



ASSESSMENT OF THE CNC MACHINING CENTERS MARKET FINAL REPORT

SUBMITTED TO
JYOTI CNC AUTOMATION
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DISCLAIMER

The market research process for this study has been undertaken through secondary/ desktop research as well as primary research, which involves discussing the status of the market with leading participants and experts. The research methodology used is the Expert Opinion Methodology. Quantitative market information was sourced from interviews by way of primary research as well as from trusted portals, and therefore, the information is subject to fluctuations due to possible changes in the business and market climate. Frost & Sullivan's estimates and assumptions are based on varying levels of quantitative and qualitative analyses, including industry journals, company reports, and information in the public domain.

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ABBREVIATIONS

Title	Abbreviations
APAC	Asia-Pacific
CAGR	Compound Annual Growth
CPI	Consumer Price Index
CY	Calendar Year (January to December)
FTA	Free Trade Agreement
FY	Financial Year (April to March)
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GVA	Gross Value Added
IMF	International Monetary Fund
IIP	Index of Industrial Production
KSA	Kingdom of Saudi Arabia
LATAM	Latin America
MEIS	Merchandise Exports from India Scheme
MoSPI	Ministry of Statistics and Programme Implementation
MSMEs	Micro, Small, and Medium Enterprises
OPEC	Organization of Petroleum Exporting Countries
VAT	Value Added Tax

Simultaneous 2 Axis, 3 Axis, 4 Axis, 5 Axis CNC Machines will be referred as 2 Axis, 3 Axis, 4 Axis, 5 Axis CNC machines.

Unless otherwise specified, any reference to a year in this report shall mean calendar year.

Chapter 1: Global Macro-Economic Overview



1.1 Global Real GDP and Growth Outlook

The Global Economy (real GDP), which is now on the path of steady recovery, has undergone significant stress in the last few years due to extended trade conflicts, the slowdown in investments across the world and then a novel virus. The global economy was showing signs of slowdown since 2018 and then entered into a recession in 2020 owing to the unprecedented crisis caused by COVID-19 pandemic. The pandemic started from China around December 2019 and then spread across the continents with alarming speed, infecting millions and bringing economic activity to near standstill in Q2 and Q3 of 2020 as many countries had to impose strict restrictions to curb the spread of the virus. World now has vaccines to fight this disease and companies have developed innovative business models including adoption of digital measures to continue with their businesses. In 2021, the world economy was grown by 5.5%. The robust recovery in 2021 – driven by strong consumer spending and some uptake in investment, with trade in goods surpassing pre-pandemic levels – marked the highest growth rate in more than four decades. But growth momentum slowed considerably by the end of 2021 including in big economies like China, the European Union and the United States of America, as the effects of fiscal and monetary stimuli dissipated, and major supply-chain disruptions emerged.

Emerging markets and developing economies will register 3.3% growth in 2023 compared with a meagre 0.2% growth for advanced economies. Stronger growth for Asia, the Middle East, and Africa will help avert a global recession, although there will be marked global growth slowdown from 3.3% in 2022 to 2.0% in 2023. The United States and Europe will slip into recessions, with a relatively deeper, protracted recession expected in the United Kingdom.

1.2. Macroeconomic trends and analysis of global economy

Realignment of Global Trade Flows:

The Russia-Ukraine conflict is expected to set-off a reconfiguration of global trade flows as energy and food security considerations assume further importance. The European economy, with significant dependence on Russian energy, will increasingly diversify its imports with greater sourcing from the Middle East and North Africa over the medium-term. On the other hand, Russian and Ukrainian food grain exports are being supplanted by supplies from Australia, India, and Latin America. Australia and South Africa are also poised to benefit from increased metal and coal exports in the near-term. The war in Ukraine will have far-reaching economic consequences on Asian economies as Russian energy is the major driver of the economic growth in the region. As most of the Asian economies are consumption-based with food and energy accounting for nearly half of the consumption expenditure, the rising oil prices will affect the emerging Asian markets more than any other region of the world.

