

# BROOKINGS

Report

## **Global manufacturing scorecard: How the US compares to 18 other nations**

Darrell M. West and Christian Lansang Tuesday, July 10, 2018

### **Executive summary**

**M**anufacturing is enjoying a resurgence in the United States. After years of falling output and a diminishing percentage of the labor force, the last few years have seen renewed growth. According to PriceWaterhouseCoopers, the catalysts for this revival include factors such as the strengthening economy, workforce quality, tax policies, the regulatory environment, and transportation and energy costs.<sup>[1]</sup>

Yet in order to move forward, it is important to see how American manufacturing compares to that of other nations. In this report, we develop a global manufacturing scorecard that looks at five dimensions of the manufacturing environment: 1) overall policies and regulations; 2) tax policy; 3) energy, transportation, and health costs; 4) workforce quality; and 5) infrastructure and innovation.

For the analysis, we compiled data on 20 indicators and scored 19 leading nations on a 100-point scale. The countries analyzed included Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Netherlands, Poland, Russia, South Korea, Spain, Switzerland, Turkey, United Kingdom, and the United States.

The top ranked nations in overall manufacturing environment were the United Kingdom and Switzerland (both with 78 points out of 100), followed by the United States (77 points), Japan (74 points), and Canada (74 points). We found these nations performed well due to their policies, cost considerations, workforce investments, and infrastructure.

At the low end were nations such as Brazil (51 points), Indonesia (53 points), Mexico (56 points), Russia (56 points), and India (57 points). Generally, these places do not have advantageous tax policies and are not making adequate investments in education or infrastructure.

In addition, we compiled data on manufacturing output, manufacturing employment, and changes overtime. China is the top nation in terms of manufacturing output and the percentage of its national output that is generated by that sector. Poland meanwhile has the highest percentage of its workforce employed in manufacturing, followed by Germany, Italy, Turkey, and South Korea.

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There have been important changes over the past few decades in country rankings based on manufacturing output. Most nations show fairly stable patterns over the past 40 years, but a few have increased their performance. One

such example is India, which improved its output ranking from 14th in 1990 to sixth in 2015. In contrast, Spain had dropped in manufacturing performance from ninth in 2005 to 14th in 2015. The same is true for Russia, as it was ranked second in manufacturing output in 1980 but now has dropped to 15th in the world.

Based on our analysis, we make a number of recommendations for improving the manufacturing environment. Our suggestions include:

1. Pursue a governance strategy that emphasizes political and economic predictability, and open trade policies. Developing policies that provide access to global markets and facilitate technology diffusion will help the manufacturing sector.
2. Provide the proper financial incentives to promote innovation, education, and workforce development. This includes R&D tax credits and equipment expensing tax credits that help companies overcome the fixed costs of production and distribution. Additionally, providing grants and loans to domestic manufacturers can aid in the growth of businesses and their technology innovation.
3. Unlock 21st century tools such as Big Data, automation, and artificial intelligence. These forms of technology have the capacity to revolutionize manufacturing from the initial design of goods to the successful delivery of products.
4. Help small firms through technology research and workforce development. Technology development and its diffusion into the manufacturing sector leads to the creation of higher paying jobs, and workers with more developed skills.
5. Rules that encourage transparency of business practice help to alleviate corruption and its damaging ripple effects. Whistleblower protection and investing in detection capabilities can aid in weakening the roots of corruption.

6. Finance the necessary physical and digital infrastructure to support business development. Physical infrastructure such as roads, bridges, dams, and ports are necessary to connect supply chains as is the deployment of digital infrastructure such as high-speed broadband and mobile technology. The creation of adequate infrastructure helps companies operate efficiently and grow overtime.

## Top countries in terms of manufacturing output

China leads the world in terms of manufacturing output, with over \$2.01 trillion in output (see Table 1). This is followed by the United States (\$1.867 trillion), Japan (\$1.063 trillion), Germany (\$700 billion), and South Korea (\$372 billion).

Manufacturing constitutes 27 percent of China's overall national output, which accounts for 20 percent of the world's manufacturing output. In the United States, it represents 12 percent of the nation's output and 18 percent of the world's capacity. In Japan, manufacturing is 19 percent of the country's national output and 10 percent of the world total. Overall, China, the United States, and Japan comprise 48 percent of the world's manufacturing output.

**Table 1: Leading countries on manufacturing output, 2015**

Country	Manufacturing Output (USD in billions)	Percent of National Output	Percent of Global Manufacturing
China	\$2,010	27%	20%
United States	1,867	12	18
Japan	1,063	19	10
Germany	700	23	7
South Korea	372	29	4
India	298	16	3

Country	Manufacturing Output (USD in billions)	Percent of National Output	Percent of Global Manufacturing
France	274	11	3
Italy	264	16	3
United Kingdom	244	10	2
Taiwan	185	31	2
Mexico	175	19	2
Spain	153	14	2
Canada	148	11	1
Brazil	146	11	1
Russian Federation	139	11	1
Turkey	125	18	1
Indonesia	115	22	1
Poland	100	20	1
Switzerland	93	18	1
Netherlands	88	12	1

*Source: United Nations Conference on Trade and Development, 2015*

## Proportion of workforce employed in the manufacturing sector

Poland is the leading country in terms of the percentage of its population employed in manufacturing (see Table 2). A total of 20.2 percent is employed there, followed by Germany (19 percent), Italy (18.5 percent), Turkey (18.1 percent), South Korea (16.9 percent), China (16.9 percent), and Japan (16.9 percent). About 10.5 percent of the American workforce is employed in manufacturing.

