemed local: housing, food away from home, fees and admission, medical services, vehicle maintenance, public transportation, utilities, fuel, and public services, personal household services, and personal care products and services. This results in a conservative estimate of local spending given that many local purchases of imported products still generate local value added in the retail sector.

To determine the share of advanced industry firms' own spending that would flow to other foreign and domestic firms, we relied on additional data on import values by commodity provided within the BEA I-O Use tables and assumed that the import content of specific commodities was the same no matter which industry purchases it. We also used IRS corporate tax return data to estimate tax revenue from the advanced industries sector.

To translate the spending of advanced industries workers and companies into jobs, we divided the spending figures for these firms and workers (calculated using the method described above) by U.S. GDP per worker (approximately $107,000). The result is an estimate of the number of workers whose economic activity induced by the advanced industries sector supports. See Table A-2 for details.

Table A-2. Summary of Methods Used to Estimate Local and National Jobs Multiplier for Advanced Industries

Concept	Sources	Assumptions needed for calculation
Output per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Intermediate value per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Gross value added per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Compensation per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Tax revenue per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Gross operating surplus (profit) per worker	BEA 2007 I-O Use Tables for values and Moody's Analytics for employment	None
Allocation of compensation to personal consumption expenditure categories	CES 2012-2013	Assign advanced industries worker allocations to households with incomes of $120,000 to $140,000. The mean earnings for this group are $132,000 for households and $106,000 for estimated individuals using an adjustment factor of 1.24 to match household earnings to individual earnings. This is close to the advanced industries average of $105,634 (using 2007 BEA data). The adjustment of 1.24 divides 2012 mean income for households by mean incomes of individual workers using American Community Survey data. Meanwhile, BEA data suggest the average worker is compensated at $55,258, close to average household-adjusted individual income in the CES, which is $52,000. In other words, these consumption allocations should accurately reflect the average advanced industry and non-advanced industry worker, provided their spending patterns are similar to other Americans with similar incomes.

Allocation of compensation to foreign sources	CES 2012-2013; BEA 2013 Table 1.1.5. Gross Domestic Product	The value of all imports represents 16 percent of U.S. GDP, so this figure is applied to all U.S. incomes to represent the share of personal spending on foreign goods and services.
Allocation of compensation to local sources	CES 2012-2013	The following categories of spending were deemed local: Housing, food away from home, fees/admission, medical services, vehicle maintenance, public transportation, utilities, fuel, public services, personal household services, and personal care products and services.
Allocation of intermediate value added to foreign sources	BEA 2007 I-O Use tables for values and Moody's Analytics for employment	Given the import value of each detailed commodity, which is reported by BEA, one can multiply this value by the industry share of total commodity purchase value to estimate industry import values for each commodity. The sum of total imports for each industry can then be summed by AI and other super-sectors and deduced from total intermediate value to get domestic intermediate value.
Allocation of intermediate value added to local vs domestic sources	BEA 2007 I-O Use tables for values and Moody's Analytics for employment	Commodities are deemed local if the value of imports and exports combined divided by total intermediate value for that commodity is 3 percent or less. 86 commodities are considered local vs. 280 that are considered traded.
Allocation of business taxation to foreign vs domestic governments	IRS, Returns of Active Corporations by Minor Industry Table 1, 2010 Tax year; BEA 2007 I-O Use tables for values; Moody's Analytics for employment	Advanced industries were approximated using three-digit codes. Corporate tax returns assumed to reflect U.S. business.
Translating spending into jobs	BEA 2007 I-O Use tables for values and Moody's Analytics for employment	U.S. GDP per worker represents the amount of GDP--the value of economic transactions net of input--required to generate one additional job. Given that additional spending in an economy is analogous to GDP, values are translated into jobs by dividing value per worker averages by U.S. GDP per worker (approximately $107,000).

Note: BEA = Bureau of Economic Analysis; CES = Consumer Expenditure Survey; I-O = Input-Output Use tables.

Calculating Advanced Industry Patenting Rates

Patents are not classified by the industry of the patent owner. The U.S. Patent and Trademark Office (USPTO) classifies patents into approximately 473 different primary classes (a number which increases as technologies change), but these technologies can be patented by a firm in any industry. Because we are interested in understanding how patenting activity differs for companies in advanced industries, we classified the 1,000 companies (i.e., patent owners) with the most patents granted since 2007. For patents data, we use the Strumsky Patents Database, which is described in other Brookings research.[6] We use industry intelligence provider Hoovers to identify the industry of the company's headquarters, which is meant to reflect the company's primary industry.[7] The top 1,000 patent owners account for 65 percent of all patents during this period. This method may slightly overstate advanced industries' share of patents because we find that patenting outside of advanced industry technology classes appears to be more common for firms with few patents, that is, those further down the list.[8]