High Inflationary Pressures:

While sizeable fiscal stimulus measures and lower interest rates fueled an uptick in consumer demand in 2021, supply-side disruptions in the form of higher freight costs and semiconductor shortages constrained output over the same period, resulting in surging price pressures. The Russo-Ukrainian war in 2022 resulted in a sharp increase in global commodity prices and a hike in freight costs, further exacerbating inflationary pressures. China's zero lockdown policy amid a surge in the viral caseload will also result in a higher build-up of inflationary pressures in the short-term as input supplies are delayed.

Rapid Tightening of Global Financial Conditions:

Inflation has showed some signs of easing in the United States and Europe in recent months, with global inflation expected to fall from 8.8% in 2022 to 6.1% in 2023. The US Federal Reserve and European Central Bank started to dial back the pace of rate hikes in December 2022. While smaller rate hikes and potentially even some rate cuts are expected in 2023, global interest rates will nonetheless remain elevated.

Moreover, monetary policy tightening in advanced economies raises the risk of higher capital outflows from emerging markets such as India. To attract foreign investors, emerging markets will be forced to hike interest rates, which will slow down economic growth as consumption and investment sentiment moderates.

Major Economies are looking for alternative manufacturing hubs

With the gradual expansion of the capacity of its local sourcing and distribution networks accompanied by the provision of key incentives and regulatory relaxations to foreign investors India is on its way to reshaping the global supply chain and becoming an alternative to China. In this regard, Japanese Prime Minister, Fumio Kishida announced an investment of Yen 3.5 trillion (\$42 billion) in India over five years during the India-Japan Annual Summit in Delhi. India has identified a dozen of sectors where global supply chains can shift away from China. These sectors include energy, automobiles, steel, pharma, textiles and garments, marine products, financial services, IT services and tourism, etc. To avoid manufacturing and supply chain disruptions, global companies are looking to diversify their strategy and India stands to gain from this move which will also break the concentrated supply chain in China. With the 'Make in India' programme, India has started to produce electronics, electrical goods, solar panels, chemicals, bulk drugs, metals, furniture, household/gifts items, toys, footwear, hardware, automobile components, tires, bicycle parts, bearings and machinery, etc. Some India-based businesses have also set up domestic sourcing and distribution networks to de-risk from China, and to drive manufacturing costs down.

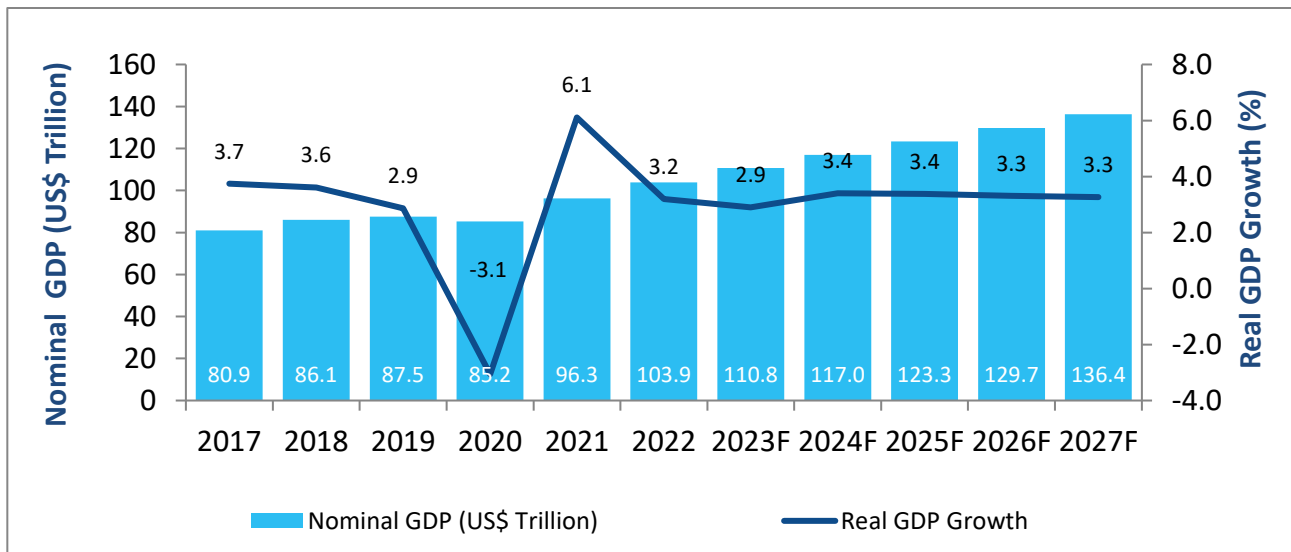
Owing to greater opportunities with cheaper prices over land purchasing rights, labour wages, and operational expenses for factories and warehouses, Vietnam may replace China as the factory of the

