MAKING IT IN AMERICA: REVITALIZING US MANUFACTURING

TECHNICAL APPENDIX

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This appendix provides additional detail on the methodologies and data sources employed by the McKinsey Global Institute in *Making it in America: Revitalizing US manufacturing.* The following items are covered:

1. Definition of manufacturing

2. Classification of manufacturing industries in five segments

3. Calculation of historical real value added

4. Assessment of the decline in labor's share of US GDP

5. Calculation of the US incremental manufacturing opportunity over the next decade

6. Evaluation of US competitiveness relative to other major manufacturing nations

7. Calculation of the US consumption-weighted exchange rate

8. Comparison of the financial performance of large vs. small manufacturing firms

9. Evaluation of working capital productivity and the receivables-payables gap

10. Estimation of the investment needed to upgrade the manufacturing asset base for digital readiness

11. Estimation of the cost of a national apprenticeship program

1. DEFINITION OF MANUFACTURING

The manufacturing sector refers to the broad part of the economy made up of establishments that turn raw materials into processed goods, whether sold as intermediate or final products. Specifically, we focus on establishments engaged in production activity that fall within North American Industry Classification System (NAICS) codes 31-33. Any establishment engaged in manufacturing-type activities is considered part of the manufacturing sector, and those with similar production processes are classified under the same NAICS code. Any analysis in this report that relies on national accounts, such as the US Bureau of Economic Analysis (BEA) input-output tables, relies on US Census surveys of establishments.

Any non-manufacturing establishment that participates in the downstream distribution and sale of manufactured goods (such as retail stores, wholesale distribution centers, or logistics warehouses) is excluded from the manufacturing sector, even if it is part of a manufacturing enterprise. These downstream activities are accounted for in other industries such as retail trade, wholesale trade, or transportation.

This raises the question of how to account for upstream activities such as research, design, software development, and computer systems design and related services. These activities are treated differently than downstream activities such as distribution and retail. Data on R&D, software, and computer systems design activity is based on R&D expenditure data from the US National Science Foundation (NSF), which covers not just R&D but also spending on software and computer designs. Unlike the national economic accounts and US

Census data, the NSF data classifies R&D by enterprise (i.e., by company, not by establishment). The NSF data also specifies how much of the activity is paid for by the company ("own-account") versus by others ("sales").[1]

To reconcile NSF data with national accounts, the BEA estimates a portion of these "sales" based on Census data on R&D activity by auxiliary establishments. It subtracts that portion from the primary NSF industry and attributes it instead to establishments in the scientific R&D services industry (NAICS 5417) or the computer systems design and related services industry (NAICS 5415) as appropriate.

This process ends up retaining a significant portion of the initial NSF estimate of R&D spending (both own-account and sales) in the primary industry designated by the NSF. Therefore, most of the R&D, software, and computer design activity in manufacturing enterprises ends up calculated as manufacturing establishment GDP in the industry accounts.

One exception is the pharmaceuticals industry, for which a significant portion (roughly 50 percent of the NSF estimate of R&D in pharmaceutical enterprises) is taken out of the pharmaceutical and medicine manufacturing industry (NAICS 3254) and reclassified as scientific R&D services (NAICS 5417). One BEA estimate from 2004 shows that the scientific R&D service industry's share of total private-sector R&D increased from 5.5 percent to 21 percent after this adjustment, almost entirely at the expense of the pharmaceutical and medicine manufacturing industry.[2]

There are two implications of this definition for the statistics and analyses of manufacturing activity in this report. One is a potential underestimation of value added in what we refer to as the "tech-driven innovative products" manufacturing segment, since some share of the upstream value added is reclassified in the services sector. Interestingly, real value added in the computer systems design and related services industry (NAICS 5415) has grown by 7.5 percent annually since 2005, almost exactly matching the growth rate of the computer and electronics manufacturing industry (NAICS 334). This suggests significant overlap in the establishments of NAICS 5415 with the establishments (and firms) of NAICS 334.

Another implication is a potential underestimation of value added in manufacturing industries in which firms have vertically integrated their production activity with downstream activities such as distribution and customer service. This group primarily consists of industries with significant spending on downstream activity, including those in the vehicles and heavy machinery segment, the resource-intensive commodities segment, and the locally processed goods segment. Some of these downstream establishments have also contributed to the decline in labor's share of GDP—indicating that there may be linkages between the decline of manufacturing firms and their impact on labor's share from activities downstream of production.

