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Mapping Industrial Strength: US Machine Tool Production and Consumption

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Machine tools are key to and indicative of the health of a nation's manufacturing sector. The United States lags behind in both the production and consumption of machine tools, especially compared with other high-wage economies.

KEY TAKEAWAYS

- The machine tools industry enables national power. U.S. machine tool production as a share of GDP ranked 25th out of 29 and 70 percent below the global average in 2022.
- Machine tool consumption indicates the technological sophistication of a nation's manufacturing.
- In 2022, the United States ranked 8th out of 28 nations as a share of manufacturing workers.
- That same year, the U.S. machine tool trade balance was 14th out of 24 nations, with the United States running a significant trade deficit.
- Policymakers should seek to double machine tool production and consumption in the next decade.

CONTENTS

Key Takeaways 1
Introduction 2
Machine Tools Production 4
Machine Tools Output as a Relative Share of Durable Goods Manufacturing Workers 6
Metal-Forming Machine Tool Production 8
Metal Cutting Machine Tool Production 10
Machine Tools Consumption 13
Machine Tool Consumption as a Relative Share of Durable Goods Workers 17
Metal-Forming Machine Tool Consumption 19
Metal Cutting Machine Tool Consumption 22
Machine Tool Trade Balance 26
Machine Tools Industry: United States Versus China 27
Conclusion 29
Endnotes 30

INTRODUCTION

The machine tool industry is important for national competitiveness and power. At the same time, robust machine tool consumption is key to U.S. manufacturing health.

Machine tools are used not only to cut or form metal parts for final products such as automobiles, but also to make machines that are used in a vast proportion of manufacturing industries. For example, machine tools can be used to make metal parts for an automobile, but they can also be used to make robotic arms and joints for the micro-assembly of chips in a semiconductor fab. In other words, machine tools are the underlying foundation for producing a vast proportion of goods in the United States. As a result, a strong machine tools industry is necessary for the United States to have a healthy manufacturing sector and remain globally competitive in advanced manufacturing industries.

However, the U.S. machine tool industry is relatively weak. While the United States was one of the largest producers in machine tools in the early 1980s, with about 20 percent of the world market, U.S. firms, such as Cincinnati Milacron and Browne and Sharpe, declined quickly over the next few years, resulting in more than two-thirds of firms closing.[1] Japan, Germany, and Italy surpassed the United States in machine tool production and became world leaders.[2] Meanwhile, other nations' firms, such as China's, have also grown, producing large shares of the globe's machine tools. Indeed, as an Information Technology and Innovation Foundation (ITIF) report highlights, "In 1981, the United States was the largest producer of machine tools at $5.1 billion. By 2022, China was the world's leading producer at $27.1 billion per year, while the

United States ranked fifth at $5.9 billion."[3] As a result, the United States imports a vast proportion of machine tools from abroad for its manufacturing workers to use.

This report analyzes U.S. machine tools production and consumption compared with other top economies. First, the report uses an analytical statistic known as a location quotient (LQ), which measures the production value of machine tools as a share of a country's gross domestic product (GDP) relative to the global average concentration. Then the report examines other relative indicators of machine tool production, such as production value per worker in the economy or per worker in durable goods manufacturing industries compared with the global average. Next, the report examines the LQ and concentration measures of the United States metal cutting and metal forming (subsectors of metal working) producers compared with the top nations with the highest production.

While the United States was one of the largest producers in machine tools in the early 1980s, with about 20 percent of the world market, U.S. firms, such as Cincinnati Milacron and Browne and Sharpe, declined quickly over the next few years, resulting in more than two-thirds of firms closing.

On the consumption side, the report analyses the relative consumption value of machine tools as a share of a country's GDP, labor force, manufacturing workers, and durable manufacturing workers. The report also examines U.S. consumption of metal cutting and metal forming tools. It then examines trade balance concentration, which is the trade balance of machine tools as a share of a country's GDP versus the global average. The report concludes with a short examination of the machine tools industry in the United States versus China.

There are strengths and weaknesses to each of the concentration indicators in this analysis. (See table 1 and table 2.)

Table 1: Strengths and weaknesses of different types of machine tool production indicators

Type of Indicator	Strengths	Weaknesses
Location quotient (GDP)	Indicates a nation's specialization in machine tools production	Given that machine tool prices are somewhat similar between nations, this indicator overstates performance of lower income nations.
Machine tool output as a relative share of all workers	Indicates the availability of machine tools for workers and the overall level of manufacturing	Controls for income levels
Output as a share of durable goods manufacturing workers	Controls for the higher amount of machine tools used in durable goods manufacturing industries	Data not available for all nations

Table 2: Strengths and weaknesses of different types of machine tool consumption indicators

Type of Indicator	Strength	Weakness
Machine tool consumption as a share of GDP	Measures how much of a nation's income goes to machine tools	Given that machine tool prices are somewhat similar between nations, this indicator overstates performance of lower income nations.
Consumption as a share of all workers	Controls for income and indicates the size of a nation's manufacturing sector and the intensity of the sector's machine tool usage	Does not control for size of manufacturing sector
Consumption as a share of all manufacturing workers	Indicates machine tool usage intensity in manufacturing	Does not control for size of durable goods sector, where most machine tools are used
Consumption as a share of durable goods manufacturing workers	Controls for the higher amount of machine tools used in durable goods manufacturing industries; indicates the machine tool usage intensity in manufacturing industries that rely on these tools the most for efficiency	Data not available for all countries.

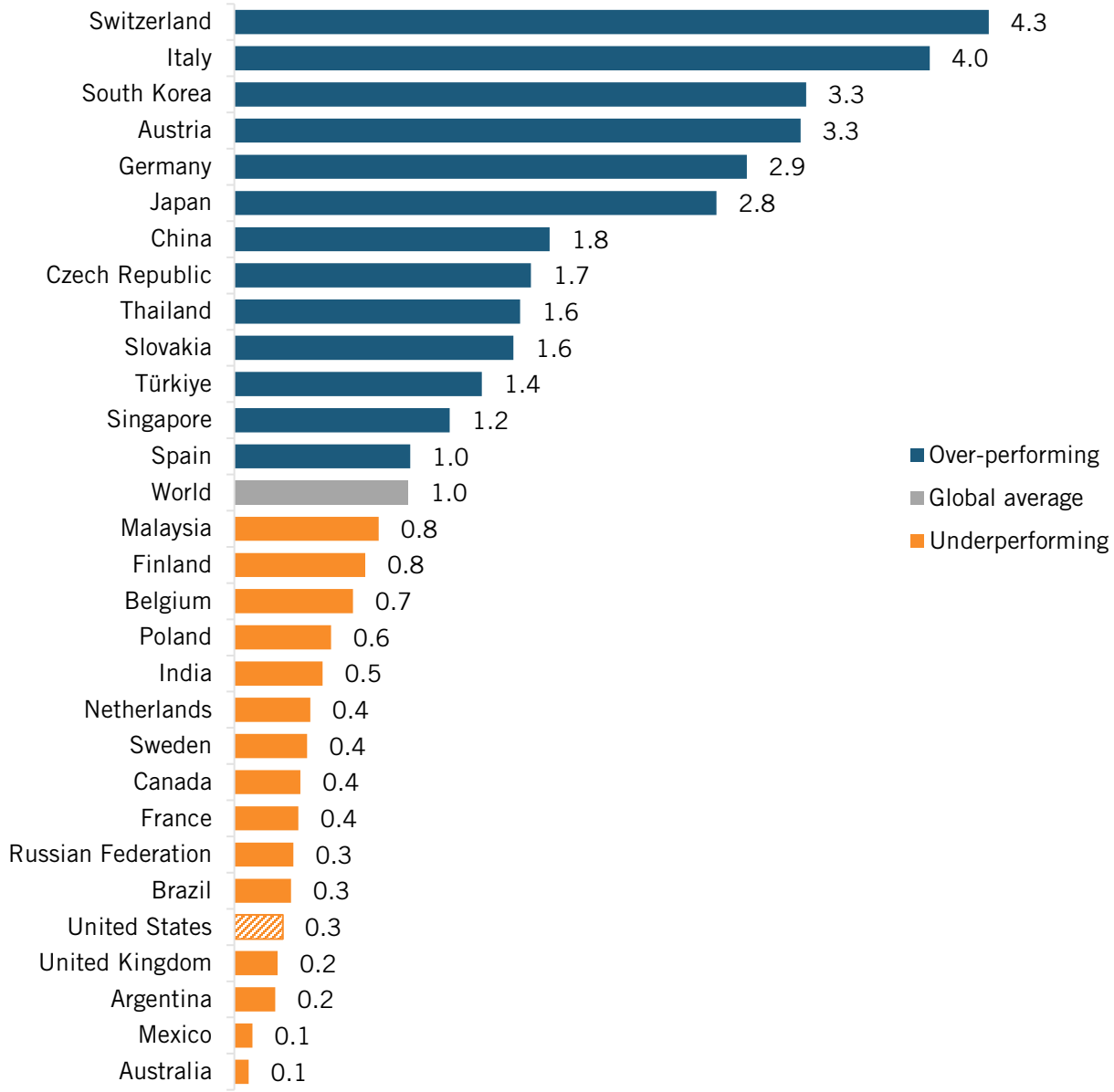
MACHINE TOOLS PRODUCTION

Machine tools production plays an essential role in a nation's manufacturing capabilities and efficiency because manufacturing industries, especially the durable goods ones, require machine tools for efficient production. Indeed, a RAND study highlights that "machine-tool makers worldwide typically sell their newest products close to home … a weak domestic machine-tool industry means that U.S. manufacturers risk losing access to the latest manufacturing technologies … the industry helps foster innovation in manufacturing processes."[4] Machine tool production value as a relative share of GDP (LQ) is a good indicator of a nation's specialization in the industry, or the importance of machine tool output to a nation. Meanwhile, machine tool production value as a share of workers is a good indicator of the availability of machine tools for workers. This section examines these two indicators for nations with the level of highest machine tool production.

China, a major rival of the United States, produced 80 percent more in machine tool value than the global average and 6.5 times more than the United States did in 2022.

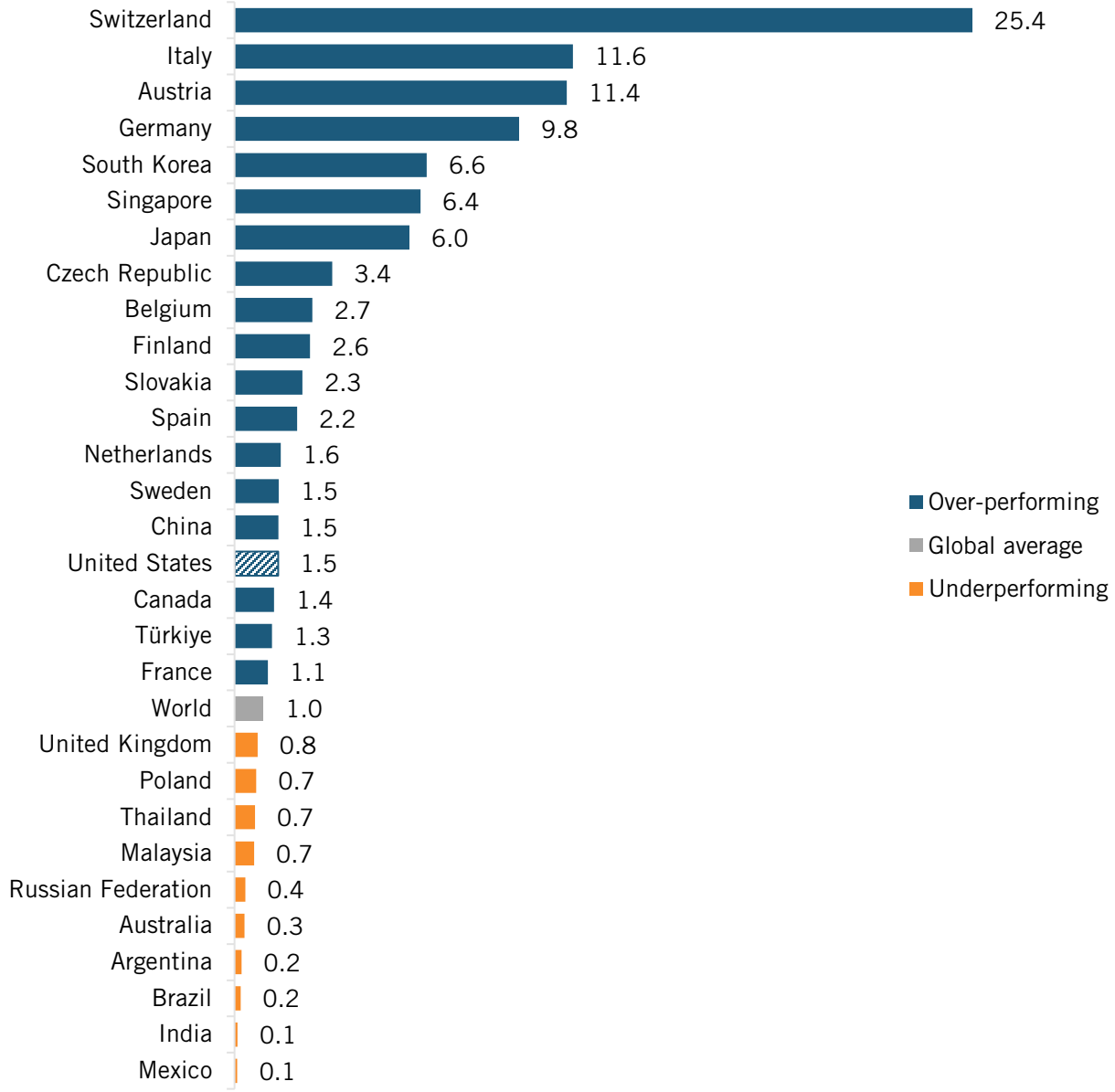
In 2022, the United States' machine tool production LQ ranked 25th out of 29 nations with the highest machine tool production. Indeed, the United States' LQ was 0.3, indicating that the production value of machine tools as a share of GDP was 70 percent below the global average. In comparison, China, a major rival of the United States, ranked 7th with an LQ of 1.8, indicating that it produced 80 percent more in machine tool value than the global average and 6.5 times more than the United States did. Meanwhile, Switzerland, Italy, and South Korea had the highest LQs at 4.3, 4.0, and 3.3, respectively. (See figure 1.)