world in near future. For the near future, Vietnam will continue to remain an attractive market for foreign investment and a destination for supply chain diversification.

1.3. Global GDP Growth

The global economy expanded at an average rate of 3.7% in 2017 and 2018 due to strong economic performance in emerging markets across Asia and Europe that resulted in an uptick in investment, manufacturing, and trade. However, growth moderated to 2.9% in 2019 as enduring trade disputes including the US-China trade dampened manufacturing activity and exports in addition to slowing investment growth owing to trade policy uncertainty. In 2020, the global economy contracted 3.1% due to pandemic containment measures that lowered merchandise and service exports and subdued consumer and business sentiment. China, Taiwan, Vietnam, and Bangladesh were some of the few emerging markets that saw an expansion of their GDP in 2020 with successful early containment of the virus.

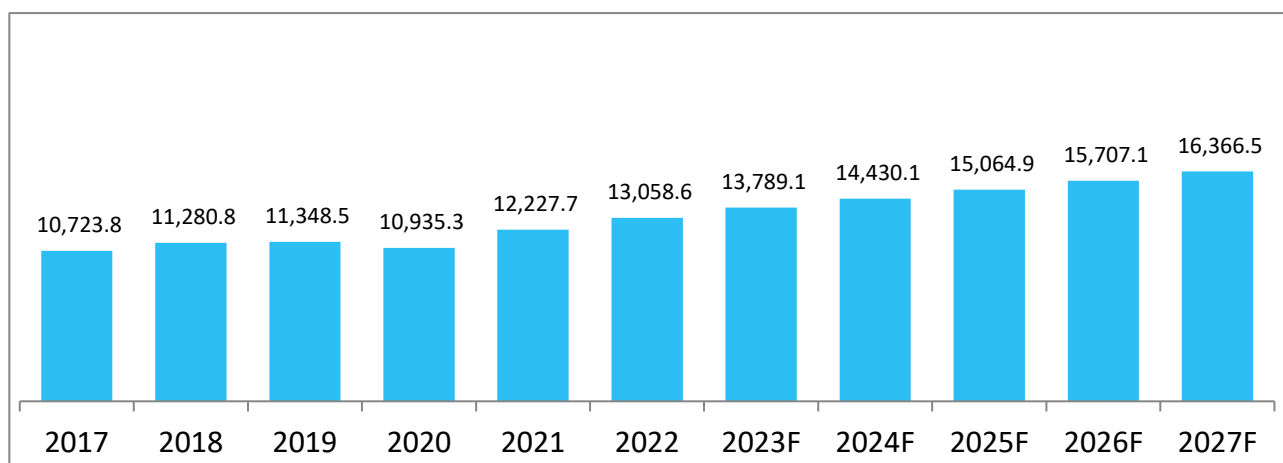
Figure 1.1: Nominal GDP and Real GDP Growth, Global, 2017-2027



1) Data pertains to each calendar year; Estimates and forecasts start from 2023; Population Estimates between 2017 and 2027 for calculating Nomial GDP per Capita are sourced from the World Bank

Source: International Monetary Fund (IMF) World Economic Outlook, Oct 2022;
Data updated as on 27th February 2023

Figure 1.2: Nominal GDP Per Capita, Global, 2017-2027¹, (US\$)