2. CLASSIFICATION OF MANUFACTURING INDUSTRIES IN FIVE SEGMENTS

We identify five broad manufacturing segments that vary significantly in their sources of competitive advantage and how different factors of production influence where companies build factories, carry out R&D, and go to market. The five segments are: locally processed goods, vehicles and heavy machinery, tech-driven innovative products, and basic consumer

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[1] Marissa Crawford et al, *Measuring R&D in the national economic accounting system,* US Bureau of Economic Analysis and National Science Foundation, November 2014.[1]

[2] Carol Robbins et al., *Methodology for the industry estimates in the 2007 R&D satellite account,* US Bureau of Economic Analysis and National Science Foundation, December 2007.

goods. Exhibit A1 below provides examples of which industries are included in each of these segments.

Exhibit A1. Defining the five manufacturing segments (1/2)

	NAICS code	Industry name
Basic consumer goods	313	Textiles mills
	314	Textile product mills
	315	Apparel manufacturing
	316	Leather and allied product manufacturing
	335	Electrical equipment, applicance, and component manufacturing
	3399	Other miscellaneous manufacturing
Locally processed goods	311	Food manufacturing
	312	Beverage and tobacco product manufacturing
	323	Printing and related support activities
	3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
	3255	Paint, coating, and adhesive manufacturing
	3256	Soap, cleaning compound, and toilet preparation manufacturing
	3259	Other chemical product and preparation manufacturing
	326	Plastics and rubber products manufacturing
	332	Fabricated metal product manufacturing
	337	Furniture and related product manufacturing

Exhibit A1. Defining the five manufacturing segments (2/2)

	NAICS code	Industry name
Resource-intensive commodities	321	Wood product manufacturing
	322	Paper manufacturing
	324	Petroleum and coal products manufacturing
	3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
	3251	Basic chemical manufacturing
	3253	Pesticide, fertilizer, and other agricultural chemical manufacturing
	327	Nonmetallic mineral product manufacturing
	331	Primary metal manufacturing
Tech-driven innovative products	3254	Pharmaceutical and medicine manufacturing
	334	Computer and electronic products
	3391	Medical equipment and supplies manufacturing
Vehicles and heavy machinery	333	Machinery manufacturing
	336	Transportation equipment

We find this segmentation a helpful way to see the nature of different industries and anticipate where manufacturing activities are most likely to take place. It is also a useful way to explain the evolution of different parts of companies' operations, from individual business units to various stages of their supply chains.

For each segment, we evaluate the importance of inputs in three aspects: innovation, cost, and tradability. Innovation is determined by the relative importance of R&D. Cost is analyzed

through capital, labor, and energy. Finally, tradability is assessed on the importance of freight cost and trade.

The locally processed goods segment is the largest in terms of both value added and employment (accounting for 29 percent and 43 percent of total US manufacturing, respectively). The group includes labor-intensive industries such as fabricated metal products, rubber and plastics, and food and beverages. These products are neither heavily traded nor highly dependent on R&D.

Industries making vehicles and heavy machinery make up the second-ranking segment by value added (23 percent of the national total) and employ almost a quarter of the total manufacturing workforce. Industries in this group are moderately to highly R&D-intensive and depend on a steady stream of innovations and new models to compete. In spite of an increasing level of automation, they still have medium labor intensity.

Tech-driven innovative industries represent a big share of US manufacturing value added (23 percent) but a much smaller share of employment (11 percent). This segment includes industries such as pharmaceuticals and computers and electronics, which are all highly dependent on R&D and innovation. In terms of capital, they typically have an asset-light structure, with variable trade intensity.

Resource-intensive commodities such as basic metals make up 16 percent of manufacturing employment and represent one-fifth of total US manufacturing value added. For these companies, energy prices are crucial, but they are also tied to markets in which they sell, due to high capital and transportation costs.

The presence of basic consumer goods industries such as apparel has significantly shrunk in the United States over the past two decades. Today they represent only 4 percent of US manufacturing value added and 7 percent of employment. These products are highly tradable and still moderately labor intensive.

3. CALCULATION OF HISTORICAL REAL VALUE ADDED

In our analyses, we look at time series of real value-added of manufacturing industries (aggregated into the five major industry segments described above). We cannot simply aggregate (or subtract) real values between industries, as the value-added deflators by industry and segment are different. Therefore, we follow a specific weighted index methodology to more accurately capture real aggregated values. The approach is roughly equivalent to estimating a real weighted growth rate for an industry segment, where the weights are the nominal shares of each industry in that segment in any year.