**Table 2: Proportion of workforce employed in the manufacturing sector**

Country	Total Number Employed in Manufacturing Sector	Percentage of Population Employed in Manufacturing
Poland	3,540,000	20.2%
Germany	7,911,000	19
Italy	4,090,000	18.5
Turkey	5,012,000	18.1
South Korea	4,499,000	16.9
China	128,869,000	16.9
Japan	10,958,000	16.9
Mexico	9,154,000	16.3
Russian Federation	10,260,000	14.4
Indonesia	16,363,000	13.5
Switzerland	612,000	13
France	3,396,000	12.4
Spain	2,332,000	12.3
Brazil	10,388,000	11.4
India	57,244,000	11.4
United States	16,381,000	10.5
Netherlands	898,000	10.4
United Kingdom	3,069,000	9.5

*Source: International Labour Organization, 2017*

## **Changes in regional manufacturing employment, 1970-2011**

There have been significant shifts in manufacturing employment between 1970 and 2011 (see Table 3). In developed countries, manufacturing comprised 16.8 percent of the workforce in 1970, but only 12.8 percent in 2011. In contrast, several regions have increased their focus on manufacturing. For example, manufacturing in East Asia (including China and South Korea) totaled 13.9 percent of the workforce in 1970, but 21.5 percent in 2011. Southeast Asia went from 11.4 percent in 1970 to 14 percent in 2011. India increased from 9.4 percent in 1970 to 11.6 percent in 2011.

**Table 3: Percent of workforce employed in manufacturing, 1970-2011**

Region	1970	1980	1990	2000	2007	2011
Developed Countries (U.S., Europe, Japan)	26.8%	23.9%	20.7%	16.9%	14.3%	12.8%
East Asia (China and South Korea)	13.9	22.5	24.3	20.9	21.2	21.5
Southeast Asia (Indonesia, Malaysia, Philippines, Thailand)	11.4	14.4	15.6	16.3	15.4	14.0
India	9.4	9.1	10.5	11.4	11.9	11.6
Latin America	15.5	15.4	15.3	13.2	12.4	11.5
North Africa	12.6	13.8	14.4	14.0	12.9	11.9
Sub-Saharan Africa	5.8	7.2	8.3	8.3	8.6	8.4

Region	1970	1980	1990	2000	2007	2011
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Source: United Nations Conference on Trade and Development, 2016

## Changes in country manufacturing output, 1970-2015

Most countries have been fairly stable in their manufacturing output over the past few decades, but there have been some shifts since 1970. For example, in 1970, the top countries were the United States, USSR, Japan, Germany, China, the United Kingdom, France, Italy, and Canada (see Table 4). However, by 2015, the leaders had shifted to China, the United States, Japan, Germany, South Korea, India, Italy, the United Kingdom, and France.

**Table 4: Changes in country rank ordering on manufacturing output, 1970-2015**

Year	U.S.	Russia	Japan	Germany	China	U.K.	France	Italy	Canada	Spain
1970	1	2	3	4	5	6	7	8	9	10
1980	1	2	3	4	5	8	6	7	11	10
1990	1	7	2	3	8	6	5	6	11	10
2000	1	16	2	3	4	5	7	7	9	11
2005	1	14	2	4	3	7	6	5	10	9
2006	1	14	2	4	3	7	6	5	10	9
2007	1	12	3	4	2	8	6	5	13	10
2008	1	9	3	4	2	7	6	5	14	11
2009	1	17	3	4	2	10	6	5	14	11
2010	2	11	3	4	1	10	8	6	14	12
2011	2	11	3	4	1	10	9	6	14	15
2012	2	10	3	4	1	11	8	7	14	15



Year	U.S.	Russia	Japan	Germany	China	U.K.	France	Italy	Canada	Spain
2013	2	9	3	4	1	11	8	6	14	15
2014	2	11	3	4	1	9	8	7	14	15
2015	2	15	3	4	1	8	9	7	13	14

Source: <http://www.madeherenow.com/news/post/2017/01/27/britain-moves-up-the-world-manufacturing-league-table>

Year	Taiwan	India	Brazil	Mexico	Switzerland	Turkey	South Korea	Thailand	Indonesia
1970	11	12	13	14	15	16	17	18	19
1980	14	13	9	12	15	16	17	19	18
1990	17	14	9	13	16	15	12	19	18
2000	14	13	12	10	17	15	8	19	18
2005	15	12	10	11	17	16	8	19	18
2006	16	12	10	11	18	17	8	19	15
2007	17	9	11	14	18	16	7	19	15
2008	17	12	10	13	18	16	8	19	15
2009	16	9	8	13	18	18	7	19	15
2010	16	9	7	13	18	17	5	19	15
2011	17	8	7	13	16	18	5	19	12
2012	16	6	9	12	18	17	5	19	13
2013	16	7	10	12	18	17	5	19	13
2014	16	6	10	12	17	18	5	19	13
2015	16	6	12	10	17	18	5	19	11

Source: <http://www.madeherenow.com/news/post/2017/01/27/britain-moves-up-the-world-manufacturing-league-table>

During this time period, one nation that improved considerably is India. It raised its output ranking from 14th in 1990 to sixth in 2015. In contrast, Spain dropped in manufacturing performance from ninth in 2005 to 14th in 2015. The same is true for Russia, as it was ranked second in manufacturing output in 1980 but now has dropped to 15th in the world.

## **Ranking countries on manufacturing environment**

One of the important determinants of how countries perform is their overall manufacturing environment. To assess this, we looked at five dimensions of the overall environment: policies and regulations; tax policy; energy, transportation, and health costs; workforce quality; and infrastructure and innovation (see Appendix for details on measures and information sources).