To analyze advanced industry trends over time, we attempted to identify advanced industry-intensive technology classes. With the caveat that a company in any industry could invent and patent an advanced industry technology, we believe this method provides value by allowing us to identify trends nationally and across metropolitan areas in the propensity-to-patent-in-technology classes that are heavily oriented to advanced industries. For a patent class to be designated advanced industries, 50 percent or more of the patents in the class must belong to advanced industries firms (recall that the sample is restricted to the subset of patents for which we could identify the industry, that is, the 1,000 largest firms). We calculated these advanced industry-intensity measures for each patent class for three periods 1975–1989, 1990–1999, and 2000–2012 using the year the patent was granted.

Calculating Price Inflation

The Bureau of Labor Statistics publishes data on the prices received from sellers of products. The commodity and industry aggregate amounts for these sale prices compose the "Producer Price Index" (PPI). Unlike the Consumer Price Index, which measures prices that consumers pay, the PPI includes purchases of businesses from other businesses and therefore measures a broader base of economic activity. As with both indices, quality changes are estimated using well-defined procedures by BLS economists to deliver a quality-constant measure of price changes.[9] A relative decrease in an industry's PPI signifies a relative increase in the welfare of its customers.

We use these data to calculate how prices of advanced industries' products have changed over time relative to products made by other producers. We distinguish between manufacturing and service-sector products, but exclude energy products because oil and gas prices are largely determined by international commodities markets, rather than national competition and innovation. To aggregate price indices from industries to sectors, we calculate a weighted average price using real industry GDP as the weight.

Assessing Worker Characteristics and Hiring Difficulty

We compare total earnings and salary and wage earnings for workers in advanced industries with those in other industries. The data for total earnings per worker are from the Bureau of Economic Analysis (BEA) as collected and published by Moody's Analytics. These earnings include income from business ownership, dividends, government transfers, and other sources. Because many workers do not earn significant income from these sources, we also examine wage and salary income, which we obtain from the U.S. Census Bureau's 2012 American Community Survey micro data, accessed via the Integrated Public Use Mircodata Series (IPUMS).[10] IPUMS provides a NAICS-based system, which we use to match advanced industry codes.

We also use census data from IPUMS to describe the distribution of workers by 2012 educational attainment in advanced and other industries. To observe historic changes in these measures, however, we used Current Population Survey data from IPUMS, which allowed us to create a smoother time series without having to rely only on decennial census years.

Job openings data by industry and occupation were obtained from Burning Glass, a workforce information company that collects detailed information on nearly all internet-based job advertisements. We use a subset of these data that covers only company websites to observe the duration of job vacancy advertisements, a measure of hiring difficulty. A detailed description and analysis of these data is provided in a recent Brookings publication.[11]

Devising a Metro Area Advanced Industry Typology

To classify metropolitan areas by their specializations within the advanced industries sector, we rely on location quotients (LQ), a common method of calculating the employment concentration of an industry within a particular subnational geography. Based on LQs, we were able to group all metropolitan areas into one of four categories, shown in the Table A-3.

Table A-3. Categories of Advanced Industry Production by Metropolitan Area Employment Patterns Relative to United States

Metro Area Type	Criteria
Multi-sector advanced industry concentration	MSA has LQ of 1.1 or higher in advanced industries services as well as either AI manufacturing or AI energy
Advanced industry producer	MSA has LQ of 1.1 or higher in either advanced industries manufacturing or energy, but not advanced industries services
Advanced industry service provider	MSA has LQ of 1.1 or higher in advanced industries services but not manufacturing or energy
Low advanced industry concentration	MSA has LQ of less than 1.1 or higher in advanced industries services, manufacturing, and energy

Explaining Regional Variation in Advanced Industries

To identify factors correlated with the size of the advanced industry sector in a place relative to its total employment base, we examined variables relating to population size, educational attainment, skills, and patenting while controlling for state level effects.

We measured skill in two ways. Using data from the Department of Labor and cleaned by Brookings researchers, we divided the metropolitan area share of all H-1B applications (a visa used to employ foreign-born workers to fill jobs requiring at least a bachelor's degree) with the metropolitan share of all U.S. earners with a bachelor's degree or higher.[12] Places with a value of 1 file H-1B applications consistent with their labor supply of college-educated workers. Those with higher values presumably need a disproportionate number of workers with specialized skills, typically in STEM fields. In the second method for assessing the impact of skills, we used data on the skills required and salaries noted for advertised vacancies as described in Brookings research on job vacancies.[13] We assigned each skill a dollar value based on the average salary advertised with that skill. To produce metropolitan data, we averaged the dollar value of each advertised skill on the basis of the number of ads in the metropolitan area that requested that skill.