Below is the methodology used to aggregate the real value added of different industries into segments:

■ Find nominal values and shares by NAICS code for each segment (e.g., for basic consumer goods, find the nominal share of codes 313, 314, 315, 316, and 335 out of the sum of those NAICS codes).

■ Find the real values by NAICS code for a given base year (e.g., 2009 US dollars).

■ Find the year over year (YOY) change in real values by NAICS code.

■ Multiply the YOY change from step 3 above by the nominal share from step 1 above by NAICS code to calculate the "weighted" YOY change by NAICS code.

- Calculate the sum of the weighted YOY change from step 4 by NAICS code to get the "weighted average YOY change" for the segment.

- To calculate real values, start in the year to which real dollars are normalized (2009).

- Multiply the base year value from step 6 by the weighted average YOY change from step 5 to calculate the real values for subsequent years (2010-2016) and divide by the weighted average YOY change to calculate the real values for previous years (1980-2008). This provides the real value add by segment for each year.

4. ASSESSMENT OF THE DECLINE IN LABOR'S SHARE OF US GDP

Previous MGI analysis of US national income and its components has shown a decline in labor's share of national income. For this report, we set out to further assess the relative impact of the manufacturing sector on that decline. We used the OECD-STAN industry database to find the value added (at current prices) and labor costs (compensation of employees) by industry from 1990 to 2015.

The labor share of each industry's total value add was calculated as:

$$\square \quad \frac{Labor\ share_{industry}}{Value\ add_{total}} = \frac{Labor\ share_{industry}}{Value\ add_{industry}} \times \frac{Value\ add_{industry}}{Value\ add_{total}}$$

This calculation allowed us to separate two potential drivers:

- Decline of labor share within the sector's value added

- Decline of the sector's share of value added in the total economy

First, by investigating the change in labor share to total value add, we found that industries such as manufacturing, retail, and transportation experienced the highest decrease, and therefore made the biggest contributions to the gross decline. This gross decline was offset by an increase in labor's share of value add in sectors such as real estate, information and communication, and financial services.

To identify the relative contribution of levers highlighted above, we held each lever constant to arrive at the respective sector's contribution to the decline in labor's share of US GDP.

5. CALCULATION OF THE US INCREMENTAL MANUFACTURING OPPORTUNITY OVER THE NEXT DECADE

We create three scenarios that combine consumption forecasts with industry-by-industry trajectories in the domestic content of finished goods. We focus on this variable because finished goods derive much of their value from supplier inputs and because the deterioration of the US supplier base has been one of the major factors weakening the manufacturing production in recent decades.

Historical data for domestic content shares comes from the US Department of Commerce.[3] We apply these shares to apparent consumption by industry to calculate the domestic content of consumption. We combined this with data on value added of exports from OECD to calculate total manufacturing value added of both consumption and exports.[4]

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[3] For more information, see Jessica R. Nicholson, *2015: What is made in America?*, U.S. Department of Commerce, March 2017.
[4] For more information, see OECD Trade in Value-Added (TiVA) database.

We project the evolution of domestic content to build three forward-looking scenarios:

■ **Current trend.** In the current-trend scenario, we assume that the share of domestically produced content continues its historical trajectory of decline across most industries and apply that assumption to 2025 apparent consumption projections from IHS. For example, we expect domestic content used by US makers of furniture and electrical equipment to continue declining given the increasing commoditization of inputs. On the other hand, there are limited exceptions where domestic content has been on the rise over the past few years, such as petroleum and coal products. In these cases, we do not project any reduction of domestic content.

■ **New normal.** The second scenario assumes that the United States maintains its current share of domestic content in finished goods, arresting the decline. Exceptions are made based on industry specific trends, however. For example, we expect the domestic content of basic consumer goods such as textile products to continue to decline due to the increased margin pressures on the industry and its high trade intensity.

■ **Stretch.** Finally, we consider a stretch scenario in which GDP in some industries returns to a recent historical peak. The assumptions are based on analysis of each industry's health in the United States, global trends, expected demand, as well as opportunities to take advantage of technology and value chain shifts.

As a second step, we calculate the value added impact on non-manufacturing sectors, which would result from the spillover effect of increased manufacturing production on other parts of the economy (e.g., agriculture, professional services), calculated using the domestic direct requirements table for 71 industries from the BEA.