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**Based on 20 indicators, we developed a 100-point scale to rank countries on their manufacturing environment. The top-ranked nations were the United Kingdom and Switzerland.**

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For overall policies, we included indicators on pro-business environment, a risk index, corruption, and open trade policies. With tax policies, we looked at corporate tax rates, use of R&D tax credit and expensing options, and government grants or loans to support manufacturing. On costs, we examined electricity, oil/LNG, and health care costs. Workforce quality included measures on K-12 government spending, higher education spending, family income, labor

productivity, and labor support. On infrastructure and innovation, we relied upon infrastructure spending as a percent of GDP, internet access, patent filings, R&D spending as a percent of GDP, and hazard exposure.

Based on these 20 indicators, we developed a 100-point scale to rank countries on their manufacturing environment. Table 5 shows that the top nations included the United Kingdom (a score of 78), Switzerland (78), the United States (77), Japan (74), Canada (74), and the Netherlands (74).

**Table 5: Country rankings on manufacturing environment, 2018**

Country	Total Score out of 100 Points
United Kingdom	78
Switzerland	78
United States	77
Japan	74
Canada	74
Netherlands	74
South Korea	73
Germany	72
Spain	72
France	70
Poland	69
Italy	62
China	61
Turkey	58
India	57
Russia	56
Mexico	56

Country	Total Score out of 100 Points
Indonesia	53
Brazil	51

*Source: Authors' computations*

At the low end of our scale were Brazil (a score of 51), Indonesia, (53), Mexico (56), Russia, (56), and India (57). These countries lagged the other examined nations on a number of different dimensions.

## Breakdowns on the manufacturing environment

Table 6 lists the detailed breakdowns of our 20 indicators for each nation. This table shows how each country fared on these measures for the five dimensions. As an illustration, the United Kingdom garnered top scores for its pro-business environment, risk index, lack of corruption, and corporate tax policies, but lower marks on infrastructure, patent filings, and higher education spending.

This was in contrast to Brazil, which did not perform well on its business environment, tax policies, higher education spending, infrastructure, and patent filings. Those issues limit the country's output and productivity, and act as a drag on economic prosperity.

**Table 6: Detailed breakdowns on manufacturing environment, 2018**

	U.K.	Switzerland	U.S.	Japan	Canada	Netherlands	South Korea	Germany	Spain
<b>Overall Policies</b>									
Pro-Business Environment	5	5	5	5	5	5	5	5	5
Risk Index	5	5	5	5	5	5	5	5	5
Corruption Extent	5	5	5	5	5	5	4	5	4

	U.K.	Switzerland	U.S.	Japan	Canada	Netherlands	South Korea	Germany	Spain
Open Trade	5	5	5	4	5	5	4	5	5
<b>Tax Policy</b>									
Corporate Taxes	5	5	1	3	3	4	4	3	4
R&D Tax Credits/Expensing	4	3	4	3	4	4	3	2	4
Govt Grans/Loans	4	4	2	4	4	4	2	4	4
<b>Costs</b>									
Electricity	2	1	2	2	2	1	3	1	1
Oil/LNG	4	5	5	4	1	5	3	4	4
Health care	4	1	1	4	3	3	4	3	4
<b>Workforce Quality</b>									
K-12 Spending	5	4	4	3	4	4	4	3	3
Higher Ed Spending	3	3	5	3	5	3	4	3	3
Family Income	3	5	4	3	4	4	4	4	3
Labor Productivity	4	5	4	3	4	4	3	4	4
Labor Support	4	4	5	4	4	3	3	2	3
<b>Infrastructure and Innovation</b>									
Infrastructure as Percent of GDP	2	2	2	3	2	1	3	2	3
Internet Access	5	5	5	5	5	5	5	5	5
Patent Filings	2	2	4	4	2	2	3	3	1
R&D Percent of GDP	2	4	4	4	2	3	5	4	2
Hazard Exposure	5	5	5	3	5	5	2	5	5

U.K. Switzerland U.S. Japan Canada Netherlands South Korea Germany Spain

Source: Authors' computations

France Poland Italy China Turkey India Russia Mexico Indonesia Brazil

### Overall Policies

Pro-Business 4 4 4 1 2 2 2 3 3 2

Environment

Risk Index 5 4 5 2 1 3 1 3 2 2

Corruption Extent 4 5 4 3 3 3 2 2 3 3

Open Trade 4 5 3 3 4 3 3 4 4 2

### Tax Policy

Corporate Taxes 2 5 4 4 5 3 5 3 4 2

R&D Tax

Credits/Expensing 4 2 3 2 2 4 4 3 3 3

Govt Grans/Loans 4 4 2 2 4 4 2 4 2 2

### Costs

Electricity 1 3 1 4 4 3 5 4 5 3

Oil/LNG 4 5 4 5 5 4 1 2 4 2

Health care 3 5 4 5 5 5 5 5 5 5

### Workforce Quality

K-12 Spending 4 3 3 4 3 3 2 4 3 5

Higher Ed

Spending 3 3 2 2 3 2 3 3 2 2

Family Income 4 2 3 1 1 3 2 1 1 1

Labor Productivity 4 1 4 2 3 1 3 2 1 2

Labor Support 2 3 2 3 2 2 2 3 2 2

	France	Poland	Italy	China	Turkey	India	Russia	Mexico	Indonesia	Brazil
<b>Infrastructure and Innovation</b>										
Infrastructure as Percent of GDP	3	3	2	5	2	4	2	2	4	2
Internet Access	5	4	4	3	3	2	4	3	2	4
Patent Filings	2	1	2	5	1	2	2	1	1	1
R&D Percent of GDP	3	2	2	3	1	1	2	1	1	2
Hazard Exposure	5	5	4	2	4	3	4	3	1	4

*Source: Authors' computations*

## What top country performers are doing

In looking at the nations that did well on our manufacturing index, we found that they took manufacturing seriously and had a number of policies conducive to developing that sector. We look at three different countries (the United Kingdom, Switzerland, and the United States) to see what they are doing to help manufacturing.