For longer-term correlates, we examined which factors in 1980 predicted higher advanced industries employment shares today. We regressed 1980 values for the log of patenting, the bachelor's or higher attainment rates, and population size on advanced industry employment rates in 2012. We also included the number of academic research programs ranked in the 90th percentile using data from the National Research Council described in previous Brooking research.[14]

Calculating International Comparisons

To compare the United States to other countries in terms of advanced industry employment, output (GDP), and productivity, we rely on the Organisation for Economic Co-Operation and Development's (OECD) Structural Analysis Database (STAN), which collects and publishes industry based data from countries with publicly available and comparable data. The STAN database does not use an NAICS based system, but rather the International Standard Industrial Classification (ISIC). To maximize the number of countries with available data, we use version 4 of the ISIC, and developed a crosswalk with NAICS. The list of industries is shown in Table A-4.

Table A-4. List of Four-Digit ISIC Sectors Classified as Advanced Industries for International Comparisons

D05T09 Mining and quarrying
D19T23 Chemical, rubber, plastics, fuel products and other non-metallic mineral products
D241T31 Iron and steel
D26T28 Machinery and equipment
D29T30 Transport equipment
D58 Publishing activities
D61 Telecommunications
D62T63 IT and other information services
D69T75 Professional, scientific and technical activities

These categories are too broad in that they encompass industries that are not advanced by our definition. This is particularly true for services, and yet where more detailed data are available from the OECD, the coverage declines. For example, under the professional, scientific, and technical services sector, the OECD does not report R&D services or engineering services for the United States (even though the data are readily available from the BEA) or Sweden. Thus, to capture these industries, as well as management and computer services, we used the broader category, which included non-advanced industries such as legal and accounting services. Likewise, publishing includes software and information services, but also includes traditional newspaper and magazine publishers, which would not make it into our definition.

We report data on the advanced industry share of national employment and GDP as well as advanced industry productivity across countries. To measure productivity, we divide advanced industry value added by employment. Current price GDP figures are adjusted using deflators provided by the OECD and then purchasing power parity index data to adjust for exchange rate differences and spending power.

Beyond advanced industry specific data, we also compare countries by broader measures of innovative capacity and performance and again rely mostly on OECD data. The OECD provides data on R&D expenditures, patents, and the annual number of graduates of tertiary education programs. To compare countries of various sizes on these measures, we normalize R&D spending and patents by total number of workers and graduates by the population aged 20–34.

STEM majors, for their part, consist of life, physical, mathematical, and computer sciences, as well as engineering fields. We used the most recent year for which data were available, typically 2012. Because STEM graduate data are unavailable for foreign metropolitan areas, we conducted regional comparisons only within the United States using data from IPEDS for graduates by institution and county population data from the Census Bureau. We aggregated counties to metropolitan areas using the latest Office of Management and Budget (OMB) definitions.

The most reliable international measures of patenting performance do not rely only on one patenting office because "home office" bias leads local residents to patent at higher rates at their national office.[15] Instead, developers of higher-quality inventions tend to seek international

protection so they can export to a variety of markets. Because there is no international patent, inventors must patent in multiple countries to achieve this protection. The OECD collects international patenting data using two criteria, both of which are associated with higher-quality patents.[16] First, triadic patents are those granted by the European and Japanese patent offices and with applications or approval by the USPTO. The other is Patent Cooperation Treaty (PCT) applications. These inventors submit to offices using a "universal" application form that signals their intention to seek intellectual property protection in multiple offices.

To compare international metropolitan areas, data on PCT applications per capita were obtained from the OECD for the years 2007 to 2010 and averaged over that period to account for single-year outliers and missing data for 2010 or other years. OECD reports these data for a small number of metropolitan areas in a limited number of countries, but it reports that data for a much larger number of TL3 regions, which correspond to metropolitan areas within the United States and are also based on sub-state commuting patterns.[17] One difference is that they rely on BEA definitions of metropolitan areas within the United States, which tend to be somewhat larger. For example, San Francisco and San Jose are combined into one area in these data but are distinct metropolitan areas as defined by the Census Bureau and OMB.

To supplement these data, we analyze the quality of research universities, using the Leiden University Center for Science and Technology Studies (CWTS) ranking, or "Leiden Ranking." This database offers the most straightforward and comprehensive measure of academic research quality and output from around the world by analyzing publications in nearly 13,000 science and social science journals.[18] Given that we are interested in the fields most likely to contribute to innovation, we exclude social science journals when calculating international rankings.