To calculate the implications for employment, we use labor productivity (i.e., GDP per worker) projections from Moody's Analytics for each manufacturing and non-manufacturing industry. All scenarios assume that the overall manufacturing sector achieves labor productivity growth of around 3 percent per year in real terms over the next decade, with higher growth rates in some industries such as motor vehicles, computers and electronics, and fabricated metal products. This estimation is consistent with MGI research showing that accelerated digital technology adoption can help improve productivity growth by up to 3 percent. In these industries, large firms are investing in technology upgrades, and if they follow through with the necessary organizational changes, we expect these investments to translate into incremental productivity gains. This is consistent with an expectation that greater adoption of Industry 4.0 technologies will boost real labor productivity growth above the 1.5 percent annual rate posted over the past decade. It should be noted that we do not believe that the sector will be able to replicate the rapid 6.1 percent annual gains seen during the productivity surge of 1995–2005, since this would require greater technology diffusion among small firms that are currently struggling to invest.

For robustness, we compare our baseline estimates, based on domestic content shares, to projections of other entities (e.g., BLS, Moody's Analytics). We also compared the scenario results to supply-side estimates from previous MGI research.

Data on value added from the BEA and Moody's Analytics is expressed in 2009 dollars. The final step we took was to convert value added estimates to 2015 dollars. To do that, we create a ratio of nominal to real value added (the original series expressed in 2009 dollars), and adjust it to equal to one in 2015. We use that series to convert nominal values to 2015 dollars.

6. EVALUATION OF US COMPETITIVENESS RELATIVE TO OTHER MAJOR MANUFACTURING NATIONS

The "heat map" contained in Chapter 3 combines 26 six independent and composite metrics that we believe are critical to the location decisions of manufacturing firms. Within each metric, we compare the relative position of the United States versus that of other advanced economies (or, in some cases, against that of other major manufacturing nations, including developing economies) both historically and today. In some cases, the point of historical reference is two decades ago; in others, it is one decade ago.

The metrics fall into five main categories: firms (metrics that influence the growth of firms), institutions (metrics that are influenced by the strength and nature of social, financial, economic, and regulatory institutions), infrastructure (metrics that measure the strength of physical and digital infrastructure), ideas (metrics that measure the potential for innovation and R&D commercialization), and people (metrics that measure the strength and availability of talent, labor markets, and training pathways).

We start with raw data, which includes published economic data from the following sources: IHS, the OECD, Enerdata Global Energy & CO2 Database, the US Energy Information Administration/Bloomberg, and survey values from the International Institute for Management Development (IMD) and the World Economic Forum (WEF).

The IMD publishes the annual *World Competitiveness Yearbook* with indicators spanning 61 economies. This is the result of a survey completed by more than 5,400 international executives across the primary/extractive, manufacturing, and service/finance sectors. The distribution of respondents reflects the breakdown of the economic sectors within each country, and the sample size for each country is proportional to its GDP for statistical representation. In order to ensure coverage of geographies and topics, the survey respondents are selected from local and foreign enterprises that have been in operation in the country for at least one year with both nationals and expatriates. IMD also works with 55 partner institutes globally to ensure the sample respondents are representative of the local business community.

We use the Executive Opinion Survey conducted by the WEF, which gathers responses from 13,340 business executives across 135 economies. The survey is a key component of the WEF's *Global Competitiveness Report,* which has been published annually since 1979. Administered through 160 partner institutes globally, the survey selects the respondent sample by preparing a "sample frame" of respondents representing agriculture, manufacturing, non-manufacturing industry, and services sectors, separates the frame by large and all other firms, and choses a random selection of firms based on these criteria. The survey asks respondents to rate particular aspects of a given country's operating environment on a scale of 1 to 7. We also reviewed the World Bank's *Doing Business* indicators to confirm trends gleaned from the IMD and WEF surveys. However, we did not rely directly on the World Bank source due to insufficient historical data.

The chart below includes details of the sources, historical reference years, and group of countries being compared for each metric.