### *United Kingdom*

The United Kingdom's manufacturing industry has been strengthened recently by the drop in the value of the British pound against the U.S. dollar and the euro, thereby facilitating an increased demand overseas for U.K. goods. Beyond the currency angle, though, manufacturing there retains a strong presence because of its important role in the export economy. Although the sector only contributes 10 percent to the nation's GDP, it comprises 44 percent of U.K.'s exports. Over 70 percent of all U.K. manufacturers believe that conditions are right for improving export growth and 76 percent of manufacturers in the U.K. have a strategy they believe will help their business grow overseas.

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## **The U.K. provides tax incentives that facilitate excellent manufacturing research and development.**

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In the medium to long term, the U.K.'s strength in manufacturing aims to capture a larger proportion of overseas market. This is promising as 89 percent of manufacturers say they seek to build long-term customer loyalty overseas.<sup>[2]</sup> Of course, one drawback of the weak pound is it increases import costs for certain supplies. National leaders will have to keep their eye on that fact in order to keep costs reasonable for production.

The U.K. provides tax incentives that facilitate excellent manufacturing research and development. The U.K. scored highly in each of the categories under tax policy and the country is known for its expertise in manufacturing R&D. Specifically, the automotive industry and aerospace industry in the U.K. are world-class. Contrary to the general trend across Europe, the automotive industry has achieved record growth and the country is positioned to hit an annual production target of two million vehicles by 2021.<sup>[3]</sup> Fifty percent of all automobiles built in the U.K. are exported, 2,000 companies are involved in its automotive sector, and 18 out of the 20 largest automotive suppliers are located within the country as well.

Ninety percent of all aerospace goods made in the U.K. are exported, and the industry is anticipated to grow in the U.K. by a rate of 6.8 percent for the coming years. The industry is well positioned as some of the most intricate aerospace parts like wings, engines, avionics, and systems for civil aircrafts are made within the country.<sup>[4]</sup> Though the U.K.'s success in manufacturing can largely be attributed to their expertise in aerospace and automotive industries, it is



important to note this success hinges on open trade policies. As Brexit negotiations unfold, the future of the industry likely will experience considerable turbulence if free-trade is stifled in any major way through rules or tariffs.

### ***Switzerland***

Switzerland's strong manufacturing industry has been helped by its effective governance policies. The country has transparent and fair processes, strong judicial effectiveness, and considerable economic and political stability due to its long-held international neutrality. Although the Swiss franc is currently a very strong currency, there is very little currency inconvertibility or transfer restriction risk and investors are free to convert and transfer funds in and out of Switzerland without the fear of restrictive policies. Additionally, Switzerland prioritizes being a strong trading country; the combined value of imports and exports equals 114 percent of its GDP and its applied tariff rate averages 0 percent.<sup>[5]</sup> Coupled with a low corporate tax rate, these policies lay down the groundwork for a very successful manufacturing base as investors maintain confidence in the business climate.

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**Although Swiss costs of production and a strong franc do pose some risks, the country has capitalized on its workforce advantages as well as its stable political environment to build one of the strongest manufacturing industries in the world.**

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The workforce talent and manufacturing quality in Switzerland are top-flight. The country has a large stock of highly skilled workers, and the value-add to their economy through their manufacturing industry is one of the highest in the world. Because their economy is developed and stable, they are home to some of the biggest pharmaceutical and computer product giants globally such as Novartis and Hoffman-La Roche. According to Bloomberg's Innovation Index, Switzerland's pharmaceutical manufacturing industry and computer and electronics industry respectively added \$27.02 billion and \$26.96 billion in gross revenue.<sup>[6]</sup> Although Swiss costs of production and a strong franc do pose some risks, the country has capitalized on its workforce advantages as well as its stable political environment to build one of the strongest manufacturing industries in the world.

### ***United States***

The United States manufacturing sector has benefited from a talented workforce, advanced technology, and pro-business policies. American manufacturing drives 35 percent of productivity growth, 60 percent of exports, and 70 percent of private sector R&D.<sup>[7]</sup> Additionally, manufacturers contributed \$2.17 trillion to the United States economy which is nearly 12.1 percent of the U.S. GDP.<sup>[8]</sup> Although labor costs in the United States are significantly higher than other countries, the levels of productivity found in the United States make up for this difference and have made the country an attractive location for manufacturing investment. Moreover, the gap in labor costs found in the United States in comparison to other countries has started to drop and likely will continue to drop as the cost of industrial robots falls. Disruptive technologies like additive manufacturing, 3D-printing, advanced robotics, and the utilization of the Internet of Things and Big Data are revolutionizing U.S. manufacturing.<sup>[9]</sup> This has not only increased levels of productivity but has also made the United States one of the most attractive locations for high-technology manufacturing firms.

John Deere, for example, has added sensors to some of its models and the company sells the data retrieved from these sensors to farmers in order to offer new insights and improve agricultural practices.