Figure 1: Machine tool production LQ for the top 29 nations with the highest machine tool production in 2022[5]



On the other hand, the U.S. machine tools' relative output as a share of workers was higher but still only ranked 16th out of the top 29 nations with the highest production. In other words, the United States fell behind Slovakia, Spain, and the Netherlands. Indeed, in 2022, the U.S. relative output as a share of workers was 1.5, meaning the average U.S. worker had 50 percent more machine tool value available to them than the global average. China also had a relative intensity level of 1.5, indicating that the average Chinese worker had the same machine tool value available to them as the average American worker did. However, both nations were surpassed by Germany, South Korea, and Singapore with relative intensity scores of 9.8, 6.6, and 6.4, respectively. (See figure 2.)

Figure 2: Machine tool output as a share of workers relative to the global average for the 29 nations with the highest machine tool production in 2022[6]



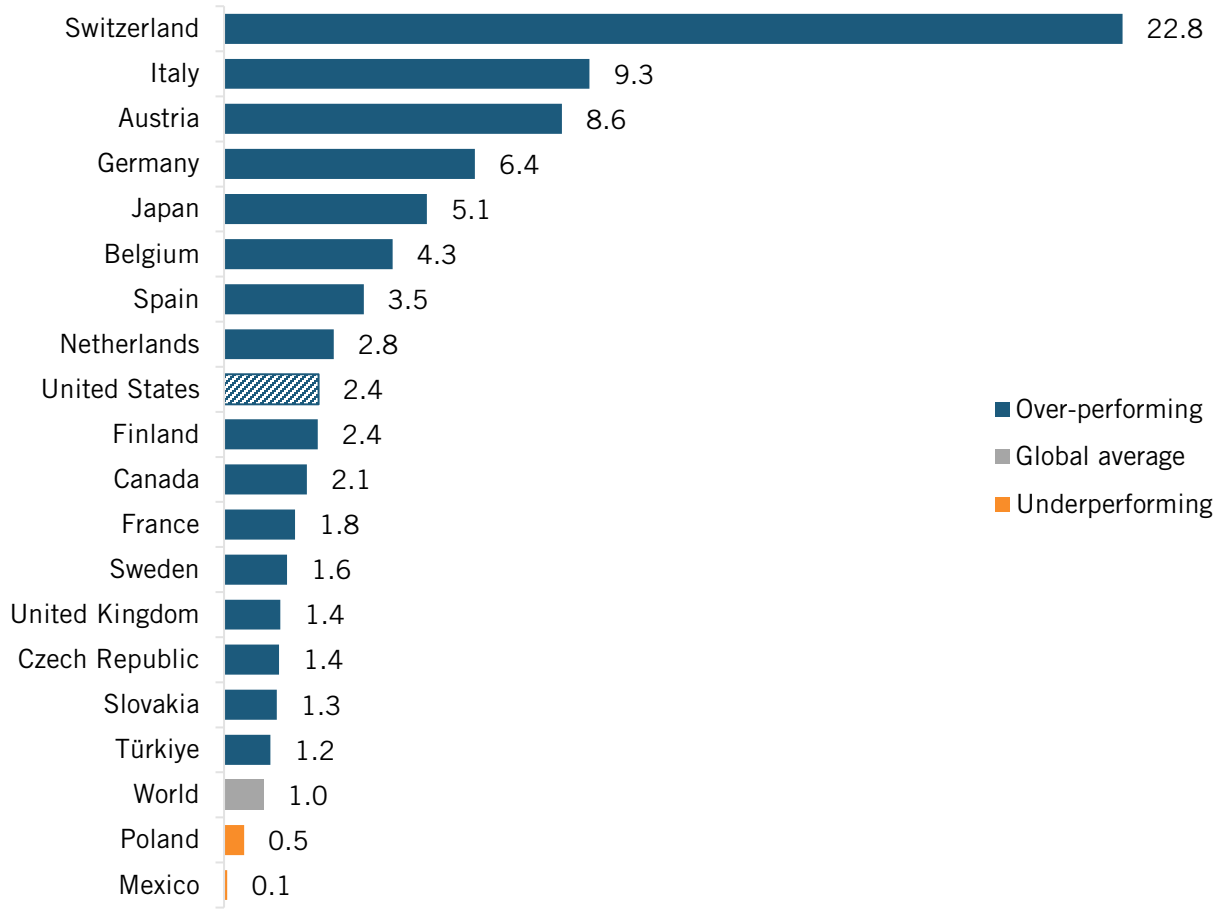
Machine Tools Output as a Relative Share of Durable Goods Manufacturing Workers

Although LQ and output as a relative share of workers are good indicators of the importance of the machine tool industry and the availability of machine tools for all workers, output as a relative share of durable goods manufacturing workers is a better indicator for the availability of machine tools. This is because it examines the availability of machine tools for manufacturing industries that rely on them the most. Indeed, the availability of machine tools for the electronics manufacturing industry, which relies heavily on them, is much more important to a nation's manufacturing well-being than the availability of machine tools for the food industry, which is less likely to use them. This section examines machine tool output as a relative share of durable

goods manufacturing workers in the United States and 18 other nations that were on the list of top 30 producers of machine tools.

In 2022, the United States ranked 9th, behind, Belgium, Spain, and the Netherlands. The U.S. relative intensity score was 2.4, indicating that the average U.S. durable goods manufacturing worker had 140 percent more machine tool value available for them to use than the global average. In comparison, major economies, such as Switzerland, Japan, and Austria, surpassed the United States in their output as a relative share of durable goods manufacturing workers, with relative intensity scores of 22.8, 5.1, and 8.6, respectively. At the lowest end, Poland and Mexico had relative intensity scores of 0.5 and 0.1, respectively, indicating that the average Polish and Mexican durable goods manufacturing worker had less machine tool value available for their usage than did the average worker in the globe. (See figure 3.)

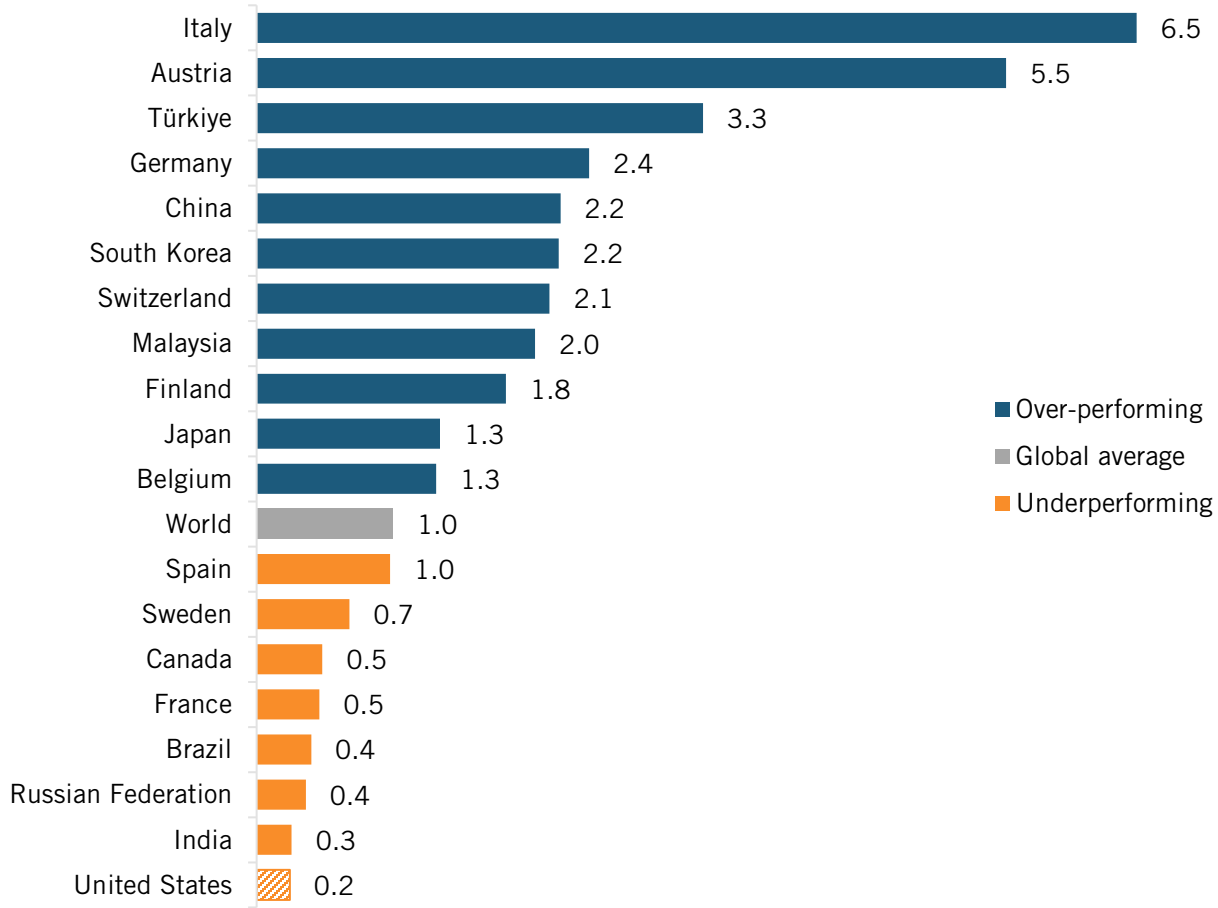
Figure 3: Machine tool output as a relative share of durable goods manufacturing workers for a subset of OECD nations with the highest machine tool production in 2022[7]



Metal-Forming Machine Tool Production

In the subset of metal-forming machine tools—machines that shape metal without removing material—the United States' LQ was the lowest of the top 19 nations with the highest machine tools production for 2022. Indeed, the U.S. LQ was 0.2, signaling that metal-forming machine tools production value as a share of GDP was 80 percent below the global average. In comparison, China's LQ was 2.2, meaning its production value as a share of GDP was 120 percent above the global average and about 9 times larger than the U.S. share of GDP. Surpassing China, Italy and Austria had the highest LQ at 6.5 and 5.5., respectively. (See figure 4.)

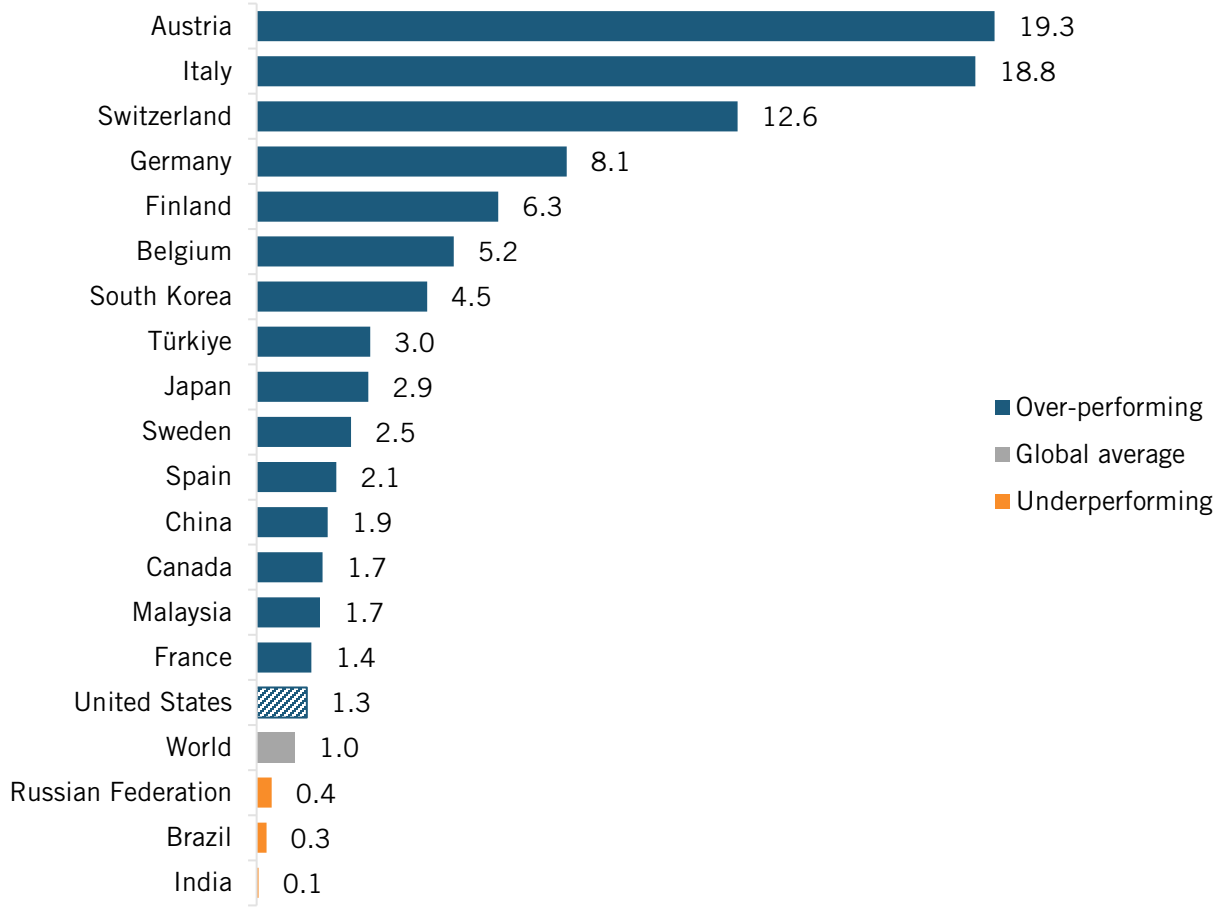
Figure 4: Metal-forming machine tool production LQ for the top 19 nations with the highest machine tool production in 2022[8]



When it comes to output as a relative share of workers, the United States had a higher intensity score but was still the fourth lowest. In 2022, the U.S. relative intensity score was 1.3, meaning the average U.S. worker had 30 percent more metal-forming machine tool value available to them than did the average worker in the globe. Despite being above the global average, the United States' output as a relative share of workers was only higher than Russia's (LQ:0.4), Brazil's (0.3), and India's (0.1). Meanwhile, China ranked higher than the United States with a relative intensity score of 1.9, indicating that its workers had more metal-forming machine tool value available to them than the average U.S. worker and worker in the world did. Of these

nations, Austria and Italy had the highest output as a relative share of their workers, with intensity scores of 19.3 and 18.8, respectively. (See figure 5.)