Table A-5. R&D Spending per Worker and Share of Workers in STEM Occupations by Industry

NAICS Code	NAICS Title	Domestic R&D Spending Per Worker (2009)	Share of Industry Workers in STEM Occupations (2012)
2111	Oil and Gas Extraction	$612.9*	0.58*
2121	Coal Mining	$0	0.26
2122	Metal Ore Mining	$835.7	0.47
2123	Nonmetallic Mineral Mining and Quarrying	$141.4	0.18
2131	Support Activities for Mining	$0	0.31*
2211	Electric Power Generation, Transmission and Distribution	$2173	0.46
2212	Natural Gas Distribution	$101.3	0.41
2213	Water, Sewage and Other Systems	$232.9	0.46
2361	Residential Building Construction	$5.8*	0.43
2362	Nonresidential Building Construction	$5.8*	0.45
2371	Utility System Construction	$3.9*	0.19
2372	Land Subdivision	$3.9*	0.21
2373	Highway, Street, and Bridge Construction	$3.9*	0.21
2379	Other Heavy and Civil Engineering Construction	$3.9*	0.22
2381	Foundation, Structure, and Building Exterior Contractors	$1.2*	0.31
2382	Building Equipment Contractors	$1.2*	0.41
2383	Building Finishing Contractors	$1.2*	0.32
2389	Other Specialty Trade Contractors	$1.2*	0.16
3111	Animal Food Manufacturing	$229.3*	0.14
3112	Grain and Oilseed Milling	$229.3*	0.23
3113	Sugar and Confectionery Product Manufacturing	$229.3*	0.13
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	$229.3*	0.15
3115	Dairy Product Manufacturing	$229.3*	0.16
3116	Animal Slaughtering and Processing	$229.3*	0.08
3117	Seafood Product Preparation and Packaging	$229.3*	0.08
3118	Bakeries and Tortilla Manufacturing	$229.3*	0.08
3119	Other Food Manufacturing	$229.3*	0.13
3121	Beverage Manufacturing	$2075	0.13
3122	Tobacco Manufacturing	$0	0.22
3131	Fiber, Yarn, and Thread Mills	$177.9*	0.16*
3132	Fabric Mills	$177.9*	0.16*
3133	Textile and Fabric Finishing and Fabric Coating Mills	$177.9*	0.16*
3141	Textile Furnishings Mills	$8*	0.1*
3149	Other Textile Product Mills	$8*	0.1*

3151	Apparel Knitting Mills	$74.1*	0.07*
3152	Cut and Sew Apparel Manufacturing	$74.1*	0.07*
3159	Apparel Accessories and Other Apparel Manufacturing	$74.1*	0.07*
3161	Leather and Hide Tanning and Finishing	$372.2*	0.1*
3162	Footwear Manufacturing	$372.2*	0.1*
3169	Other Leather and Allied Product Manufacturing	$372.2*	0.1*
3211	Sawmills and Wood Preservation	$131.5*	0.13
3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	$131.5*	0.18
3219	Other Wood Product Manufacturing	$131.5*	0.16
3221	Pulp, Paper, and Paperboard Mills	$203*	0.28
3222	Converted Paper Product Manufacturing	$203*	0.16
3231	Printing and Related Support Activities	$42.9*	0.15*
3241	Petroleum and Coal Products Manufacturing	$693.3*	0.41*
3251	Basic Chemical Manufacturing	$14679.2	0.5
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	$11109.7	0.46
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	$33109.1	0.42
3254	Pharmaceutical and Medicine Manufacturing	$143110.2	0.47
3255	Paint, Coating, and Adhesive Manufacturing	$265.4*	0.23
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	$265.4*	0.23
3259	Other Chemical Product and Preparation Manufacturing	$45778.4	0.29
3261	Plastics Product Manufacturing	$349.1*	0.27
3262	Rubber Product Manufacturing	$349.1*	0.24
3271	Clay Product and Refractory Manufacturing	$6308.5	0.3
3272	Glass and Glass Product Manufacturing	$69.7*	0.25
3273	Cement and Concrete Product Manufacturing	$69.7*	0.19
3274	Lime and Gypsum Product Manufacturing	$69.7*	0.23
3279	Other Nonmetallic Mineral Product Manufacturing	$4557.5	0.21
3311	Iron and Steel Mills and Ferroalloy Manufacturing	$2704.5	0.29
3312	Steel Product Manufacturing from Purchased Steel	$63.8*	0.32
3313	Alumina and Aluminum Production and Processing	$4329.2	0.32
3314	Nonferrous Metal (except Aluminum) Production and Processing	$63.8*	0.41
3315	Foundries	$1372.3	0.36
3321	Forging and Stamping	$152.9*	0.36
3322	Cutlery and Handtool Manufacturing	$152.9*	0.36
3323	Architectural and Structural Metals Manufacturing	$152.9*	0.35
3324	Boiler, Tank, and Shipping Container Manufacturing	$152.9*	0.32
3325	Hardware Manufacturing	$152.9*	0.31
3326	Spring and Wire Product Manufacturing	$152.9*	0.3
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	$152.9*	0.58
3328	Coating, Engraving, Heat Treating, and Allied Activities	$152.9*	0.15
3329	Other Fabricated Metal Product Manufacturing	$152.9*	0.39