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**The U.S. has, until recently, benefited from open trade policies. For manufacturing growth to continue, the country should avoid tariff wars or overly restricted trade policies.**

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The development of programs like the National Network for Manufacturing Innovation (NNMI) represent some of the biggest drivers in this advanced technology development. NNMI brings together manufacturers, university engineering schools, federal agencies, non-profit organizations, and regional organizations to invest in novel manufacturing technology. Nine manufacturing innovation institutes that are funded by the Department of Defense or the Department of Energy are a part of NNMI and their research areas cover technology developments from 3D printing to lightweight metals manufacturing. [10] Other incentives programs like grants from the U.S. Commerce Department's National Institute of Standards and Technology (NIST) help accelerate the growth of advanced manufacturing in the country.<sup>[11]</sup>

Advanced manufacturing technology development can be found throughout the United States. In Indiana for example, Rolls Royce, which makes jet engines, employs thousands of engineers. Zimmer Biomet makes surgical products in Warsaw, Indiana, a city that has become a national hub for orthopedic products.

<sup>[12]</sup> The United States has, until recently, benefited from open trade policies, and

in order for manufacturing growth to continue, the country should avoid tariff wars or overly restricted trade policies. Canada and Mexico bought one fifth of all U.S. manufactured goods in 2016<sup>[13]</sup> and nearly half of the manufactured goods made in the United States were exported to countries with whom the United States has free trade agreements.<sup>[14]</sup> Moving forward, it is vital for American leaders to continue the policies that have helped the recent resurgence of the manufacturing sector.

## **Obstacles constraining manufacturing in other nations**

In this section, we examine several countries that did not perform very well on our index, looking at what problems they face and how their policies inhibit manufacturing development. We discuss the low-performing countries of Brazil, Indonesia, and Mexico to discern the barriers to manufacturing output.

### ***Brazil***

Brazil's flailing manufacturing sector can be attributed at least in part to the corruption that has plagued the country. Generally speaking, corruption makes investors fearful of pouring money into business operations in a country because of long-term uncertainty, and this in turn dampens prospects for long term investment and business growth.

This fear is warranted in the case of Brazil as the amount of money lost due to corruption continues to rise. Petrobras, Brazil's state owned oil company, is alone estimated to have cost the country more than 5 billion dollars in paybacks.<sup>[15]</sup> Moreover, the manufacturing sector in Brazil is specifically implicated by this nation-wide corruption. That sector is responsible for 60 percent of the country's

exports. Fifty-seven percent of the foreign bribery cases in Brazil from 1999 to 2014 were found in the manufacturing, extractives, construction, and transport sectors.<sup>[16]</sup>

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**A healthy manufacturing sector is contingent upon transparency in financial transactions, relative certainty in a future a country's political environment, and individuals being held accountable for illegal action.**

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Brazil's "Operation Car Wash" has revealed some of the illegal dealings that have taken place in the country, but there are several holes that need to be filled or else there exists a very real possibility this corruption will never be completely eliminated. Companies have hired compliance teams over the past two years<sup>[17]</sup> and Brazil's Clean Companies Act has started a movement in the right direction, but improved whistleblower protection and detection and enforcement capabilities are necessary in order to establish a framework that stymies corruption. A healthy manufacturing sector is contingent upon transparency in financial transactions, relative certainty in a future a country's political environment, and individuals being held accountable for illegal action. Every country seeking to improve their manufacturing sector should decrease corruption because Brazil has shown how the ripple effects of such corruption hampers manufacturing growth.

### ***Indonesia***

A decade ago, Indonesia's manufacturing industry contributed 27.4 percent to its GDP. In the third quarter of 2017, this figure dropped to 21 percent, which was the lowest percentage since 2000.<sup>[18]</sup> Our breakdown of the country's manufacturing environment shows the limits of its workforce. Specifically, Indonesia is hampered by anemic labor productivity. Its manufacturing industry has been described as having a "missing middle," meaning that its large proportion of small and unproductive firms is dragging down the entire sector.<sup>[19]</sup>

In order to become more globally competitive, Indonesia needs to develop its workforce and advance its manufacturing sector. Its leaders should incentivize manufacturing firms with low productivity to either exit the industry or improve their productivity through technology and higher skilled labor. The existence of unproductive manufacturing firms can be partially explained by low wages in Indonesia. The availability of low-paid workers makes firms complacent, and consequently these firms are not incentivized to upgrade skills of their workers or innovate their technology. That limits the entire sector.<sup>[20] [21]</sup>

In addition to improving wages, Indonesia must strengthen its worker training. Airlangga Hartarto, Indonesia's minister of industry, has already established the framework for policies designed to bring about this improvement. The minister has said he plans to provide tax incentives for vocation programs to improve training, encourage manufacturers to make innovative products, and get manufacturers to focus on exports.<sup>[22]</sup> The country's "Industry 4.0" plan seeks to improve its global competitiveness through technologies such as automation, robotics, and artificial intelligence.

Finally, Indonesia needs to improve its infrastructure and traffic flow. A survey of small manufacturing industries has shown that congestion problems and logistics performance problems rooted in poor infrastructure represent substantial

constraints for manufacturing plants. By developing more infrastructure in the country, Indonesia would reap benefits like more skilled workers and technology diffusion from international corporations establishing branches in Indonesia.

## *Mexico*

Although Mexico's manufacturing sector has in many ways surpassed pre-NAFTA expectations, the country still experiences stagnant labor productivity and scores as one of the worst countries in this category. In the 1960s and 1970s, Mexico's productivity grew at a rate of four percent per year, but in the past 10 years, this figure has dropped to around 0.8 percent per year. This low labor productivity acts as a major drag on economic growth and societal prosperity. Despite this limitation, Mexico is a very strong exporter and 36 percent of its GDP comes from merchandise exports. That is one of the highest rates in Latin America.<sup>[23]</sup>

In a recent Moody's Analytics study, Abhilasha Singh and Jesse Rogers note that the shortage of formal jobs in Mexico has motivated the creation of informal work arrangements throughout the country. Although the productivity at large manufacturing firms in Mexico has improved due to technology innovation and the pressure of keeping up with the competitive, global market, these firms only constitute a third of total employment in the country. Smaller firms, which often engage in the use of informal employment, have declined in productivity at a rate of two percent from 2004 to 2014.