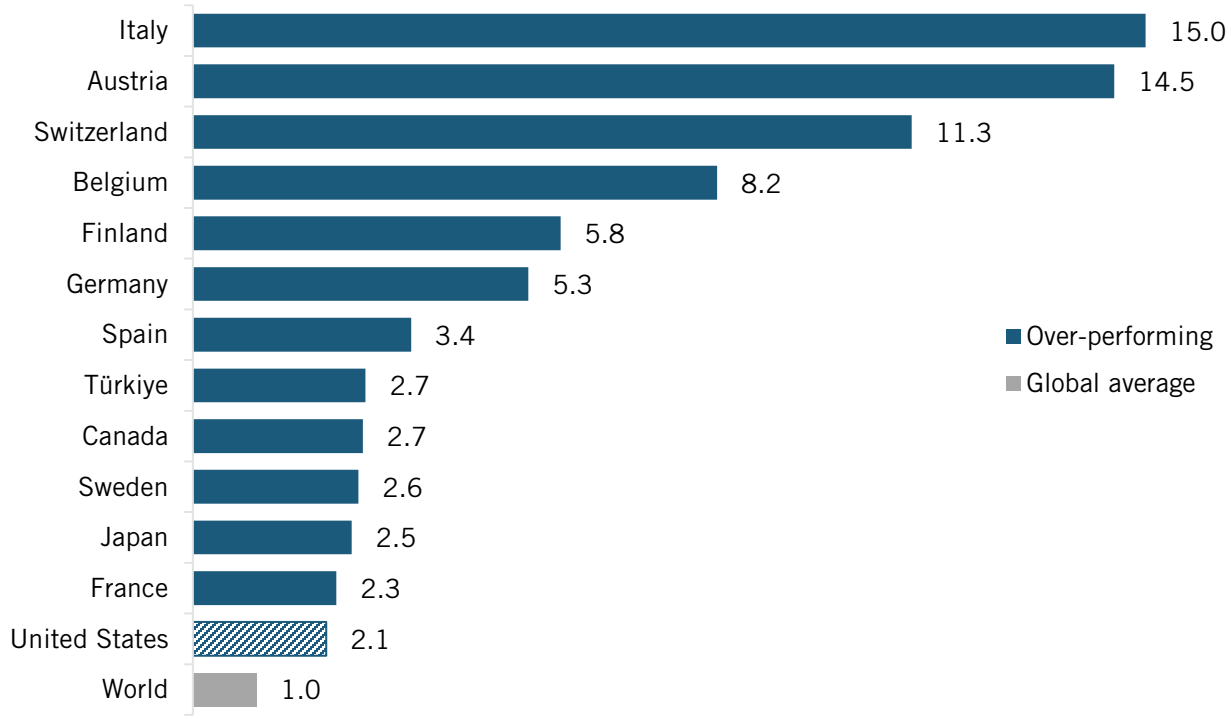
Figure 5: Metal-forming machine tool output as a relative share of workers for the top 19 nations with the highest machine tool production in 2022[9]



Metal-Forming Machine Tools Output as a Relative Share of Durable Goods Manufacturing Workers

The United States' metal-forming machine tools output as a relative share of durable goods manufacturing workers was the lowest of the 13 Organization for Economic Cooperation and Development (OECD) with available data. These nations were in the top 20 nations with the highest metal-forming machine tools production in 2022. Despite this, the U.S. relative intensity score was still 2.1, indicating that the average U.S. durable goods manufacturing worker still had 110 percent more metal-forming machine tool value available to them than the average worker in the world did. In comparison, Italy, Austria, and Switzerland had the highest output as a relative share of durable goods manufacturing workers, with intensity scores of 15.0, 14.5, and 11.3, respectively. (See figure 6.) This is partly due to their low number of durable goods manufacturing workers. For instance, Austria produced $676 million in metal-forming machine tools but only had 484,039 durable goods manufacturing workers. On the other hand, Germany produced $2.7 billion but had 5.2 million workers, leading to its lower output as a relative share of durable goods manufacturing workers.

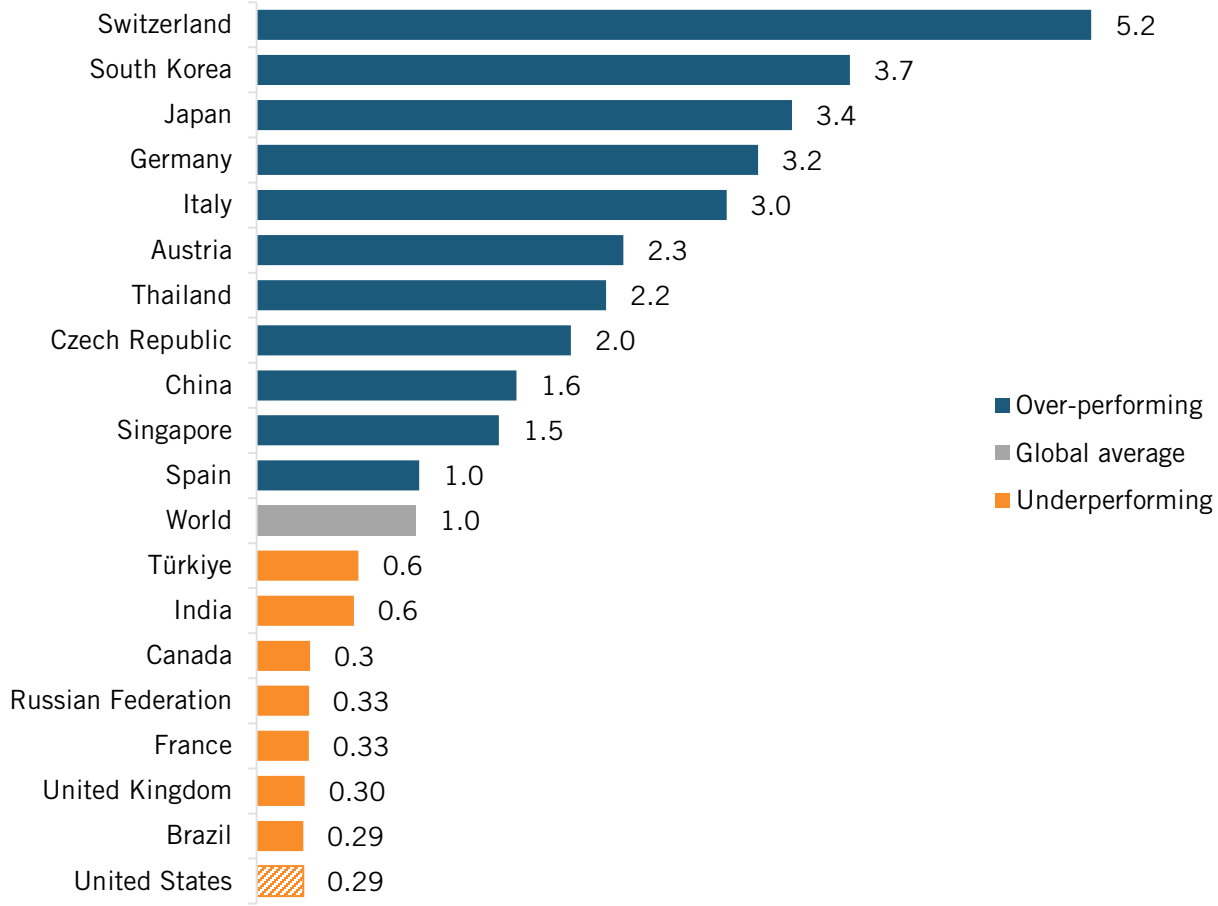
Figure 6: Metal-forming machine tool output as a relative share of durable goods manufacturing workers for a subset of OECD nations with the highest machine tool production in 2022[10]



Metal Cutting Machine Tool Production

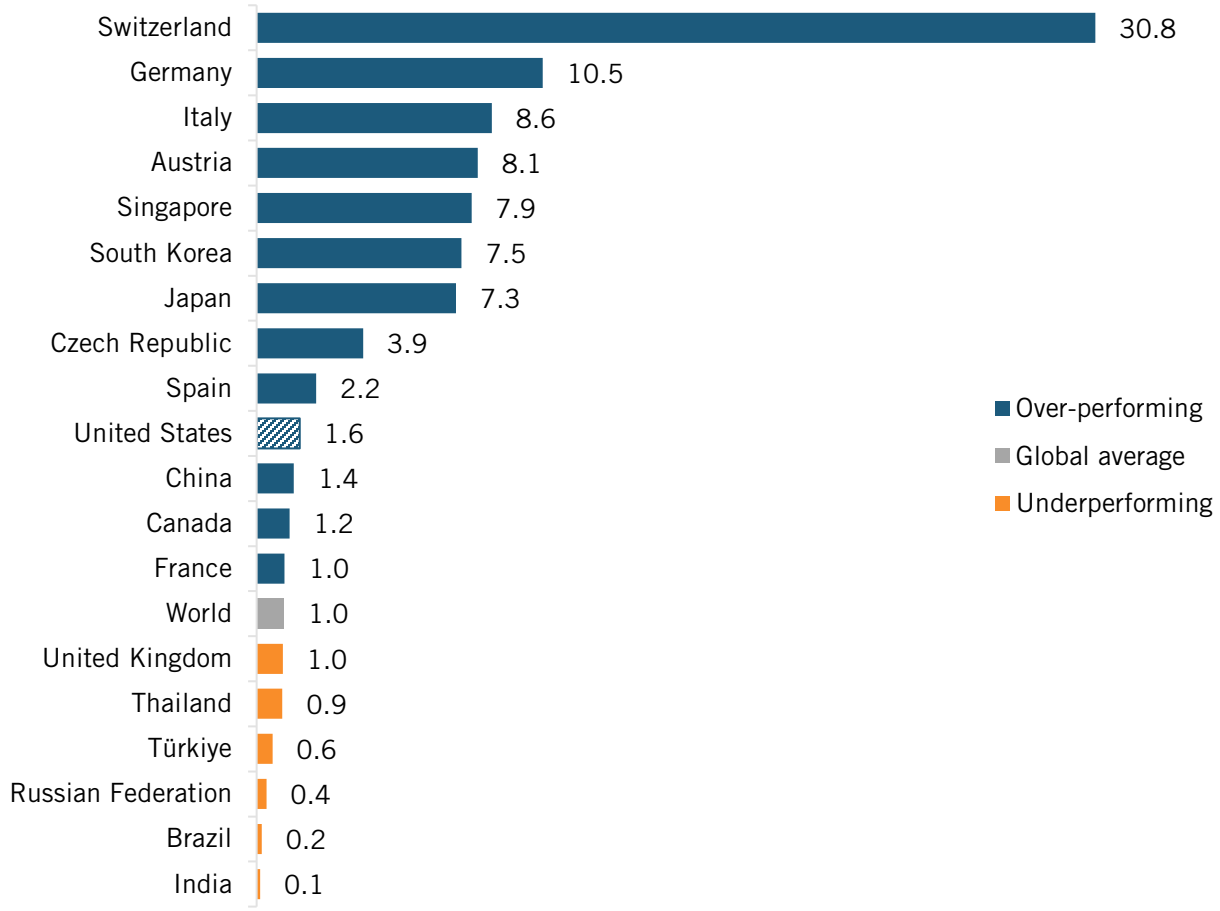
In the subsector of machine cutting tools—tools or machines that remove material from a workpiece (usually metal) to shape it into a desired form—U.S. production LQ was the lowest of the top 19 nations with the highest production. In 2022, the U.S. LQ was 0.3, meaning that metal cutting machine tool production value as a share of GDP was 70 percent below the global average. The United States was surpassed by India, Türkiye, and Spain, with LQs of 0.6, 0.6, and 1.0, respectively. More concerningly, China also surpassed the United States with an LQ of 1.6, or 60 percent above the global average and 5.6 times larger than the U.S. share of GDP. Of these 19 nations, Switzerland, South Korea, and Japan had the highest LQs at 5.2, 3.7, and 3.4, respectively. (See figure 7.)

Figure 7: Metal cutting machine tool production LQ for the top 19 nations with the highest machine tool production in 2022[11]



When adjusting for workers, the United States' output as a relative share of workers in metal cutting machine tool production was higher, ranking 10th out of the top 19 nations with the highest production. In 2022, U.S. relative intensity score was 1.6, meaning the average American worker had 60 percent more metal cutting machine tool value available to them than did the average worker in the globe. The United States surpassed France, Canada, and China. Indeed, China's output as a relative share of workers was slightly lower at 1.4, meaning the average Chinese worker had 40 percent more machine tool value available to them than did the average worker in the world and 14 percent less than the average U.S. worker. Despite surpassing these nations, the United States still fell significantly short of Germany and Japan, which had relative intensity scores of 10.5 and 7.3, respectively. (See figure 8.)