3331	Agriculture, Construction, and Mining Machinery Manufacturing	$11709.2	0.39
3332	Industrial Machinery Manufacturing	$23671.5	0.5
3333	Commercial and Service Industry Machinery Manufacturing	$13330.1	0.42
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	$78.2*	0.31
3335	Metalworking Machinery Manufacturing	$78.2*	0.57
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	$13557.4	0.44
3339	Other General Purpose Machinery Manufacturing	$5293.3	0.41
3341	Computer and Peripheral Equipment Manufacturing	$60338.9	0.71
3342	Communications Equipment Manufacturing	$91428	0.57
3343	Audio and Video Equipment Manufacturing	$28074.2	0.32
3344	Semiconductor and Other Electronic Component Manufacturing	$49612.4	0.5
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	$14265.4	0.57
3346	Manufacturing and Reproducing Magnetic and Optical Media	$5919.1	0.28
3351	Electric Lighting Equipment Manufacturing	$820.8*	0.27
3352	Household Appliance Manufacturing	$820.8*	0.27
3353	Electrical Equipment Manufacturing	$820.8*	0.37
3359	Other Electrical Equipment and Component Manufacturing	$820.8*	0.37
3361	Motor Vehicle Manufacturing	$48461.4	0.27
3362	Motor Vehicle Body and Trailer Manufacturing	$759.1	0.22
3363	Motor Vehicle Parts Manufacturing	$6791	0.36
3364	Aerospace Product and Parts Manufacturing	$20501.4	0.59
3365	Railroad Rolling Stock Manufacturing	$2782	0.32
3366	Ship and Boat Building	$4640.1	0.39
3369	Other Transportation Equipment Manufacturing	$13475.7	0.29
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	$96.8*	0.14
3372	Office Furniture (including Fixtures) Manufacturing	$96.8*	0.22
3379	Other Furniture Related Product Manufacturing	$96.8*	0.1
3391	Medical Equipment and Supplies Manufacturing	$24343.1	0.32
3399	Other Miscellaneous Manufacturing	$8547.4	0.22
4231	Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers	$19.3*	0.18
4232	Furniture and Home Furnishing Merchant Wholesalers	$19.3*	0.08
4233	Lumber and Other Construction Materials Merchant Wholesalers	$19.3*	0.08
4234	Professional and Commercial Equipment and Supplies Merchant Wholesalers	$19.3*	0.41
4235	Metal and Mineral (except Petroleum) Merchant Wholesalers	$19.3*	0.16
4236	Household Appliances and Electrical and Electronic Goods Merchant Wholesalers	$19.3*	0.3
4237	Hardware, and Plumbing and Heating Equipment and Supplies Merchant Wholesalers	$19.3*	0.13
4238	Machinery, Equipment, and Supplies Merchant Wholesalers	$19.3*	0.25
4239	Miscellaneous Durable Goods Merchant Wholesalers	$19.3*	0.1
4241	Paper and Paper Product Merchant Wholesalers	$11.9*	0.07