Exhibit A2. Metrics for assessing US competitiveness (1/3)

	Metric	Definition	Source	Historical year
Firms	Market size[1]	Apparent consumption of US as share of world apparent consumption	IHS	1995-1997
	Market growth[1]	US share of global consumption growth	IHS	1995-1997
	Local supplier quality[1]	How do you assess the quality of local suppliers?	WEF	2007
	Local supplier quantity[1]	How numerous are local suppliers?	WEF	2007
Institutions	Ease of doing business[2]	Ease of doing business is supported by regulations	IMD	2005-2007
	Statutory corporate tax rate[2]	Statutory corporate tax rate (combined corporate income tax rate)	OECD	2005-2007
	Availability of capital[2]	Access to capital (average of direct investment flows inward, foreign investors, venture capital, capital markets and credit)	IMD	1995-1997
	▪ Direct investment flows inward	Investment flows inward	IMD	1995-1997
	▪ Foreign investors	Foreign investors are free to acquire control in domestic companies	IMD	1995-1997
	▪ Venture captial	Venture capital is easily available for business	IMD	1995-1997
	▪ Capital markets	Capital markets (foreign and domestic) are easily accessible	IMD	2005-2007
	▪ Credit	Credit is easily available for business	IMD	1995-1997
	Incentives for investment[2]	Investment incentives are attractive to foreign investors	IMD	1997-1999
	Competition regulation[2]	Average of Extent of competition and Legal/regulatory framework	IMD	1995-1997
	▪ Extent of competition	Competition legislation is efficient in preventing unfair competition	IMD	1995-1997
	▪ Legal and regulatory framework	The legal and regulatory framework encourages the competitiveness	IMD	1997-1999
	Regulatory transparency and flexibility[2]	Legal/regulatory framework, adaptability of government policy, bureaucracy, and transparency	IMD	1995-1997
	▪ Transparency	Adaptability of government policy to changes in the economy is high	IMD	1995-1997
	▪ Adaptability of government policy	Transparency of government policy is satisfactory	IMD	1995-1997
	▪ Bureaucracy	Bureaucracy does not hinder business activity	IMD	1995-1997

1 Benchmark includes China, United States, Japan, Germany, South Korea, India, Brazil, UK, Italy, France, Mexico, Indonesia, Canada, Taiwan, and Russia
2 Benchmark includes United States, Italy, France, Canada, Germany, Japan, UK, and South Korea

Exhibit A2. Metrics for assessing US competitiveness (2/3)

	Metric	Definition	Source	Historical year
Infra-structure	Quality of roads[1]	How is the quality (extensiveness and condition) of roads?	WEF	2007
	Quality of port infrastructure[1]	How is the quality (extensiveness and condition) of seaports?	WEF	2007
	Quality of rail infrastructure[1]	How is the quality (extensiveness and condition) of airports?	WEF	2009
	Electricity cost[2]	Electricity cost/kwH	Enerdata	2005-2007
	Natural gas cost[3]	Cost/unit of natural gas	EIA/Bloomberg	2006-2007
	Technological adoption[1]	Average of availability of latest tech, firm level tech absorption, fdi and tech transfer	WEF	2007
	▪ Availability of latest techologies	To what extent are the latest technologies available?	WEF	2007
	▪ Firm-level technology absorption	To what extent do businesses adopt the latest technologies?	WEF	2007
	▪ FDI and technology transfer	To what extent does FDI bring new technology into your country?	WEF	2007
Ideas	Protection of intellectual property[1]	Intellectual property rights are adequately enforced	IMD	1995-1997
	Public and private R&D spend[1]	Total expenditure on R&D	IMD	1995-1997
	University-industry collaboration in R&D[1]	To what extent do business and universities collaborate on research and development (R&D)?	WEF	2007

1 Benchmark includes United States, Italy, France, Canada, Germany, Japan, UK, and South Korea
2 Benchmark includes United States, Italy, France, Germany, Japan, UK, and South Korea
3 Benchmark includes United States, Japan, and UK

Exhibit A2. Metrics for assessing US competitiveness (2/3)

	Metric	Definition	Source	Historical Year
People	Availability of scientists and engineers[1]	To what extent are scientists and engineers available?	WEF	2007
	Size of high-quality labor pool[1]	Size of labor force	IMD	1995-1997
	Ability to attract and retain talent[1]	Average of Attracting and retaining talent and Foreign highly skilled personnel	IMD	2005-2007
	▪ Attracting and retaining talent	Attracting and retaining talent is a priority in companies	IMD	2007
	▪ Foreign highly skilled personnel	Foreign highly skilled personnel are attracted to your country's business environment	IMD	2005-2007
	Flexibility of labor market[1]	Labor regulations (hiring/firing practices, minimum wages, etc.) do not hinder business activities	IMD	1995-1997
	Cooperation in labor employee relations oration[1]	How do you characterize labor-employer relations?	WEF	2007
	Availability of specialized training services[1]	Employee training and apprenticeships	IMD	1995-1997
	▪ Employee training	Employee training is a high priority for companies	IMD	1995-1997