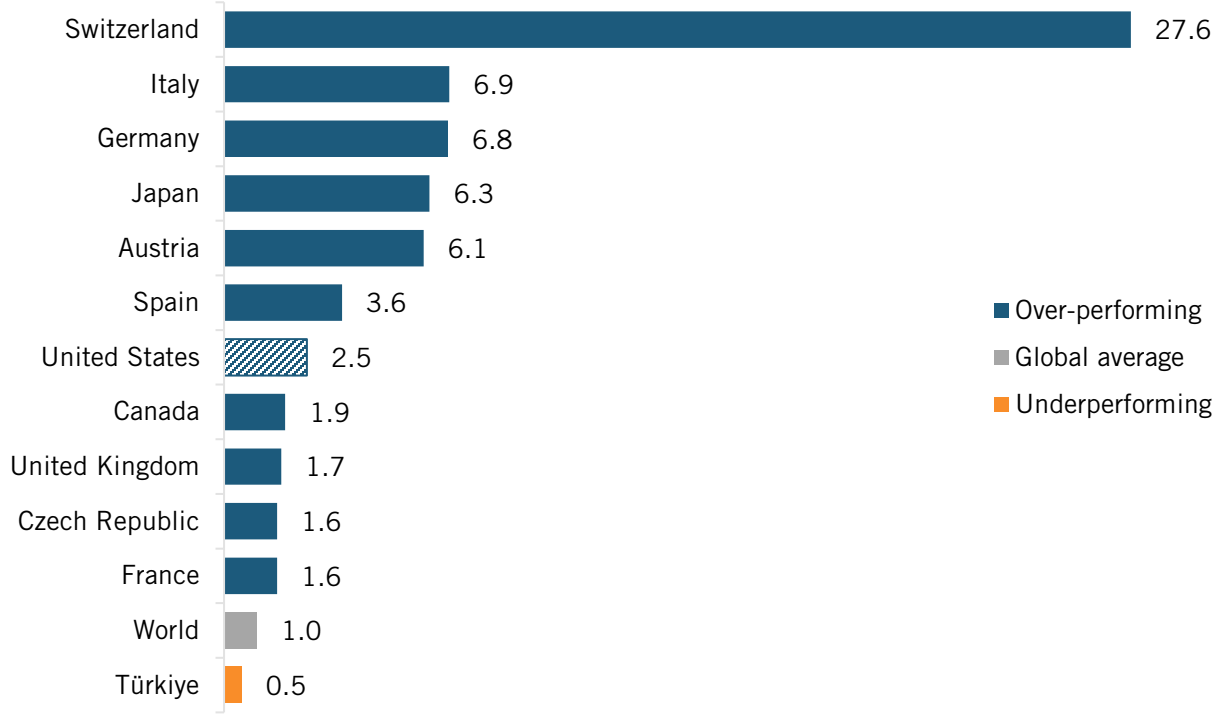
Figure 8: Metal cutting machine tool output as a relative share of workers for the top 19 nations with the highest machine tool production in 2022[12]



Metal Cutting Machine Tools Output as a Relative Share of Durable Goods Manufacturing Workers

In 2022, the United States' output as a relative share of durable goods manufacturing for metal cutting machine tools production ranked 7th out of 12 OECD nations with available data. These countries were in the top 20 of nations with the highest metal cutting machine tools production in 2022. Despite this, the U.S. relative intensity score was still at a high 2.5, indicating that the average U.S. durable goods manufacturing worker had 150 percent more metal cutting machine tool value available to them than the average worker in the world did. Surpassing the United States and the world, Switzerland had the highest output as a relative share of durable goods manufacturing with an intensity score of 27.6, partly due to its higher levels of production value but lower number of durable goods manufacturing workers—production was $2.7 billion, but workers were only about 426,000. Germany and Japan also surpassed the United States with relative intensity scores of 6.8 and 6.3, respectively, indicating that their average durable goods manufacturing worker had 580 and 530 percent, respectively, more metal cutting machine tool value available to them than the average worker in the world. Only Türkiye had a relative intensity score below 1 at 0.5, indicating that the average Turkish durable goods manufacturing worker had 50 percent less metal cutting machine tool value available to them than the average worker in the world did. (See figure 9.)

Figure 9: Metal cutting machine tool output as a relative share of durable goods manufacturing for a subset of OECD nations with the highest machine tool production in 2022[13]



MACHINE TOOLS CONSUMPTION

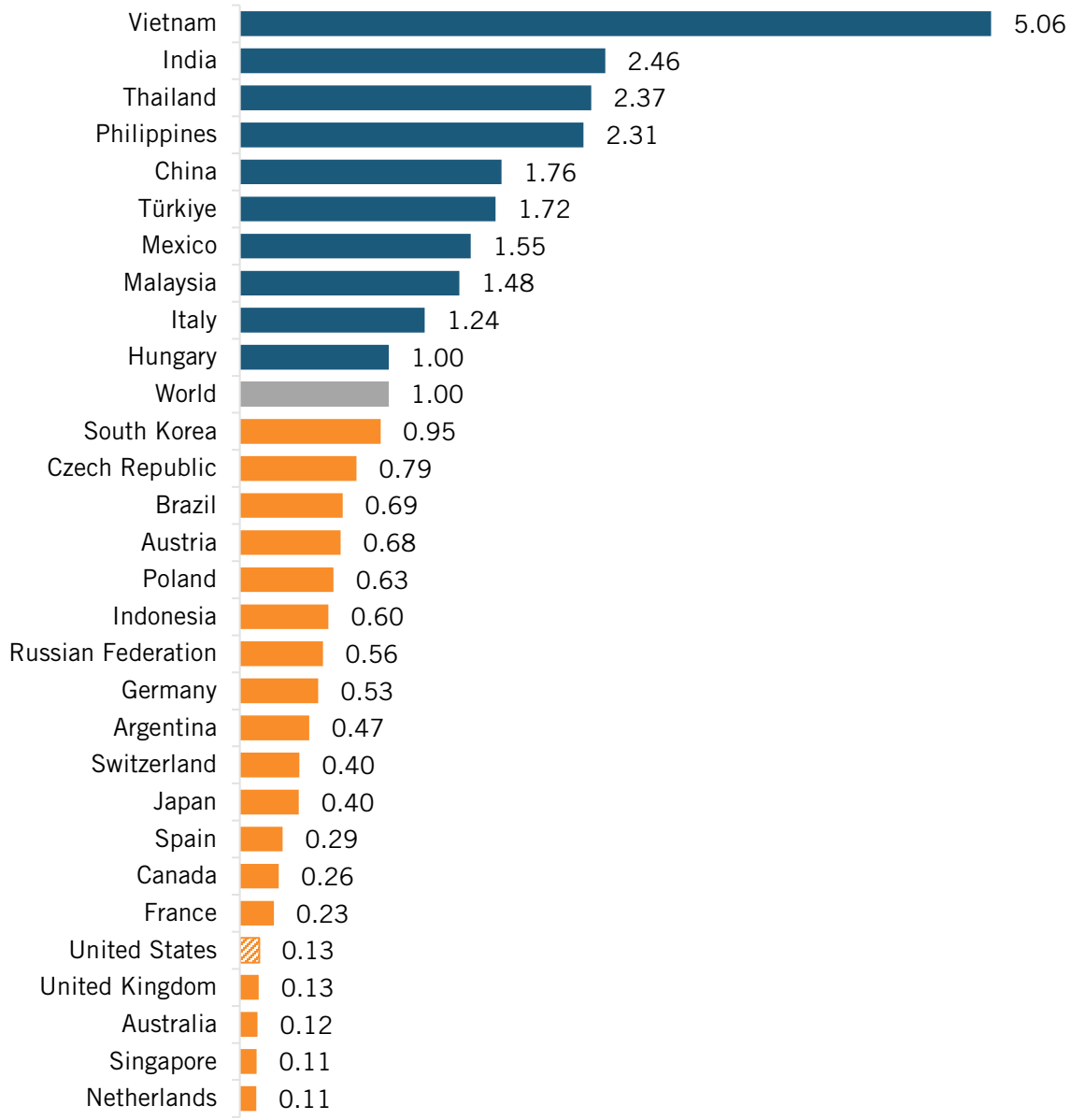
Machine tool consumption is an indicator of national manufacturing strength and modernization. Indeed, a study by Leah Boustan et al. highlights that "the diffusion of CNC [or computer numerical control} technology led to rising productivity in manufacturing. In particular, the advent of CNC was associated with growing capital investments, rising labor productivity, and a falling labor share in manufacturing industries more exposed to this new technology."[14] In other words, a nation that uses more machine tools tends to have a more productive and larger manufacturing sector due to the efficiency gains from using machine tools. However, machine tool use is higher in discrete parts industries rather than in continuous process industries, such as chemicals and food, so an apples-to-apples comparison of machine tool consumption would ideally control for these differences.

In 2022, the U.S. machine tool consumption was 50 percent below the global average. On the other hand, China's consumption as a share of GDP was the highest at 90 percent above the global average.

The United States machine tools consumption value as a relative share of GDP was one of the lowest compared with the other top 28 nations with the highest consumption. Indeed, in 2022, the U.S. consumption value as a relative share of GDP was only 0.5, meaning it was 50 percent below the global average. As a result, the United States ranked 25th out of the top 29 nations, surpassing only Indonesia (0.4), the Netherlands (0.4), Australia (0.4), and the United Kingdom (0.3). Concerningly, China surpassed the United States with a relative intensity score of 1.9, or 90 percent above the global average and almost 4 times larger than the U.S. share of GDP.

South Korea and Austria surpassed both nations, with relative consumption scores of 2.3 and 2.2, respectively. (See figure 10.) In other words, this indicates that U.S. manufacturing is weak, as the nation only consumes a relatively small share of machine tools compared with the size of its economy.

Figure 10: Machine tool consumption value as a relative share of GDP for the top 29 nations with the highest machine tool consumption in 2022[15]

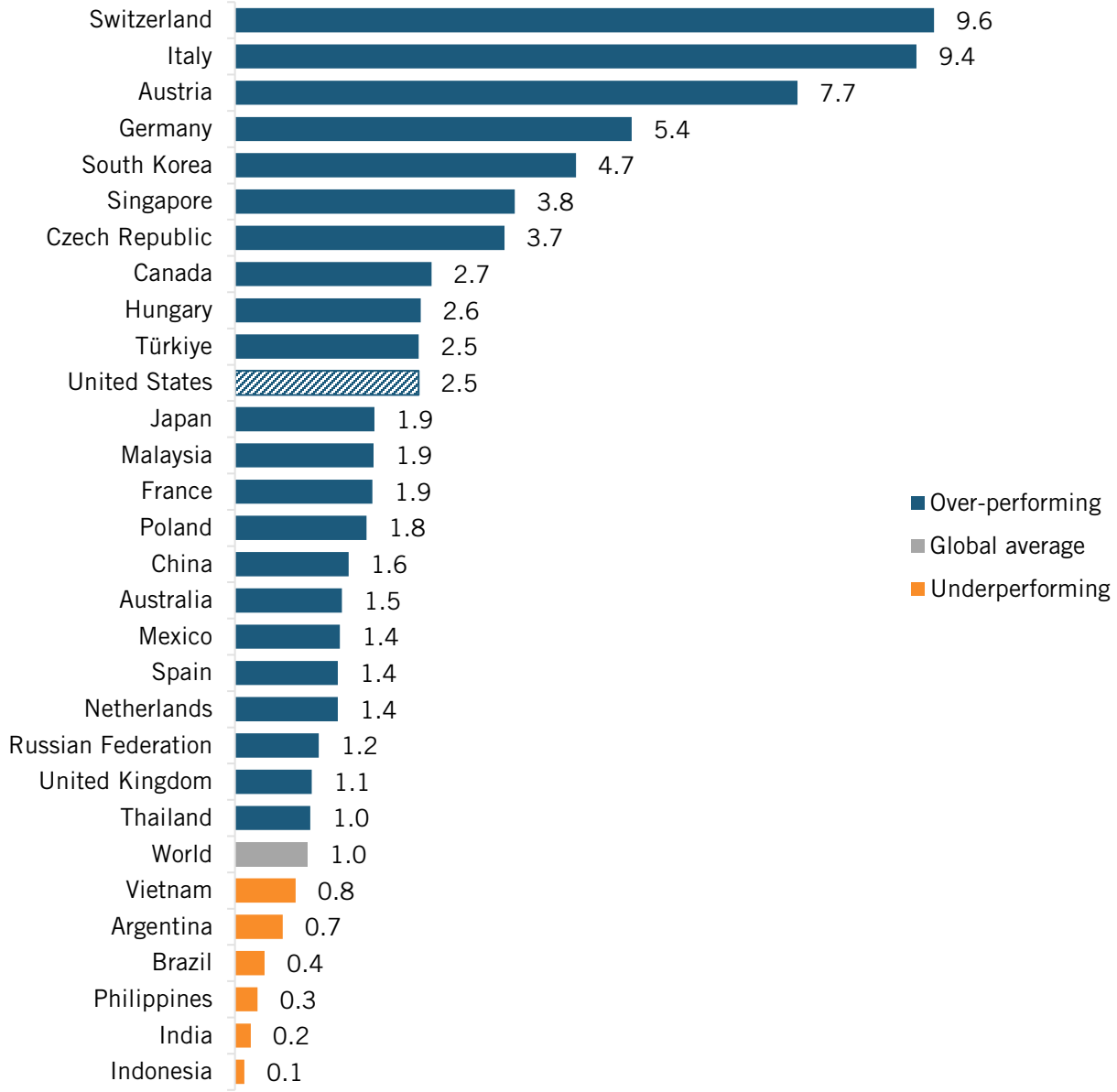


Consumption as a share of GDP could indicate how large a nation's manufacturing sector is but may have some limitations, such as overstating some low-income countries' consumption of machine tools. For example, consumption as a share of GDP overstates India's consumption of machine tools because the country likely has to purchase some of these tools—its production was only about 2 percent of global production—from other nations and pay higher prices relative to its low per capita GDP. In contrast, consumption as a share of GDP might nevertheless have some relevance when comparing these major economies. For instance, China's consumption as a share of GDP might still be of relevance because the nation produces a large share of machine tools—about 32 percent of the global production—so its manufacturing industries can also purchase those tools at a cheaper price, meaning its consumption of machine tools is still accurate. However, the United States' low relative consumption intensity compared with other high-income countries such as Austria, Germany, and Switzerland does appear to be an accurate indicator of low machine tool consumption.

Importantly, the U.S. consumption value of machine tools as a relative share of workers surpassed that of China.