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Another factor contributing to productivity problems is poor education in Mexico. Although our evaluation of Mexico's K-12 and higher education spending is around average in comparison to the other countries in this study, this money is not spent efficiently or effectively. The average Mexican has only 10 years of formal education, which is below average for an OECD country and lower than other Latin American countries. Because of the low average level of education, Mexicans often cannot fill vacancies that require technical expertise in larger manufacturing firms and are forced to engage in low-skill occupations. As a result, developing vocational training policies and policies that incentivize high school graduation and university enrollment are crucial for Mexico's future.

The country should seek to integrate small manufacturing firms with their informal labor into the formal economy. Providing greater incentives for the domestic development of technology would help these smaller and medium sized firms increase their margins and boost their productivity. In addition, upgrading Mexico's infrastructure would increase the productivity of smaller manufacturing plants. Production chains that require materials from outside the immediate area are often stifled by extra costs due to poor connectivity between cities.<sup>[24]</sup> The development of infrastructure is critical for large manufacturing firms as well, as it is estimated that by 2020, bottlenecks at the ports of Veracruz and Lazaro Cardenas could cause delays to as much as 25 percent of the shipments from Mexico to the United States.<sup>[25]</sup>

Lastly, working on corruption and bringing down the prevalence of crime in the country should be prioritized as well. The cost of crime in Mexico is estimated to add two-to-three percent to the cost of doing business. Small firms bear the brunt of corruption as they find it harder to hire security and ward off extortion attempts.<sup>[26]</sup>



## Recommendations for improving manufacturing

Based on our analysis, we make a number of recommendations for improving the manufacturing sector. We discuss them in the section below.

### *Pursue a governance strategy that emphasizes political and economic stability, and open trade policies*

Economic and political stability alongside open trade policies are necessary for investors and industry leaders. Having a positive environment for conducting business facilitates manufacturing and overall economic growth. It is vital to have trade policies that provide access to global markets and encourage technology diffusion in the production of goods. When a nation is known to be economically and politically stable, many advanced manufacturing industries with high fixed costs are more willing to set up shop even if the cost of doing so is higher than in other countries.

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Creating an environment conducive to stability requires respect for the rule of law, protecting property rights, enforcing contracts, and mitigating the risks of corruption. These features encourage foreign direct investment and lead to technologically advanced companies wanting to do business in-country.

### ***Provide the proper financial incentives to improve the workforce and overall productivity***

Developing financial incentives that include a low corporate tax rate, R&D tax credits, government grants, and government loans can help countries improve their manufacturing sectors. Increased productivity results from technological development, but often times high initial fixed costs operate as financial barriers that preclude the ability to develop these sorts of disruptive and transformative technologies. By providing these incentives to domestic manufacturers, the growth of businesses and their respective technologies can take place. The entrance of new firms induces greater competitiveness and encourages innovation in general.

### ***Unlock 21st century technology such as Big Data, automation, and artificial intelligence***

For economically advanced countries, competing on the cost-side of production is very difficult. In order for these countries to keep their manufacturing sectors flourishing, value unlocked through robots, artificial intelligence, and the use of Big Data is essential. As the cost of developing robots decreases and as efficiency is increased through Big Data and artificial intelligence, these countries can retain their place as manufacturing powerhouses. Public-private partnerships and government sponsored initiatives can assist the continual development of 21st century innovations.

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### ***Help small firms through technology and education***

Our case studies have demonstrated that manufacturing industries as a whole are being hamstrung in many places by small, inefficient firms. Increasing scale would force small firms to innovate their processes and increase productivity. Having more advanced technologies requires workers with the skills necessary to work in these new, more-productive industries. Many medium- and large-sized firms have job openings, but have difficulty finding the skilled workers they need due to a lack of formal education. Vocational training programs and education focused on incentivizing individuals to study in STEM fields is imperative.

In addition, officials should help small businesses learn how to navigate global supply chains and export rules. As pointed out by Jared Bernstein and Somin Park, “customized services for small- and medium-sized manufacturers help them to overcome financing and information barriers, improve their technology and product design, and link them up to global supply chains.”<sup>[27]</sup> Setting up one-stop places for small firms to access expertise and understand how to build trade is a great way to boost manufacturing.

### ***Develop mechanisms to reduce corruption***

Corruption functions as a disincentive for manufacturing investment in some countries. The risk of money being taken by the host government outweighs the cheap labor costs that can be found in that country. Additionally, because of the ripple effects of corruption, different portions of the supply chain are subject to instantaneous breakdown which can cost companies astronomically. Legislation that mandates the transparency of business practice can help to alleviate corruption. More whistleblower protection and better detection capabilities can assist in reducing corruption. Encouraging more compliance and audit personnel can help in creating a culture of accountability and performance.

### ***Finance the necessary physical and digital infrastructures for businesses***

Developing the physical and digital infrastructures for businesses to operate is something almost all countries' manufacturing sectors require. Physical infrastructure such as roads, bridges, ports, etc., are necessary to connect supply chains in more efficient ways and to export products. The same is true for high-speed broadband and mobile technology.

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**Small manufacturing firms often cite congestion, logistical, or connectivity problems as major barriers to overcome. As developing economies look to export more, increased transportation infrastructure investment is necessary in order to reach global markets.**

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Small manufacturing firms often cite congestion, logistical, or connectivity problems as major barriers to overcome. As developing economies look to export more, increased transportation infrastructure investment is necessary in order to reach global markets. Moreover, countries that already have sound transportation infrastructures need efficient supply chains. One cannot have high-performing manufacturing companies without adequate infrastructure.