1 Benchmarks are United States, Italy, France, Canada, Germany, Japan, UK, and South Korea   McKinsey & Company | 5

For each metric, we calculate the average and standard deviation for the countries in the comparison set. For most metrics, the comparison set includes other developed economies (United States, Italy, France, Canada, Germany, Japan, United Kingdom and South Korea), but there are a few exceptions. Metrics on market size and growth, for example, use the top 15 manufacturing countries by value add in order to capture rapid growth of emerging markets in the past two decades.[5]

We then find the "standard values," or the number of standard deviations away from the mean for each country by year. The US value would follow the calculation below for any given metric:

$$\frac{2016\ survey\ or\ raw\ data\ value - 2016\ average\ across\ comparison\ set}{2016\ standard\ deviation\ of\ population\ for\ comparison\ set}$$

Some metrics (e.g., availability of capital) incorporate a number of sub-metrics. In these instances, we find the average of all standard values.

Higher values indicate a stronger relative US position, with the exception of the statutory corporate tax rate.

We replicate this calculation for current and historical US position:

■ For the current position, we take the average of 2015–17 or 2014–16 depending on data availability.

5 The top 15 manufacturing nations, ranked in order, are as follows: China, the United States, Japan, Germany, South Korea, India, Brazil, United Kingdom, Italy, France, Mexico, Indonesia, Canada, Taiwan, and Russia.

- For the historical position, we take the average of 1995–97 (or the average of 2005–07, depending on data availability). For values from the World Economic Forum, the historical value is 2007. In some instances, 1997–99 or 2006–07 values are used due to data availability or to exclude outlier years.

We place the US position on a continuum, with "frontier" defined as the position of the most competitive country and "laggard" as the least competitive one, with the center being the mean. We show its placement both today and historically to illustrate trends in competitiveness over time.

7. CALCULATION OF THE US CONSUMPTION-WEIGHTED EXCHANGE RATE

A commonly used economic indicator is the trade-weighted exchange rate, calculated as an average of a country's bilateral exchange rates with its trading partners, weighted by the amount of trade with each trading partner.

The trade-weighted exchange rate for the US dollar does not account for markets with which the United States does not trade but where consumption of manufactured goods might still be significant. In addition, the trade-weighted US dollar exchange rate reflects trade arbitrage opportunities that are already captured by US or foreign producers—unlike a consumption-weighted exchange rate, which reflects arbitrage that has not yet been captured.

In order to complement the trade-weighted indicator, we calculate a consumption-weighted exchange rate for the US dollar. This reflects the US dollar's exchange rate weighted by each country's apparent consumption of manufactured goods. To calculate the consumption-weighted exchange rate, we first find the 2010 real absolute apparent consumption values for the output of manufacturing industries and the share of total by country for the top 15 countries in global manufacturing value-added.[6] Subsequently, we use real absolute exchange rates with the United States by country using the 2010 base year and index the real exchange rate by country to this base year to find the real exchange rate index. Then we multiply each country's apparent consumption share by the indexed real exchange rate for a given year to calculate the consumption-weighted bilateral exchange rate index of each country. Finally, we calculate the sum of these index values of the top 15 countries by value added to calculate the US apparent consumption-weighted exchange rate index, based to 2010.

8. COMPARISON OF THE FINANCIAL PERFORMANCE OF LARGE VS. SMALL MANUFACTURING FIRMS

There has been an increasing debate among economists about the winner-take-most dynamic that is appearing in multiple industries across the US economy, which involves a handful of companies cornering the greatest returns and in effect hollowing out the larger ecosystem. The purpose of this analysis is to test this hypothesis within the manufacturing sector.

For this analysis, we use the publicly released QFR (quarterly financial reports) data for the manufacturing sector from the US Census Bureau. The QFR statements consider sample companies, both publicly traded and privately held, across a cross-section of US manufacturing. The constituent firms are instructed to complete QFR surveys that provide clarity on their balance sheets and income statements covering their domestic operations.

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[6] The top 15 manufacturing nations, ranked in order, are as follows: China, United States, Japan, Germany, South Korea, India, Brazil, United Kingdom, Italy, France, Mexico, Indonesia, Canada, Taiwan, and Russia.