The consumption value of machine tools as a share of workers controls for income and is a reflection of the size of a nation's manufacturing sector and the intensity of the sector's machine tool use. On this measure, the United States ranked higher but still fell below some major economies, such as that of Switzerland, Italy, Austria, Germany, South Korea, and Singapore. The U.S. relative intensity score was 2.5, indicating that the average U.S. worker used 150 percent more machine tool value than the average worker in the world did. The United States exceeded Japan, Malaysia, and France, all with a relative intensity scores of 1.9. Importantly, the U.S. consumption value of machine tools as a relative share of workers surpassed that of China, which had a relative intensity score of 1.6, indicating that the average Chinese worker used 60 percent more machine tool value than the average worker in the world did, but about 40 percent less than that of the average U.S. worker. (See figure 11.)

Figure 11: Machine tool consumption value as a relative share of workers for the top 29 nations with the highest machine tool consumption in 2022[16]

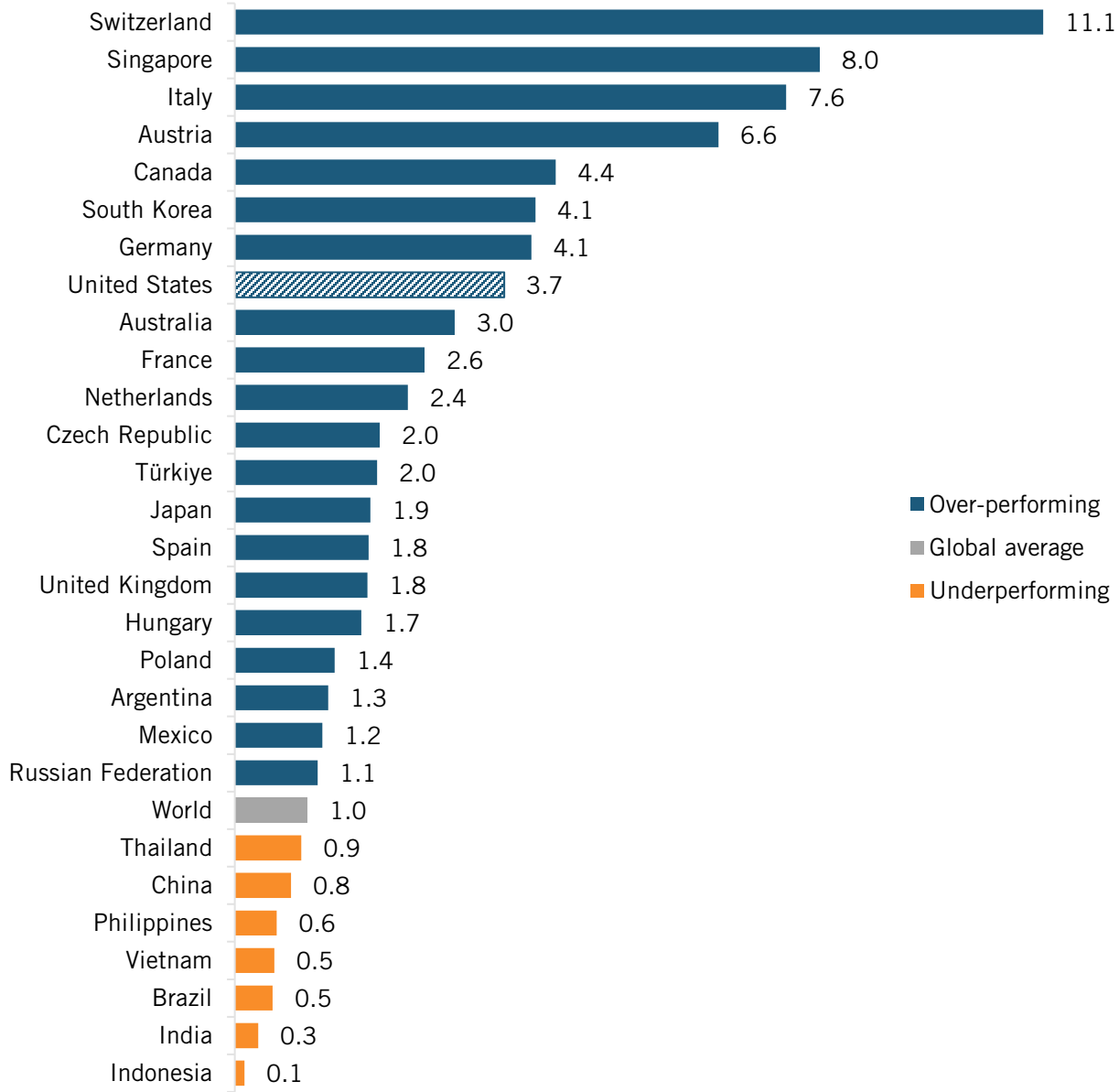


The consumption value as a share of manufacturing workers is an indicator of machine tool usage intensity in manufacturing. In 2022, the United States ranked 8th out of the top 28 nations with the highest consumption as a relative share of manufacturing workers. The U.S. intensity score was 3.7, meaning the average U.S. manufacturing worker used 270 percent more in machine tool value than did the average worker in the world.

The United States' high relative intensity score is partly because of its high consumption of machine tools value ($10.5 billion) combined with a modest number of manufacturing workers (15.7 million). In comparison, China's relative intensity score was only 0.8, or consuming 20 percent below the global average in machine tools, partly due to its high number of

manufacturing workers. The United States also surpassed Australia and France, which had relative intensity scores of 3.0 and 2.6, respectively. (See figure 12.)

Figure 12: Machine tool consumption value as a relative share of manufacturing workers for the top 28 nations with the highest machine tool consumption in 2022[17]



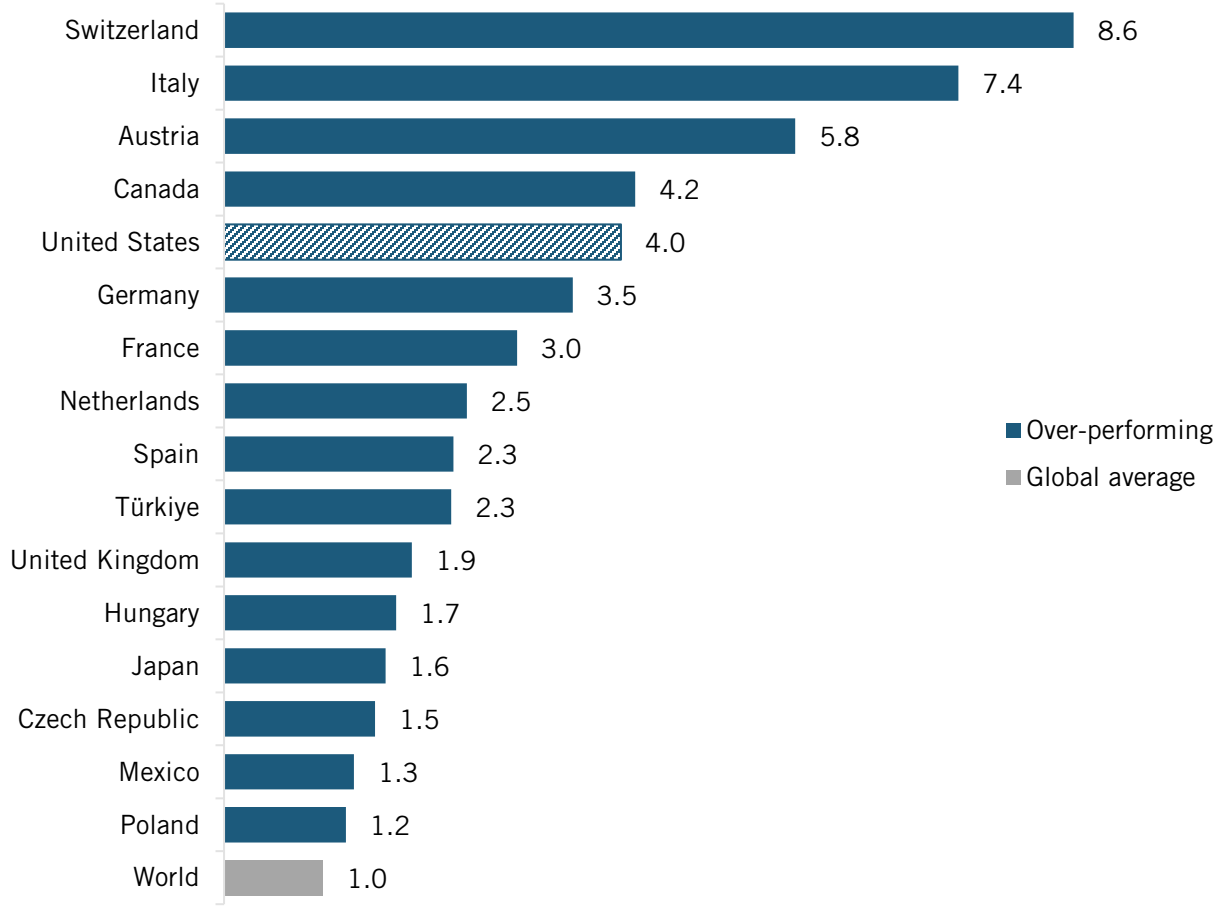
Machine Tool Consumption as a Relative Share of Durable Goods Workers

Although the previously mentioned three measures are good indicators of a nation's manufacturing sector's well-being and the intensity of machine tools usage in manufacturing, they do not examine the intensity of machine tool usage for the manufacturing industries that rely on them the most. In other words, these indicators do not take into account that durable goods manufacturing industries, such as electronics manufacturing, rely on machine tools more than do nondurable goods industries, such as bread manufacturing. As such, machine tools

consumption as a relative share of durable goods workers is a good inclusion in this report, as it highlights the real intensity of machine tool usage in the manufacturing sector. This section examines machine tools consumption value as a relative share of durable goods workers in the United States and a subset of OECD nations that were among the top 30 nations with the highest consumption of machine tools.

In 2022, the United States ranked 5th out of 16 OECD nations in its machine tool consumption as a relative share of durable goods manufacturing workers, surpassing Germany, France, and the Netherlands. The U.S. relative intensity score was 4.0, indicating that the average U.S. durable goods manufacturing worker used 300 percent more machine tool value than did the average durable goods manufacturing worker in the world. In comparison, Switzerland, Italy, and Austria had the highest consumption values as a relative share of durable goods manufacturing workers, with intensity scores of 8.6, 7.4, and 5.8, respectively. Despite the U.S. relative intensity score falling below these nations, it did surpass Germany and France at 3.5 and 3.0, respectively. (See figure 13.)

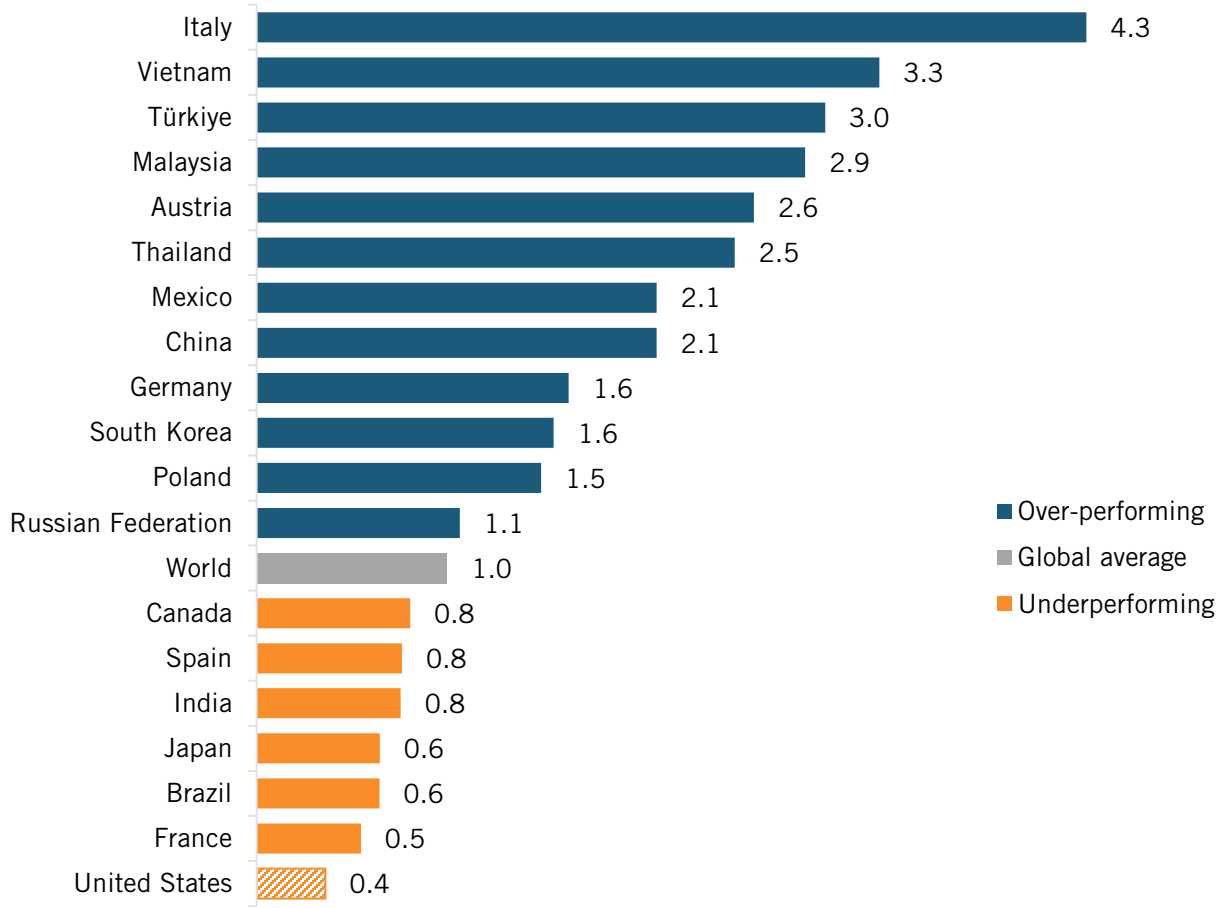
Figure 13: Machine tool consumption as a relative share of durable goods manufacturing workers for a subset of OECD nations with the highest machine tool consumption in 2022[18]



Metal-Forming Machine Tool Consumption

In the subset of metal-forming machine tools, the United States' consumption as a relative share of GDP was the lowest of the top 19 nations with the highest consumption. In 2022, the U.S. intensity score was 0.4, indicating that it was 60 percent below the global average. Surpassing the United States, the nations of Japan, Brazil, and France had relative intensity scores of 0.6., 0.6, and 0.5, respectively. More concerningly, China far surpassed the United States with a relative intensity of 2.1, meaning that its consumption was 110 percent higher than the global average and almost six times more than the United States' share of GDP. At the top, Italy and Vietnam had the highest relative consumption, with intensity scores of 4.3 and 3.3, respectively. (See figure 14.)