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## Appendix: Data and Methodology

We looked at five dimensions of the manufacturing environment: overall policies and regulations; tax policy; energy, transportation, and health costs; workforce quality; and infrastructure and innovation. Across these dimensions, we compiled data on 20 indicators and scored them on a five point scale. This yields a total possibility of 100 points.

### 1. Overall Policies

Pro-business environment: Coded by using both Freedom of Government and Ease of Doing Business ratings. Countries in the top 15% of the averaged indicators' values received a 5, countries in the next 15% received a 4 (70<sup>th</sup> percentile to 85<sup>th</sup> percentile), countries in the 55<sup>th</sup> to 70<sup>th</sup> to percentile received a 3, countries in the 40<sup>th</sup> to 55<sup>th</sup> percentile received a 2, and countries in the 20<sup>th</sup> to 40<sup>th</sup> percentile received a 1. Source: Freedom House, "Freedom in the World 2018", <https://freedomhouse.org/report/freedom-world/freedom-world-2018>; The World Bank, "Doing Business", 2017 report, <http://www.doingbusiness.org/rankings>.

Risk Index: Risk is based on Expropriation risk without any adequate compensation and Currency inconvertibility and transfer restrictions. These two parts are scored 1 to 7 based on the Credendo report and are added together.

Countries with a composite score of 1-2 received a 5 (least risky), countries with a score of 3-4 received a 4, countries with a score of 5-6 received a 3, countries with a score of 7-8 received a 2, and countries with a score of 9 or higher received a 1.

Source: Credendo Country Risks and Insights Report 2018,

<https://www.credendo.com/country-risk>.

Extent of corruption: Countries in the top 20 percentile of being the least corrupt received a 5, countries in the 61-80 percentile range received a 4, 40-60 percentile received a 3, 20-40 percentile received a 2, and countries under the 20 percentile mark received a 1. Source: Transparency International, "Corruption Perceptions Index 2016",

[https://www.transparency.org/news/feature/corruption\\_perceptions\\_index\\_2016](https://www.transparency.org/news/feature/corruption_perceptions_index_2016).

Open trade policies: Countries evaluated with a 61% to 66% free score received a 1, 67%-72% received a 2, 73% to 78% received a 3, 79% to 84% received a 4, and countries above 84% received a 5 (no countries received a score about 90%).

Source: Heritage Foundation, "2018 Index of Economic Freedom",

<https://www.heritage.org/index/visualize>.

## 2. Tax Policies

Low corporate tax rates: Countries with corporate tax rates of 17% to 21% received a 5, 22% to 26% received a 4, 27% to 31% received a 3, 32% to 36% received a 2, and 37% and above received a 1. Source Info: KPMG, Corporate Tax Rates Table 2018, <https://home.kpmg.com/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/corporate-tax-rates-table.html>.

R&D tax credits and equipment expensing tax credits for business: The score is the average of the two indicators with 2 being no and 4 being yes. Source: EY, "Worldwide R&D Incentives Reference Guide 2014-2015", pgs. 2-3,

[http://www.ey.com/Publication/vwLUAssets/EY-worldwide-randd-incentives-reference-guide/\\$FILE/EY-worldwide-randd-incentives-reference-guide.pdf](http://www.ey.com/Publication/vwLUAssets/EY-worldwide-randd-incentives-reference-guide/$FILE/EY-worldwide-randd-incentives-reference-guide.pdf);

International Tax Review, "Mexico: General Rules governing Mexico's R&D tax credit", <http://www.internationaltaxreview.com/Article/3672056/Mexico-General-rules-governing-Mexicos-R-D-tax-credit.html>.

Government grants or loans to help domestic manufacturers: 2 being no and 4 being yes. Source: EY, "Worldwide R&D Incentives Reference Guide 2014-2015", pgs. 2-3, [http://www.ey.com/Publication/vwLUAssets/EY-worldwide-randd-incentives-reference-guide/\\$FILE/EY-worldwide-randd-incentives-reference-guide.pdf](http://www.ey.com/Publication/vwLUAssets/EY-worldwide-randd-incentives-reference-guide/$FILE/EY-worldwide-randd-incentives-reference-guide.pdf).

### 3. Energy, Transportation, and Health Care Costs

Electricity and Manufacturing Costs: This indicator is drawn from "Where in the World Manufacturing Report" with countries ranked 1-30 based off of their electricity and manufacturing costs (1 is the cheapest and 30 is the highest in terms of costs). Countries ranked 1-6 received a 5, 7-12 received a 4, 13-18 received a 3, 19-24 received a 2, and countries above 25 received a 1. Source: Cushman & Wakefield, "Where in the World? Manufacturing Index 2015", pg. 7.

Oil and liquefied natural gas costs: Countries' whose oil and natural gas costs comprise 0.01% to .4% of their GDP received a 5, .41% to .80% received a 4, .81% to 1.20% received a 3, 1.21% to 1.60% received a 2, and 1.61 to 2% received a 1. In order to determine oil and natural gas costs, we took the value of oil and natural gas imported for each country in 2015 based on TradeMap data. In order to take account of the cost of domestic production, we took the cost of how much it takes to drill one barrel of oil in each country on average based on Knoema information, multiplied this cost by how many million barrels were drilled a day, and multiplied this number by 365 to come out with the cost of domestic oil production that takes place in a year. Because not all of this oil drilled domestically ends up being consumed domestically, we subtracted the value of total oil exported for each country in 2015. This number was divided by its respective country's GDP in order to come out with a number that described a

country's oil and natural gas costs as a percentage of its GDP. Sources: ITC, Trade Map, Indicator 2711 Petroleum gas and other gaseous hydrocarbons, Value Imported in 2016 (USD Thousand),

[https://www.trademap.org/Country\\_SelProduct.aspx?](https://www.trademap.org/Country_SelProduct.aspx?nypm=1|||||2711||||4|1|1|1|1|1|2|1|1)

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“Cost of producing a barrel of crude oil by country,” 2014,

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Health Care Costs: Countries spending \$0-2000 per capita on health care expenditure received a 5, \$2001-4000 received a 4, \$4001 to 6000 received a 3, \$6001 to 8000 received a 2, and \$8001 and above received a 1. Source: The World Bank, “Health expenditure per capita (current US\$),”

<https://data.worldbank.org/indicator/SH.XPD.PCAP>.