4242	Drugs and Druggists' Sundries Merchant Wholesalers	$11.9*	0.29
4243	Apparel, Piece Goods, and Notions Merchant Wholesalers	$11.9*	0.06
4244	Grocery and Related Product Merchant Wholesalers	$11.9*	0.05
4245	Farm Product Raw Material Merchant Wholesalers	$11.9*	0.16
4246	Chemical and Allied Products Merchant Wholesalers	$11.9*	0.19
4247	Petroleum and Petroleum Products Merchant Wholesalers	$11.9*	0.09
4248	Beer, Wine, and Distilled Alcoholic Beverage Merchant Wholesalers	$11.9*	0.04
4249	Miscellaneous Nondurable Goods Merchant Wholesalers	$11.9*	0.1
4251	Wholesale Electronic Markets and Agents and Brokers	$3.2*	0.19*
4411	Automobile Dealers	$0.1*	0.24
4412	Other Motor Vehicle Dealers	$0.1*	0.14
4413	Automotive Parts, Accessories, and Tire Stores	$0.1*	0.16
4421	Furniture Stores	N/A	0.01
4422	Home Furnishings Stores	N/A	0.02
4431	Electronics and Appliance Stores	$1.9*	0.15*
4441	Building Material and Supplies Dealers	N/A	0.02
4442	Lawn and Garden Equipment and Supplies Stores	N/A	0.1
4451	Grocery Stores	$0.1*	0.01
4452	Specialty Food Stores	$0.1*	0
4453	Beer, Wine, and Liquor Stores	$0.1*	0
4461	Health and Personal Care Stores	N/A	0.14
4471	Gasoline Stations	N/A	0.02*
4481	Clothing Stores	$0.3*	0
4482	Shoe Stores	$0.3*	0
4483	Jewelry, Luggage, and Leather Goods Stores	$0.3*	0.01
4511	Sporting Goods, Hobby, and Musical Instrument Stores	N/A	0.03
4512	Book Stores and News Dealers	N/A	0
4521	Department Stores	$0.1*	0.01
4529	Other General Merchandise Stores	$0.1*	0.01
4531	Florists	N/A	0
4532	Office Supplies, Stationery, and Gift Stores	N/A	0.04
4533	Used Merchandise Stores	N/A	0
4539	Other Miscellaneous Store Retailers	N/A	0.04
4541	Electronic Shopping and Mail-Order Houses	$2401.5	0.14
4542	Vending Machine Operators	$139.5*	0.03
4543	Direct Selling Establishments	$139.5*	0.13
4811	Scheduled Air Transportation	$6.7*	0.32
4812	Nonscheduled Air Transportation	$6.7*	0.22
4821	Rail Transportation	$77.5*	0.18*
4831	Deep Sea, Coastal, and Great Lakes Water Transportation	$0	0.62
4832	Inland Water Transportation	$0	0.74

4841	General Freight Trucking	$1.5*	0.06
4842	Specialized Freight Trucking	$1.5*	0.06
4851	Urban Transit Systems	$0.5*	0.09
4852	Interurban and Rural Bus Transportation	$0.5*	0.07
4853	Taxi and Limousine Service	$0.5*	0.03
4854	School and Employee Bus Transportation	$0.5*	0.03
4855	Charter Bus Industry	$0.5*	0.05
4859	Other Transit and Ground Passenger Transportation	$0.5*	0.05
4860	#N/A	$7*	0.54*
4870	#N/A	$0	0.23*
4881	Support Activities for Air Transportation	$8*	0.38
4882	Support Activities for Rail Transportation	$8*	0.11
4883	Support Activities for Water Transportation	$8*	0.29
4884	Support Activities for Road Transportation	$8*	0.06
4885	Freight Transportation Arrangement	$8*	0.09
4889	Other Support Activities for Transportation	$8*	0.06
4921	Couriers and Express Delivery Services	$0.7*	0.07
4922	Local Messengers and Local Delivery	$0.7*	0.01
4931	Warehousing and Storage	$2.4*	0.06*
5111	Newspaper, Periodical, Book, and Directory Publishers	$1286.4	0.13
5112	Software Publishers	$80977.1	0.7
5121	Motion Picture and Video Industries	$35.3*	0.21
5122	Sound Recording Industries	$35.3*	0.35
5151	Radio and Television Broadcasting	$316.1	0.32
5152	Cable and Other Subscription Programming	$1369.6	0.36
5171	Wired Telecommunications Carriers	$289.7	0.52
5172	Wireless Telecommunications Carriers (except Satellite)	$454.6	0.4
5174	Satellite Telecommunications	$5948.4	0.68
5179	Other Telecommunications	$1998.6	0.57
5182	Data Processing, Hosting, and Related Services	$1020.1*	0.56*
5191	Other Information Services	$27476.4	0.4*
5211	Monetary Authorities-Central Bank	$0	0.43*
5221	Depository Credit Intermediation	$102.6	0.23
5222	Nondepository Credit Intermediation	$61.3	0.2
5223	Activities Related to Credit Intermediation	$1317.1	0.17
5231	Securities and Commodity Contracts Intermediation and Brokerage	$49.1*	0.61
5232	Securities and Commodity Exchanges	$49.1*	0.4
5239	Other Financial Investment Activities	$49.1*	0.58
5241	Insurance Carriers	$421.8	0.25
5242	Agencies, Brokerages, and Other Insurance Related Activities	$62.8	0.08
5251	Insurance and Employee Benefit Funds	$0	0.31