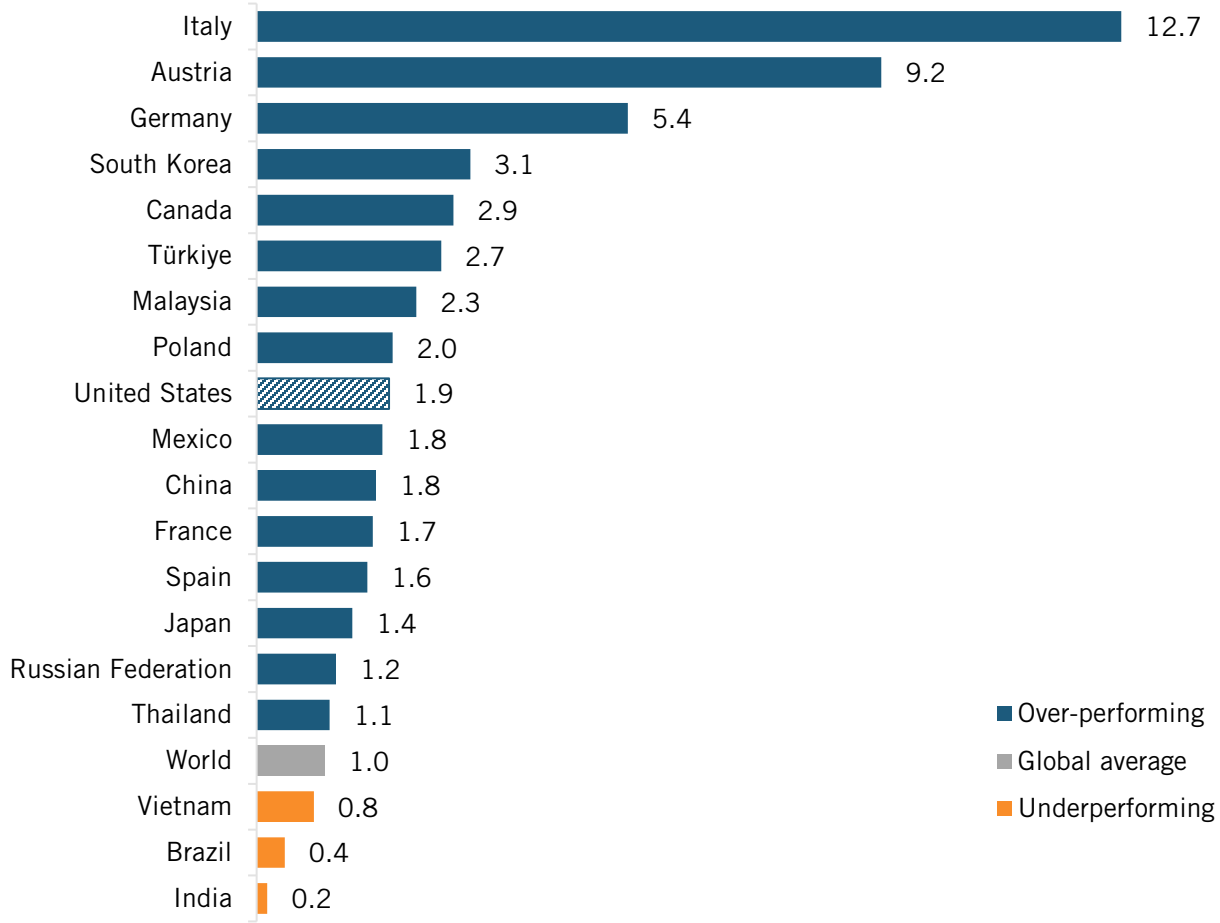
Figure 14: Metal-forming machine tool consumption as a relative share of GDP for the top 19 nations with the highest machine tool consumption in 2022[19]



The United States ranked 9th in metal-forming machine tool consumption as a relative share of workers. In 2022, the U.S. relative intensity score was 1.9, indicating that the average U.S. worker used 90 percent more metal-forming machine tools than did the average worker in the world. The U.S. intensity level surpassed that of Mexico and France at 1.8 and 1.7, respectively. Moreover, the United States slightly surpassed China, which had a relative intensity score of 1.8, indicating that the average Chinese worker used 80 percent more machine tools than did the average worker in the world, but 10 percent less than the average U.S. worker. Of these nations,

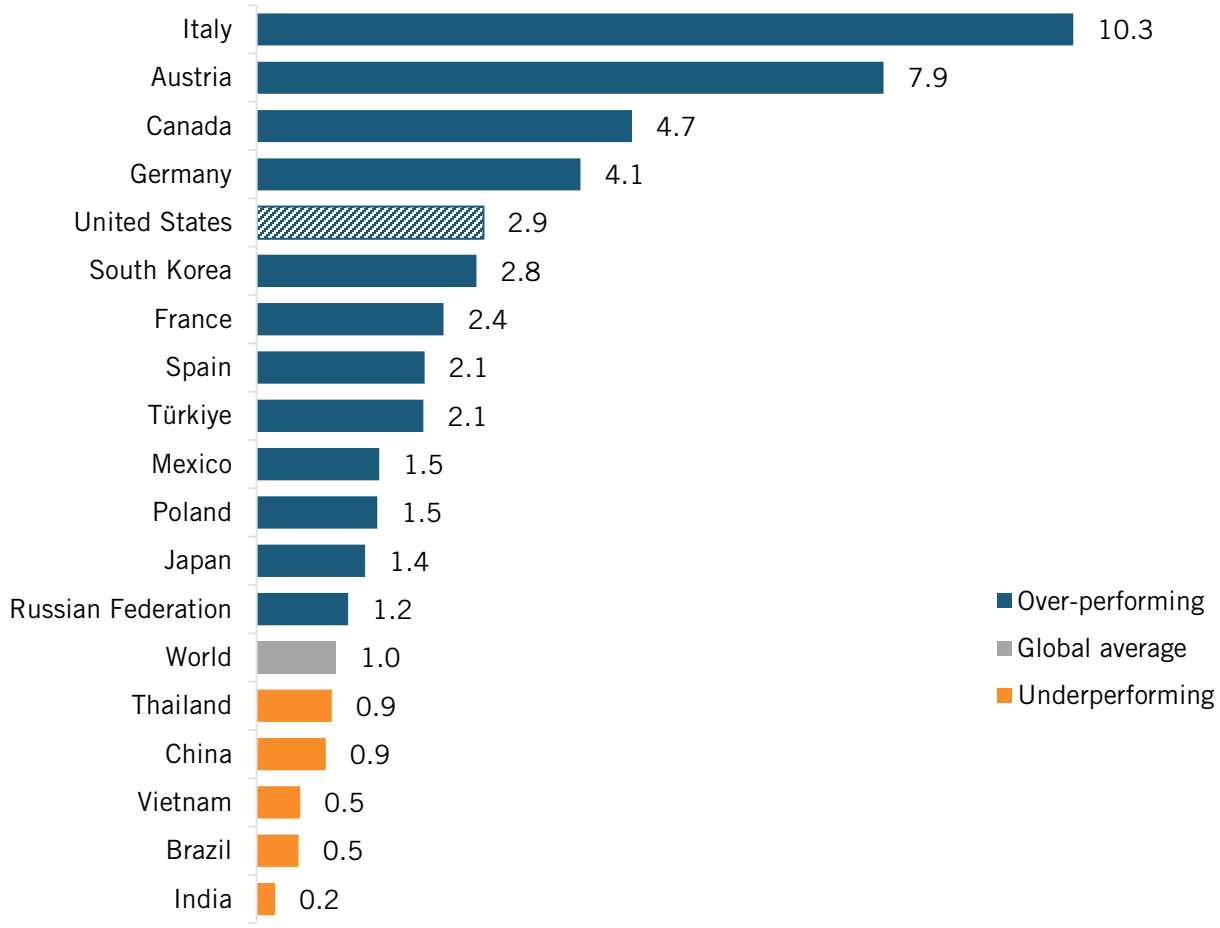
Italy and Austria had the highest consumption values as a relative share of workers, with intensity scores of 12.7 and 9.2, respectively. (See figure 15.)

Figure 15: Metal-forming machine tool consumption as a relative share of workers for the top 19 nations with the highest machine tool consumption in 2022[20]



U.S. metal-forming machine tool consumption as a relative share of manufacturing workers was even higher, ranking 5th out of the top 18 nations with the highest consumption. Indeed, in 2022, the U.S. relative intensity score was 2.9, indicating that the average manufacturing worker used 190 percent more metal-forming machine tool value than did the average worker in the world. The United States surpassed South Korea and France, with relative intensity scores of 2.8 and 2.4, respectively. More importantly, the United States far surpassed China, which had a relative intensity score of 0.9, indicating that the average Chinese manufacturing worker used 10 percent less metal-forming machine tool value than did the average worker in the world and about 70 percent less than the average U.S. manufacturing worker. (See figure 16.) In sum, despite its consumption as a share of GDP indicating that China may have a large manufacturing sector, consumption as a share of manufacturing workers indicates that it may actually be less efficient than U.S. manufacturing.

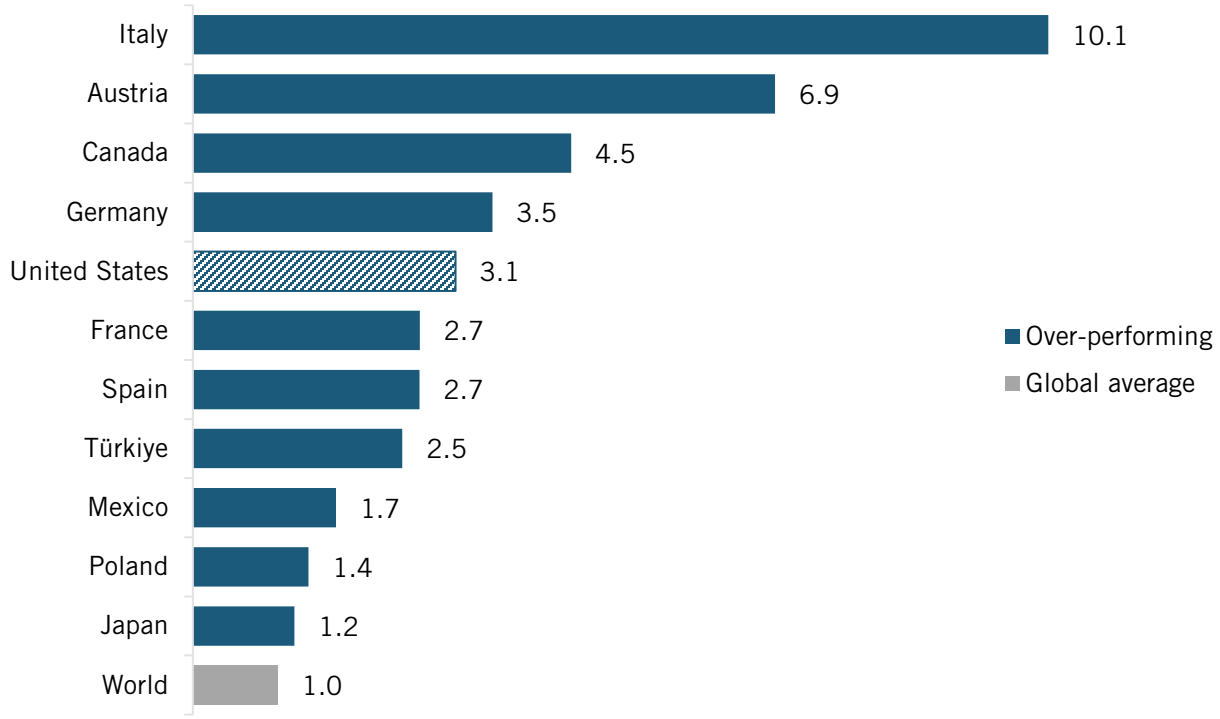
Figure 16: Metal-forming machine tool consumption as a relative share of manufacturing workers for the top 18 nations with the highest machine tool consumption in 2022[21]



Metal-Forming Machine Tool Consumption as a Relative Share of Durable Goods Manufacturing Workers

In 2022, the United States ranked 5th among 11 OECD nations with available data on metal-forming machine tool consumption as a relative share of durable goods manufacturing workers. These 11 OECD nations were in the top 20 nations with the highest consumption of metal-forming machine tools. The U.S. relative intensity score was 3.1, meaning the average durable goods manufacturing worker used 210 percent more metal-forming machine tool value than the average worker in the world did. Topping the list, Italy had the highest relative intensity score at 10.1, indicating that the average Italian durable goods manufacturer used 910 percent more machine tools than did the average worker around the globe and about 3.3 times more than the average U.S. worker. Meanwhile, Japan had the lowest consumption as a relative share of durable goods manufacturing workers with an intensity score 1.2, indicating that the average Japanese durable goods manufacturing worker used only 20 percent more metal-forming machine tool than did the average worker in the world. (See figure 17.)