Taking book value of assets as a criterion, the Bureau provides aggregate income statements and balance sheet information by various size classes of manufacturing companies. We use the following four tiers:

■ Total assets of less than $100 million

■ Total assets of $100 million to $250 million

■ Total assets of $250 million to $1 billion

■ Total assets of more than $1 billion

In the analysis, we examine two core drivers of corporate value creation: sales growth and return on invested capital (ROIC).

ROIC is a profitability metric that focuses solely on operating performance. It excludes the impact of non-operating activities and capital structuring decisions. It is calculated as net operating profit less adjusted taxes (NOPLAT) relative to average operating invested capital. ROIC is a useful analytical tool for understanding a company's performance and is preferable to return on equity or return on assets because it focuses solely on the company's operations.

To understand different strategic levers for operating performance, ROIC can be further decomposed into margins and capital turnover. ROIC can be calculated with the following equation:

$$ROIC = (1 - Operating\ tax\ rate) \times \left(\frac{Operating\ profit}{Sales}\right) \times \left(\frac{Sales}{Invested\ capital}\right)$$

Where $\frac{Operating\ profit}{Sales}$ is margins; and $\frac{Sales}{Invested\ capital}$ is capital turnover.

Some key elements of ROIC calculation are defined as follows:

■ **Operating profit** is equivalent to earnings before interest and taxes (EBIT).

■ **NOPLAT** (net operating profit less adjusted taxes): Operating profit minus operating tax (i.e., taxes attributable to core operations). We use the US marginal tax rate as a proxy for operating tax in this analysis. Unlike net income, which is profit only available to equity holders, NOPLAT represents profit available to all stakeholders (i.e., equity and debt holders).

■ **Invested capital** represents the amount invested in the core operations of the business. It is calculated as:

$$Invested\ capital = Net\ operating\ working\ capital + Net\ PP\&E + Net\ other\ operating\ costs$$

Net operating working capital equals operating current assets minus operating current liabilities; while **net PP&E** is the book value of property, plant, and equipment (e.g., production equipment and facilities) and is always included in operating assets;

9. EVALUATION OF WORKING CAPITAL PRODUCTIVITY AND THE RECEIVABLES-PAYABLES GAP

Another important part of assessing the performance of manufacturing companies within each size tier is understanding their ability to manage working capital. The key metrics we considered in this analysis are as below:

- **Net operating working capital to sales ratio:** Net operating working capital to sales ratio helps assess a company's efficiency in managing its working capital relative to sales. An important component of the ratio is the **net operating working capital**, which equals operating current assets minus operating current liabilities

  - **Operating current assets** comprise all current assets necessary to support ongoing operations, which includes operating cash (assumed one week of working cash), trade accounts receivable, inventory, and other current assets.

  - **Operating current liabilities** include liabilities related to business operations of the firm (e.g., accounts payable, income taxes payable, and other current liabilities).

  A lower net operating working capital to sales ratio implies that a company is efficiently using of its current operating assets and liabilities for supporting sales.

- **Gap between account receivables and account payables:** This gap provides a proxy for highlighting the degree of negotiating power a company commands over its debtors and creditors.

  - **Accounts receivable** include trade accounts and trade notes receivable less allowance for doubtful accounts. It represents the amount owed to a company by its clients for products received or services rendered.

  - **Accounts payable** include trade accounts and trade notes payable. It represents a company's obligations for the products or services received on credit from its suppliers.

  A consistent decline in this gap over long term would suggest that a company has been able to better negotiate payment terms with its suppliers/creditors.

10. ESTIMATION OF THE INVESTMENT NEEDED TO UPGRADE THE MANUFACTURING ASSET BASE FOR DIGITAL READINESS

The advent of digital technology creates the need to upgrade the asset base in manufacturing. We estimate the total cost of what is required by first estimating the gross stock of the US manufacturing base and then applying the estimated cost of replacement.

Using BEA data, we estimate the gross stock of the US manufacturing base for both equipment and structures by adding depreciation to net stock. We used tables 3.1E, 3.4E, 3.1S, and 3.4S from BEA's National Income and Product Accounts for this analysis. The average net stock figure is ~$2.3 trillion, while the average depreciation is ~$0.2 trillion from 2010–16. This leads to a cumulative average of ~$2.5 trillion for the gross stock of both equipment and structures.