5259	Other Investment Pools and Funds	$0	0.46
5311	Lessors of Real Estate	$1.7*	0.06
5312	Offices of Real Estate Agents and Brokers	$1.7*	0.05
5313	Activities Related to Real Estate	$1.7*	0.12
5321	Automotive Equipment Rental and Leasing	$53.5	0.15
5322	Consumer Goods Rental	$1171.6	0.06
5323	General Rental Centers	$1.6*	0.1
5324	Commercial and Industrial Machinery and Equipment Rental and Leasing	$121.2	0.22
5331	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	$56.4*	0.26*
5411	Legal Services	$0.9	0.03
5412	Accounting, Tax Preparation, Bookkeeping, and Payroll Services	$0	0.44
5413	Architectural, Engineering, and Related Services	$738.5	0.74
5414	Specialized Design Services	$607	0.2
5415	Computer Systems Design and Related Services	$7225	0.74
5416	Management, Scientific, and Technical Consulting Services	$1950.3	0.38
5417	Scientific Research and Development Services	$13626.8	0.72
5418	Advertising, Public Relations, and Related Services	$6881.7	0.14
5419	Other Professional, Scientific, and Technical Services	$1705.5	0.18
5511	Management of Companies and Enterprises	$1.2*	0.38*
5611	Office Administrative Services	$2.6*	0.21
5612	Facilities Support Services	$2.6*	0.12
5613	Employment Services	$2.6*	0.12
5614	Business Support Services	$219.7	0.05
5615	Travel Arrangement and Reservation Services	$51.6	0.06
5616	Investigation and Security Services	$26.6	0.02
5617	Services to Buildings and Dwellings	$2.6*	0.11
5619	Other Support Services	$658.4	0.16
5621	Waste Collection	$87.3	0.06
5622	Waste Treatment and Disposal	$3.4*	0.25
5629	Remediation and Other Waste Management Services	$0	0.14
6111	Elementary and Secondary Schools	$0.2*	0.04
6112	Junior Colleges	$0.2*	0.3
6113	Colleges, Universities, and Professional Schools	$0.2*	0.36
6114	Business Schools and Computer and Management Training	$0.2*	0.25
6115	Technical and Trade Schools	$0.2*	0.16
6116	Other Schools and Instruction	$0.2*	0.06
6117	Educational Support Services	$0.2*	0.24
6211	Offices of Physicians	$13.2	0.36
6212	Offices of Dentists	$9.8	0.33
6213	Offices of Other Health Practitioners	$0.5*	0.24
6214	Outpatient Care Centers	$0.5*	0.35

6215	Medical and Diagnostic Laboratories	$987.9	0.49
6216	Home Health Care Services	$2.9	0.17
6219	Other Ambulatory Health Care Services	$134.1	0.6
6221	General Medical and Surgical Hospitals	$14	0.53
6222	Psychiatric and Substance Abuse Hospitals	$0	0.22
6223	Specialty (except Psychiatric and Substance Abuse) Hospitals	$1.3*	0.45
6231	Nursing Care Facilities (Skilled Nursing Facilities)	$0*	0.1
6232	Residential Intellectual and Developmental Disability, Mental Health, and Substance Abuse Facilities	$0*	0.03
6233	Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly	$0*	0.05
6239	Other Residential Care Facilities	$0*	0.03
6241	Individual and Family Services	$0	0.04
6242	Community Food and Housing, and Emergency and Other Relief Services	$0	0.07
6243	Vocational Rehabilitation Services	$0	0.05
6244	Child Day Care Services	$0	0.01
7111	Performing Arts Companies	$10.1*	0.11
7112	Spectator Sports	$10.1*	0.08
7113	Promoters of Performing Arts, Sports, and Similar Events	$10.1*	0.06
7114	Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	$10.1*	0.06
7115	Independent Artists, Writers, and Performers	$10.1*	0.15
7121	Museums, Historical Sites, and Similar Institutions	N/A	0.13*
7131	Amusement Parks and Arcades	$9*	0.04
7132	Gambling Industries	$9*	0.03
7139	Other Amusement and Recreation Industries	$9*	0.03
7211	Traveler Accommodation	$0*	0.01
7212	RV (Recreational Vehicle) Parks and Recreational Camps	$0*	0.03
7213	Rooming and Boarding Houses	$0*	0
7223	Special Food Services	$0.4*	0
7224	Drinking Places (Alcoholic Beverages)	$0.4*	0
7225	Restaurants and Other Eating Places	$0.4*	0
8111	Automotive Repair and Maintenance	$19.9	0.36
8112	Electronic and Precision Equipment Repair and Maintenance	$1.4*	0.63
8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	$1.4*	0.51
8114	Personal and Household Goods Repair and Maintenance	$1.4*	0.2
8121	Personal Care Services	$2.3*	0
8122	Death Care Services	$2.3*	0.25
8123	Drycleaning and Laundry Services	$2.3*	0.05
8129	Other Personal Services	$2.3*	0.03
8131	Religious Organizations	$0	0.09*
8132	Grantmaking and Giving Services	$0	0.24

8133	Social Advocacy Organizations	$0	0.15
8134	Civic and Social Organizations	$0	0.03
8139	Business, Professional, Labor, Political, and Similar Organizations	$0	0.18

[1] Jonathan Rothwell. "The Hidden STEM Economy" (Washington: Brookings Institution, 2013).