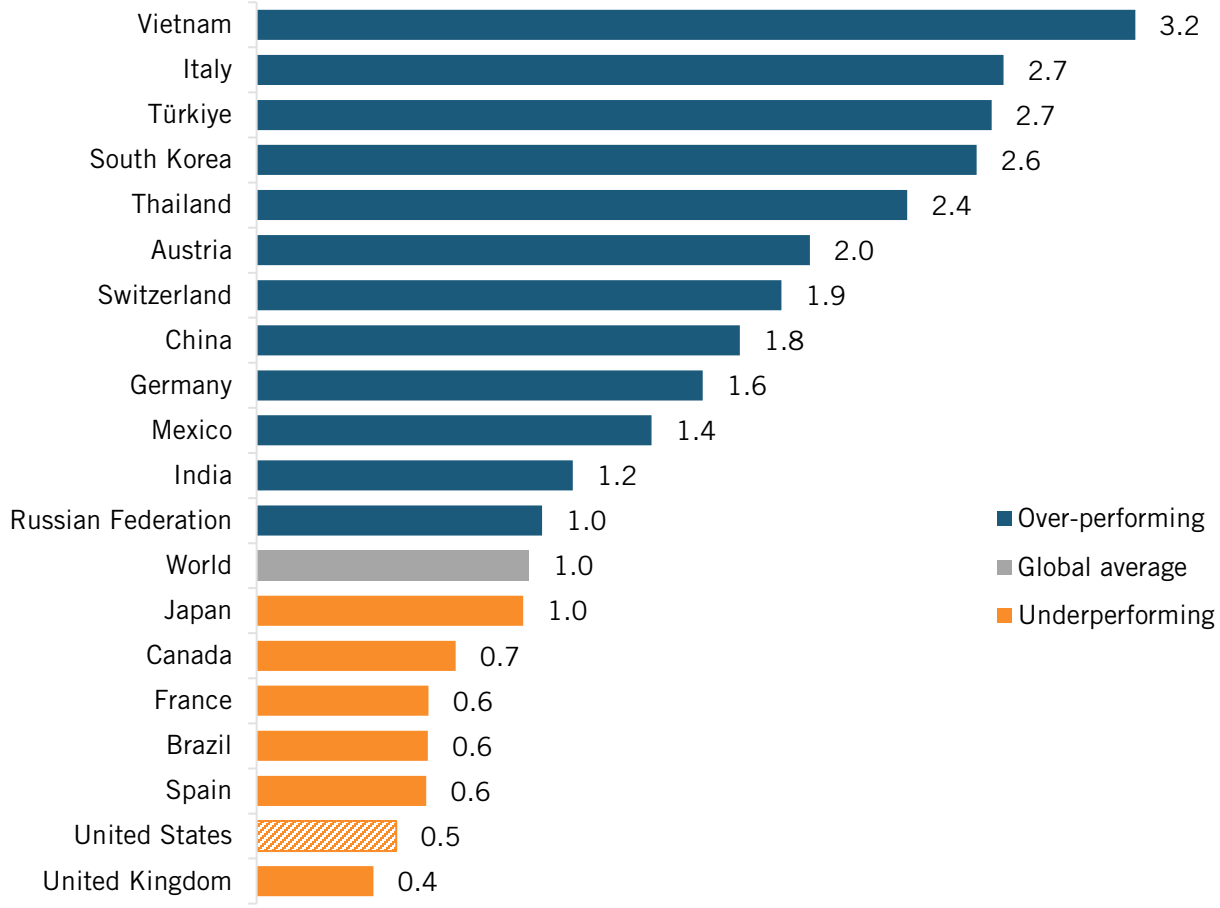
Figure 17: Metal-forming machine tool consumption as a relative share of durable goods manufacturing workers for a subset of OECD nations with the highest machine tool consumption in 2022[22]



Metal Cutting Machine Tool Consumption

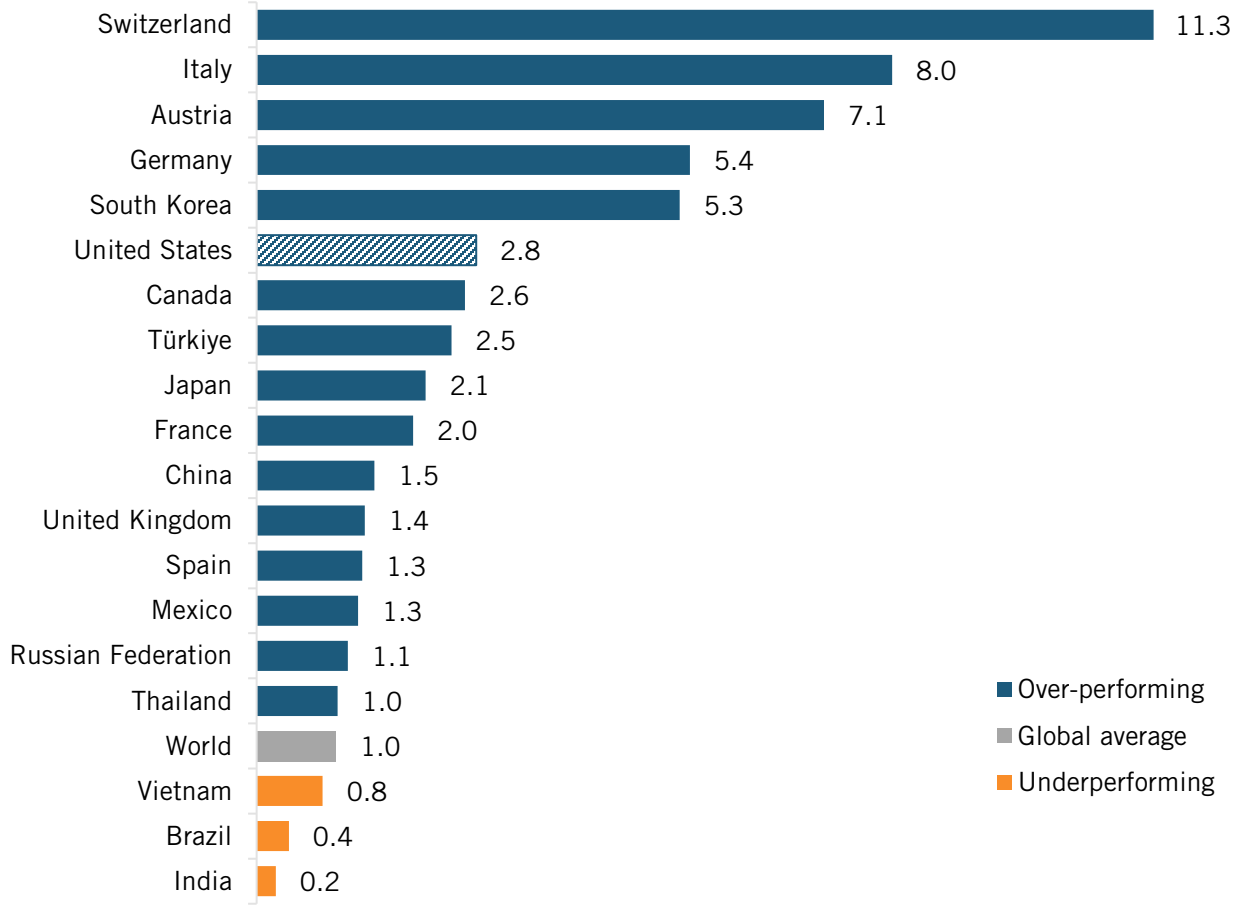
In the subset of metal cutting machine tools, U.S. consumption as a relative share of GDP was the second lowest of the top 19 nations with the highest consumption. In 2022, the U.S. intensity score was 0.5, indicating that the nation's consumption was 50 percent below the global average. The United States only surpassed the United Kingdom, which had with a relative intensity score of just 0.4. In contrast, the United States was far surpassed by South Korea, Thailand, and Austria, which had relative intensities of 2.6, 2.4, and 2.0, respectively. More importantly, China also far surpassed the United States with a relative intensity of 1.8, meaning its consumption was 80 percent above the global average and almost 3.5 times more than the U.S. share of GDP. (See figure 18.)

Figure 18: Metal cutting machine tool consumption as a relative share of GDP for the top 19 nations with the highest machine tool consumption in 2022[23]



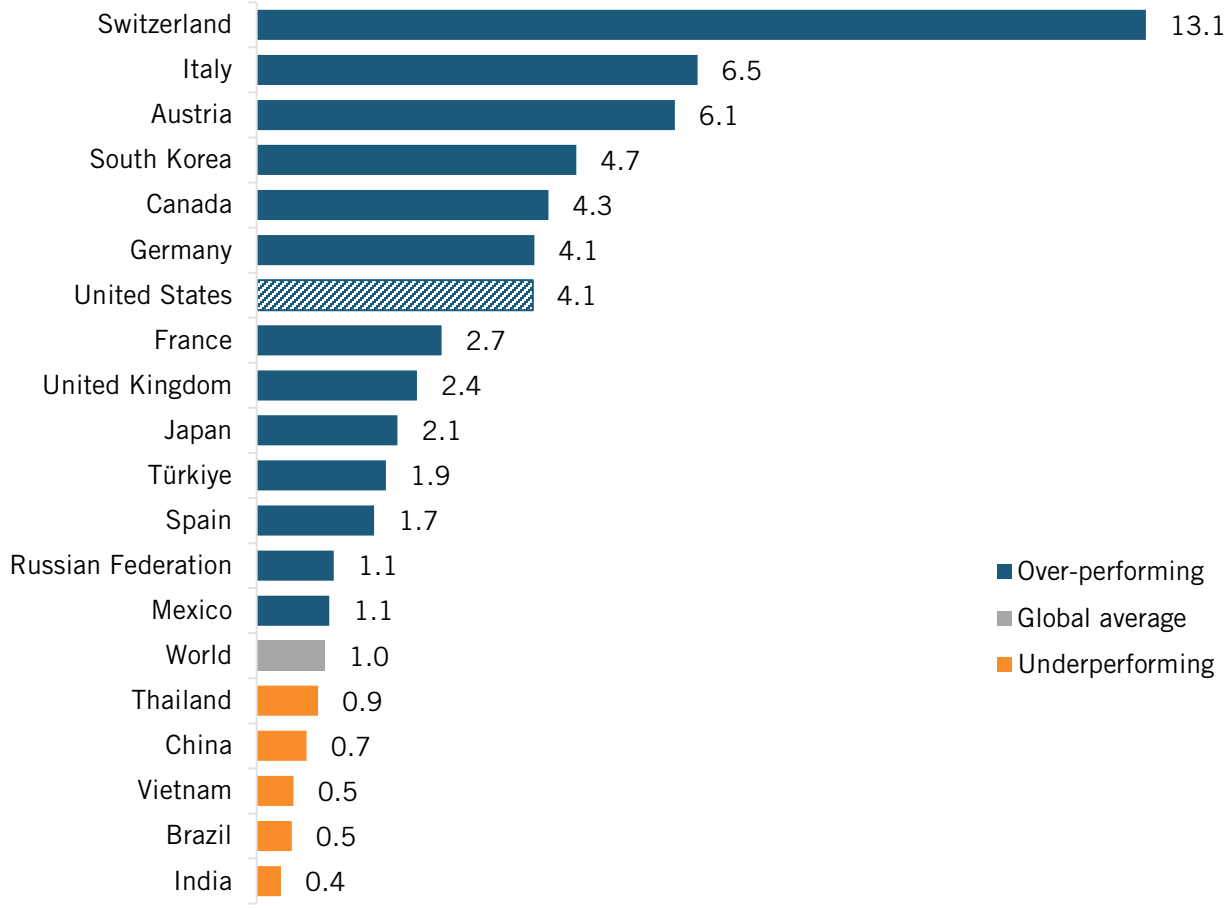
Despite the low U.S. consumption as a share of GDP, the U.S. consumption as a share of workers was higher, ranking 6th out of the 19 nations with the highest metal cutting machine tool consumption. Indeed, in 2022, the U.S. relative intensity score was 2.8, indicating that the average U.S. worker consumed 180 percent more metal cutting machine tools than the average worker in the world did. This high level of consumption as a relative share of workers meant that the United States surpassed Canada, Türkiye, and Japan, which had intensity scores of 2.6, 2.5, and 2.1, respectively. Moreover, the United States also surpassed China, which had an intensity score of 1.5, indicating that the average Chinese worker used 50 percent more metal cutting machine tools than did the average worker in the world but about 46 percent less than the average U.S. worker. Of these nations, Switzerland and Italy had the highest relative intensity scores at 11.3 and 8.0, respectively. (See figure 19.)

Figure 19: Metal cutting machine tool consumption as a relative share of workers for the top 19 nations with the highest machine tool consumption in 2022[24]



The United States' consumption as a share of manufacturing workers was also much higher than its consumption as a share of GDP. Indeed, the U.S. consumption as a share of manufacturing workers ranked 7th out of the top 19 nations with the highest consumption. In 2022, the U.S. intensity score was 4.1, meaning the average U.S. manufacturing worker used 310 percent more metal cutting machine tool value than the average worker in the world did. As a result, the United States surpassed France, the United Kingdom, and Japan, which had relative intensities of 2.7, 2.4, and 2.1, respectively. Moreover, the United States also far surpassed China's relative intensity of 0.7, indicating that the average Chinese manufacturing worker used 30 percent less than the average worker in the world and 82 percent less than the average U.S. manufacturing worker did. (See figure 20.)