#### 4. Workforce Quality

K-12 education spending: Countries under 1.49% of GDP allocated toward primary and secondary education received a 1, countries with 1.50% to 2.49% of GDP allocated towards primary and secondary education received a 2, the 2.50% to 3.49% range received a 3, the 3.50% to 4.49% received a 4, and the 4.5% to 5.5% range received a 5. Sources: OECD Report, “Education at a Glance 2015”, pg. 324; China Daily, “China increases education spending in 2016,”

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Higher education spending: Countries with less than .6% of GDP allocated towards tertiary education received a 1, those in the .61% to 1.20% range received a 2, 1.21% to 1.80% range received a 3, 1.81% to 2.4% range received a 4, and 2.41% to 3% range received a 5. Sources: Journal of Global Economics, “Trends,



Growth and Changing Patterns of Public Expenditure on Education in China”, 2016; OECD Report, “Education at a Glance 2015”, pg. 324; China Daily, “China increases education spending in 2016,”

[http://www.chinadaily.com.cn/china/2017-05/04/content\\_29203196.htm](http://www.chinadaily.com.cn/china/2017-05/04/content_29203196.htm).

Family Income: Countries with a median income of \$0-5000 received a 1, \$5001 to 10,000 received a 2, \$10,001 to 15,000 received a 3, \$15,001 to 20,000 received a 4, \$20,000 to 25,000 received a 5. Source: Giving What We Can, “Median GDP Per Capita: How Much Does the Typical Person Earn in Different Countries? A Look at Global Inequality”, May 25, 2016,

<https://www.givingwhatwecan.org/post/2016/05/giving-and-global-inequality/>.

Labor productivity: Countries whose GDP per person employed (PPP) was \$0-25,000 received a 1, countries in the \$25,001 to the \$50,000 range received a 2, the \$50,001 to \$75,000 range received a 3, the \$75,001 to \$100,000 received a 4, and the \$100,001 to \$125,000 range received a 5. Source: The World Bank, “GDP per person employed”,

<https://data.worldbank.org/indicator/SL.GDP.PCAP.EM.KD>.

Labor Support: Based on each country’s labor environment concerning minimum wages, laws related to layoffs, difficulty in hiring redundant employees, severance pay, and labor participation rate. Each country is given a score from 1-100 where 100 is the most labor freedom and 1 is the least. Countries scoring under a score of 40 are given a 1, 41-54 a 2, 55-69 a 3, 70-85 a 4, and 86-99 a 5. Data comes from <https://www.heritage.org/index/explore>.

## 5. Infrastructure and Innovation

Infrastructure spending as percent of GDP: Countries with infrastructure spending of 0 to 1.3% of their GDP received a 1, those in the 1.31% to 2.6% range received a 2, the 2.61% to 3.9% range received a 3, the 3.91% to 5.2% range received a 4, and the 5.2% to 7% range received a 5. Source: A G20 Initiative

Global Infrastructure Outlook, “Forecasting infrastructure investment needs and gaps,” 2017, <https://outlook.gihub.org>; Zambia Ministry of Finance, “World GDP Ranking 2015”, <http://zambiamf.opendataforafrica.org/oyhqaqc/world-gdp-ranking-2015-data-and-charts>.

Internet access: 0-20% internet penetration received a 1, 21% to 40% received a 2, 41% to 60% received a 3, 61% to 80% received a 4, and 81% to 100% received a 5. Source: Internet Live Stats, “Internet Users by Country (2016)”, <http://www.internetlivestats.com/internet-users-by-country/>.

Patent Filings: Countries were ranked in terms of number of resident IP filing activity. Those filing less than 20,000 patents received a 1, those filing 20,000 to 125,000 patents received a 2, those filing 125,000 to 400,000 patents received a 3, those filing 400,000 to 1,000,000 patents received a 4, and those filing over 1,000,000 patents received a 5. Source: World Intellectual Property Organization, “World Intellectual Property Indicator 2017 Report”, pgs. 85-87, [http://www.wipo.int/edocs/pubdocs/en/wipo\\_pub\\_941\\_2017.pdf](http://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2017.pdf).

R&D as percent of GDP: Countries in the 0% to .9% range received a 1, the .91% to 1.8% range received a 2, the 1.81% to 2.7% range received a 3, the 2.71% to 3.6% range received a 4, and the 3.61% to 4.5% range received a 5. Source: OECD, “Gross Domestic Spending on R&D”, 2015, <https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>.

Hazard Exposure: This is made up of exposure to natural hazards, natural hazard risk quality, fire risk quality, and inherent cyber risk. Each Country was given a percentile value reflective of where they rank among the 130 nations. Those in the top 20 percentile received a 5, those in the 60-80 percentile range received a 4, the 40-60 percentile range received a 3, the 20-40 percentile range received a 2, and the 0 to 20 percentile range received a 1. Source: Pentland Analytics, “2017 Resilience Index Annual Report”, pgs. 13-16.

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