[2] Innovative manufacturing companies, for example, do not split their workforce into scientists and researchers on one side and uneducated and unskilled factory workers on the other. Rather, they rely on an integrated workforce composed of a variety of skilled workers in trade, craft, technician, engineer, and other roles working side-by-side. Technicians, for example, assist researchers by providing guidance on design specifications and the practicality of materials. Skilled production workers use programming, electronics, and engineering skills to make products, ensure systems are running smoothly, diagnose problems, and suggest process improvements. Skilled installation, maintenance, and repair workers ensure that the industrial machines meet the specifications needed for the job and function properly. Managers of these and other workers need to be experts in the technical aspects of the supplies, materials, and processes used to produce known products and create new ones. They also need to apply that knowledge to find and evaluate new market opportunities. For a discussion and references, see Rothwell, "Hidden STEM Economy."

[3] See Census Bureau description of North American Industrial Classification System, available here http://www.census.gov/eos/www/naics/reference_files_tools/NAICS_Update_Process_Fact_Sheet.pdf

[4] This modest correlation cannot solely be attributed to our use of an expanded STEM definition. If one considers only STEM occupations requiring a bachelor's degree or higher, the correlation is 0.43. For an even smaller group—an industry's percentage of workers in occupations with high rates of patenting—based on the 2003 National Survey of College Graduates, the correlation with R&D per worker is still just 0.64.

[5] The enterprise is Columbia Insurance Company. The most frequent technology category for its patent portfolio is apparel and textile products—including footwear design, which does not appear to have anything to do with insurance.

[6] Jonathan Rothwell and others, "Patenting Prosperity: Invention and Economic Performance in the United States and its Metropolitan Areas" (Washington: Brookings Institution, 2013).

[7] In a handful of cases, we "corrected" the Hoovers classification by using a different establishment from the headquarters. For example, we believe General Electric was incorrectly classified in financial services, which likely stems from the size of GE Capital's balance sheet within the parent company.

[8] We have reason to believe that the non-advanced industry share may be higher for smaller companies. Eighty-nine percent of the 100 largest patent owners are advanced industry companies, but only 68 percent of companies ranked in the lowest decile, from 900 to 1,000, are. On the other hand, Hoovers appears to misclassify many companies as non-advanced industries that arguably should be, and this seems even more likely for companies with smaller U.S. patent portfolios, many of which are foreign subsidiaries with U.S. sales offices that Hoover's classifies outside of the company's core business. These cases were corrected by Brookings research staff whenever identified.

[9] Bureau of Labor Statistics, "Quality Adjustment in the Producer Price Index" (June 2014), http://www.bls.gov/ppi/qualityadjustment.pdf.

[10] Steven Ruggles and others, "Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]" (Minneapolis: University of Minnesota, 2010).

[11] Jonathan Rothwell, "Still Searching: Job Vacancies and STEM Skills" (Washington: Brookings Institution, 2014).

[12] Neil G. Ruiz, Jill H. Wilson, and Shyamali Choudhury, "The Search for Skills: Demand for H-1B Immigrant Workers in U.S. Metropolitan Areas" (Washington: Brookings Institution, 2012).

[13] Rothwell, "Still Searching."

[14] Rothwell and others, "Patenting Prosperity."

[15]Paola Criscuolo, "The 'Home Advantage' Effect and Patent Families: A Comparison of OECD Triadic Patents, the USPTO, and EPO," *Scientometrics* 66 (2006): 23-41.

[16]Nicholas van Zeebroeck and Bruno van Pottelsberghe de la Potterie, "Filing Strategies and Patent Value," *Economics of Innovation and New Technology* 20 (2011): 539-561.

[17] Stephane Maraut and others, "The OECD REGPAT Database: A Presentation." Working Paper (Paris: OECD Statistical Analysis of Science, Technology and Industry, 2008).

[18] Ludo Waltman and others, "The Leiden Ranking 2011/2012: Data Collection, Indicators, and Interpretation," *Journal of the American Society for Information Science and Technology* 63 (12) (2012): 2419-2432. Database available at http://www.leidenranking.com/methodology/indicators#sthash.oNhaIUYI.dpuf