Next, we use McKinsey Industry 4.0 Global Expert survey results from 2015, which indicate that companies expect about 40 to 50 percent of the existing installed base of manufacturing equipment will need to be replaced in order to achieve digital/Industry 4.0 readiness.

Assuming a 45 percent replacement ratio applied to the $2.5 trillion base estimate, we estimate an additional $115 billion annual capex investment will be required over the next decade to deploy these new technologies.

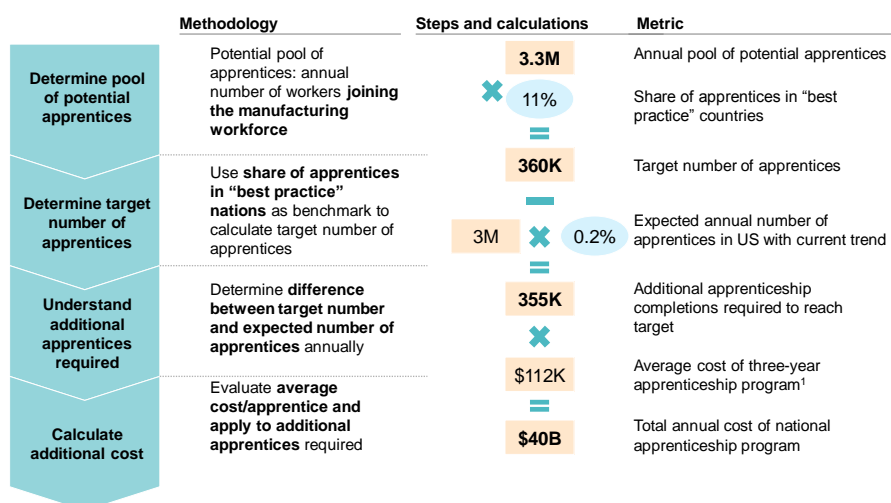## 11. ESTIMATION OF THE COST OF A NATIONAL APPRENTICESHIP PROGRAM

In order to size the annual cost of a federal apprenticeship program, we take a benchmark-driven approach.

First, we identify the potential pool of apprentices. We take this to be the 3.3 million workers hired by the US manufacturing sector in 2016 (per the BLS). We then determine the target share of apprentices trained through Vocational Education Training (VET) systems, using the ~11 percent average of estimated share of apprentices out of total recent hires in Germany, Austria, and Switzerland. Multiplying the potential pool by the target share, we arrive at our target annual number of ~360,000 apprentices joining the US manufacturing workforce annually. Since apprenticeships typically run for three years, this means that roughly one million workers would be in various stages of training at any given time once such a program was in place to ensure that the required number of apprentices complete their training and join the workforce annually.

By looking at the number of active apprentices as a share of recent hires, we estimate that ~0.15 percent of recent manufacturing hires go through an apprenticeship training program in the United States today. This confirms the notion that the United States invests relatively little in apprenticeships. Taking into account the current scale of apprenticeships, we are left with 355,000 additional apprentices needed annually to reach benchmark levels.

Lastly, we estimate that a typical apprenticeship costs $37,000 per apprentice annually and that the average apprenticeship program lasts three years. These estimates are based on case examples of apprenticeship programs worldwide. This results in an estimated $40 billion total annual cost of the national apprenticeship program. The exhibit below outlines the steps involved in this calculation.

Exhibit A3. We estimate that a national manufacturing apprenticeship program would cost ~$40 billion annually

	Methodology	Steps and calculations	Metric
Determine pool of potential apprentices	Potential pool of apprentices: annual number of workers **joining the manufacturing workforce**	**3.3M** ✖ 11% =	Annual pool of potential apprentices / Share of apprentices in "best practice" countries
Determine target number of apprentices	Use **share of apprentices in "best practice" nations** as benchmark to calculate target number of apprentices	**360K** − 3M ✖ 0.2% =	Target number of apprentices / Expected annual number of apprentices in US with current trend
Understand additional apprentices required	Determine **difference between target number and expected number of apprentices** annually	**355K** ✖ $112K	Additional apprenticeship completions required to reach target / Average cost of three-year apprenticeship program[1]
Calculate additional cost	Evaluate **average cost/apprentice and apply to additional apprentices** required	= **$40B**	Total annual cost of national apprenticeship program

1 Calculated assuming an average length of three years and average annual cost of $37K per year

McKinsey & Company | 6