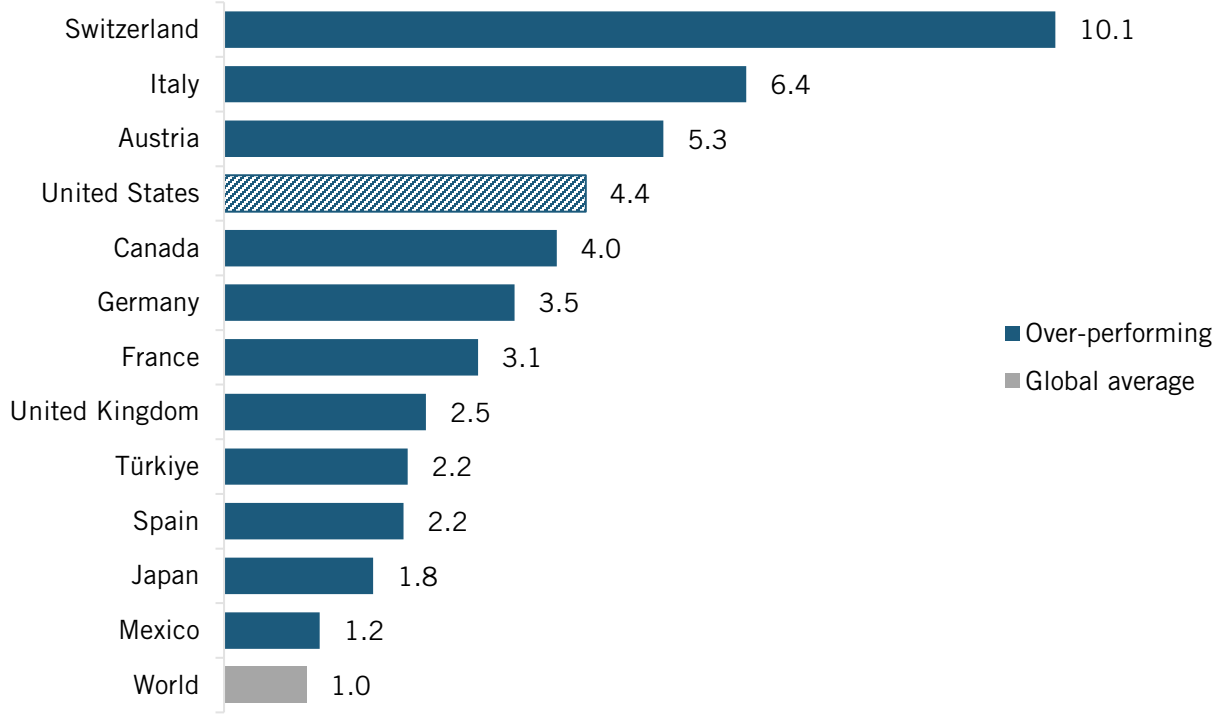
Figure 20: Metal cutting machine tool consumption as a relative share of manufacturing workers for the top 19 nations with the highest machine tool consumption in 2022[25]



Metal Cutting Machine Tool Consumption as a Relative Share of Durable Goods Manufacturing Workers

The United States ranked 4th among 12 OECD nations for which data was available on metal cutting machine tool consumption as a share of durable goods manufacturing workers. These 12 OECD nations were in the list of top 20 nations with the highest consumption of metal cutting machine tools. In 2022, the U.S. relative intensity score was 4.4, indicating that the average U.S. durable goods manufacturing worker used 340 percent more metal cutting machine tools than did the average worker in the world. Surpassing the United States, the nations of Switzerland, Italy, and Austria had the highest consumption as a relative share of durable goods manufacturing workers with intensity scores of 10.1, 6.4, and 5.3, respectively. In contrast, Spain, Mexico, and Japan had the lowest intensities at 2.2, 1.8, and 1.2, respectively. (See figure 21.)

Figure 21: Metal cutting machine tool consumption as a relative share of durable goods manufacturing workers for a subset of OECD nations with the highest machine tool consumption in 2022[26]

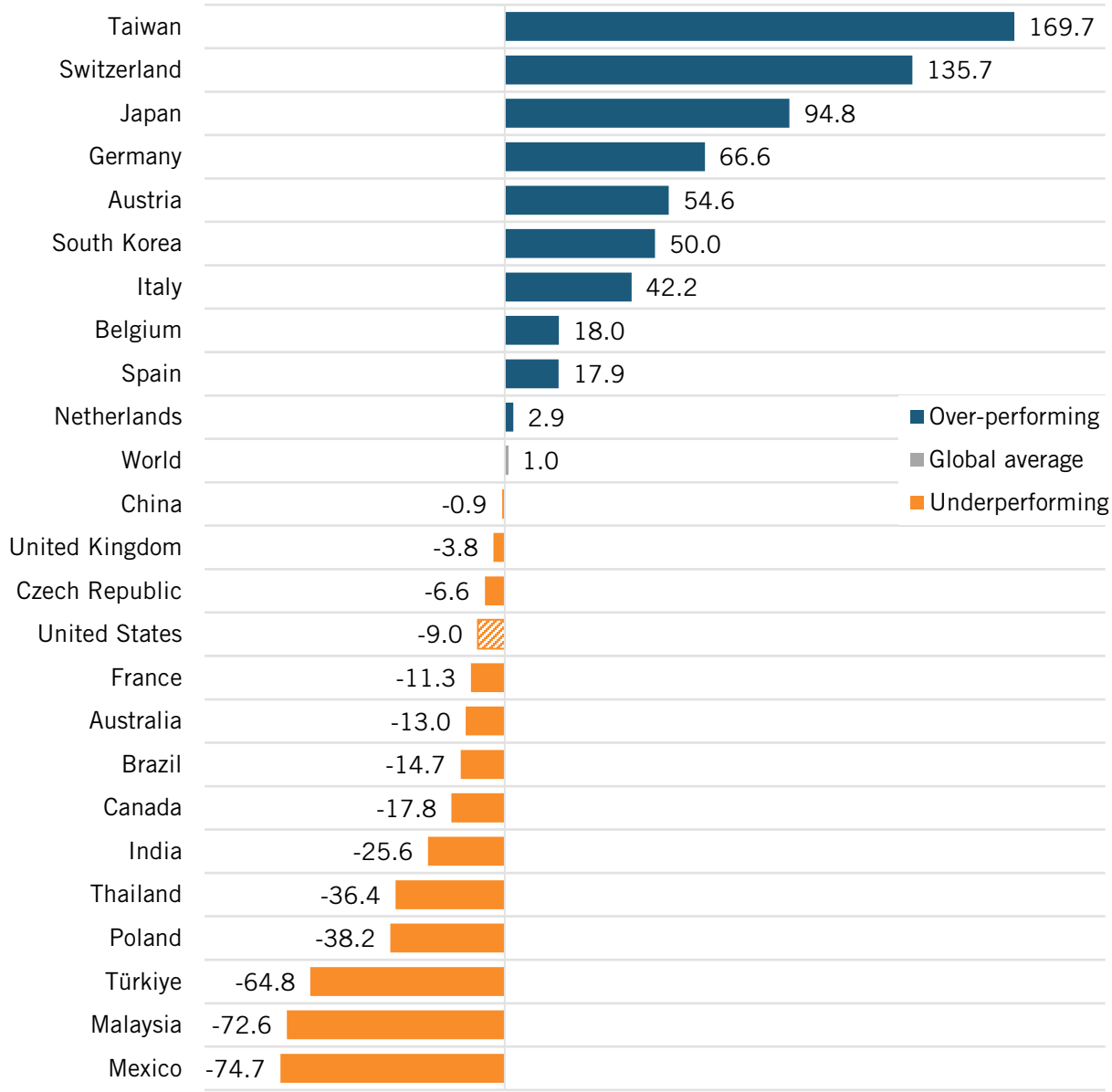


MACHINE TOOL TRADE BALANCE

The low production of machine tools means the United States imported much more machine tools used than it exported. Indeed, a Commerce Department Section 232 Filing on Industrial Machinery highlights that "most tools are purchased from a handful of builders, all of whom have large global trading networks. Most of these are big Japanese enterprises, one is a medium-sized South Korean firm and the last is a private US company."[27] Moreover, it also finds that the United States exported $550 million in machine tools while U.S. manufacturers imported $1.6 billion, indicating that the United States had a machine tool trade deficit of $1.1 billion in 2024.[28]

Accordingly, in 2022, the United States ranked 14th out of 24 nations in its trade balance as a share of GDP. The U.S. trade balance index was -9.0, indicating that the United States was in a trade deficit for machine tools and was 9 times below the global average. Surpassing the United States was China with a trade balance index of -0.9, indicating that it had a trade deficit in machine tools that was almost one times that of the global average. More importantly, the Chinese trade deficit as a share of GDP was 10 times less than that of the United States. Of these nations, Taiwan, Switzerland, and Japan had the highest trade balance indexes at 169.7, 135.7, and 94.8, respectively, meaning these nations specialized in the production of machine tools. (See figure 22.)

Figure 22: Machine tool trade balance index for the top 24 nations with the highest machine tool imports and exports in 2022[29]



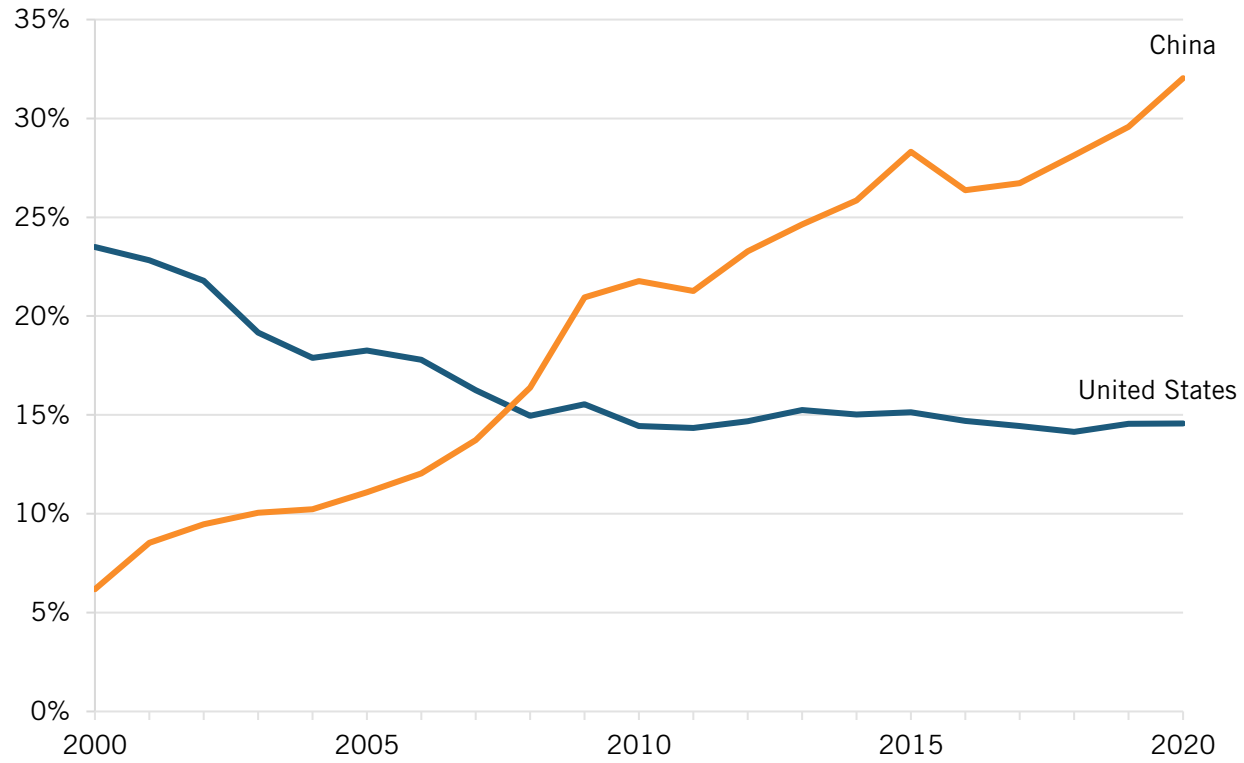
MACHINE TOOLS INDUSTRY: UNITED STATES VERSUS CHINA

In 1981, the United States was the largest producer of machine tools at $5.1 billion.[30] By 2022, China was the world's leading producer at $27.1 billion per year, while the United States ranked fifth at $5.9 billion.[31] However, even though China's domestic companies produce more than 95 percent of the domestic demand for low-end CNC machine tools, over 90 percent of its high-end CNC tools are still imported.[32]

Over time, the U.S. global market share in machinery and equipment has decreased while China's has increased. (See figure 23.) In 2000, the United States held a 23 percent global market share, and China held just 6 percent.[33] By 2020, China had a 32 percent share while the

United States only had 15 percent.[34] The United States has witnessed a decline in machine tool manufacturing.[35] Industry output is increasing at a rate slower than GDP. In contrast, China has experienced an upward trend in the metal-cutting machine tools industry, growing at a rate faster than GDP.[36]

Figure 23: U.S. and Chinese firms' global market shares in machinery and equipment[37]



Despite China's quick growth, Chinese machine tools are considered low end and low tech.[38] According to the Strategic Study of Chinese Academy of Engineering, China's machine tool industry trails behind advanced international countries by 15 years.[39] For example, fewer than 20 Chinese manufacturers of machine tools have upgraded their production lines to incorporate Industry 4.0 standards, such as Internet of Things (IoT) technologies and artificial intelligence (AI), within the high-end CNC market.[40] Consumers of Chinese-made machine tools have also reported product defects, including oil, liquid, and gas leaks.[41] Moreover, China has yet to implement additive manufacturing into the machining process on a large scale due to inadequate development.[42]

As such, China's medium- to high-end machine tool industry is heavily reliant on imports from Asian and European countries. In 2020, the largest share of high-end machine tool imports was from Japan ($2.7 billion) and Germany ($1.3 billion), accounting for 62 percent of total imports.[43] And in particular, foreign businesses currently make up 70 percent of China's medium-end machine tool industry.[44] Nevertheless, the Chinese government has made a conscious effort to break this pattern. "Made in China 2025" strives to decrease foreign dependence and increase independent innovation capabilities through the research and development of high-end machine tools and key components.[45]

CONCLUSION

Machine tool production is key to national power and sovereignty. Machine tool consumption is key to a competitive and efficient manufacturing industry. The United States is weak in both, especially production. As a result, the availability of these tools to the average American worker is also mediocre compared with major economies, such as Germany's, Japan's, and Switzerland's. In comparison, China, the United States' major geopolitical rival, has stronger trade performance, produces a higher share, and consumes more as a share of GDP. This is concerning because, if the United States does not want to lose even more manufacturing to China, it will need to focus like a laser on higher productivity through tools such as machine tools.

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About the Author

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