Data updated as on 27th February 2023

1) Data pertains to each calendar year; Estimates and forecasts start from 2023; Population Estimates between 2017 and 2027 for calculating Nomial GDP per Capita are sourced from the World Bank

Source: International Monetary Fund (IMF) World Economic Outlook, Oct 2022;
Data updated as on 27th February 2023

On the basis of a global comparison, China remained the fastest growing economy for the previous three decades, followed by India. In contrast to China, where the average GDP growth fell from above 10.0% to 7.7% between 2010 and 2019, India's GDP growth remained resilient during the same decade. While the pandemic-induced recession in India was more severe than in other major economies including Canada, Japan, the US, Germany, France, Russia, Brazil, and South Africa, it was less severe than in the UK and Italy. In part because of this, India's 2021-22 growth rebound was the strongest when compared against key countries. Due to China's persistent zero-COVID policy, which lasted until 2022, significant negative influence was seen on its medium-term growth. The manufacturing giant avoided an annual contraction in 2020. However, the nation is exhibiting signs of economic derailment, with factors such as lingering trade tensions with the US and a global shift towards manufacturing diversification beyond China restraining the growth momentum. In effect, India is expected to grow at the fastest rate (6.8%) during 2021-2027 among major economies

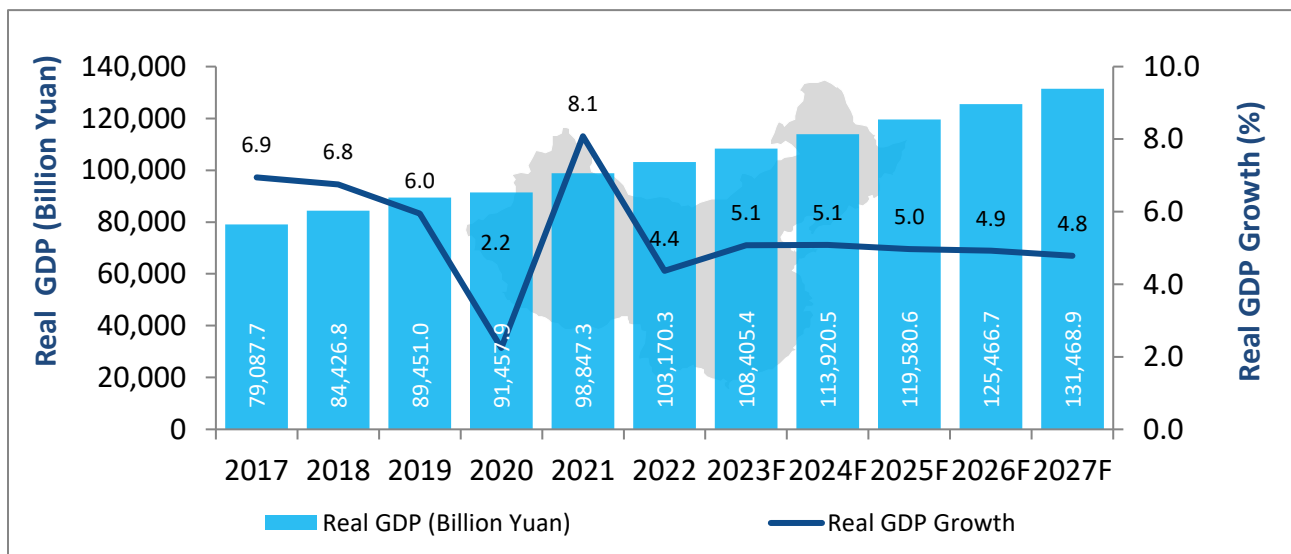
Recovery from the effects of the COVID-19 pandemic drove growth in major economies, but Russia's invasion of Ukraine in February 2022 dampened the pace of growth, exacerbated food and fuel inflation globally, and weighed heavily on global growth prospects. Emerging markets and developing economies, which grew by 3.9%, faced record-high inflation levels and tighter credit conditions. In addition, the US Federal Reserve's rate hike cycle in 2022 resulted in heavy depreciation of emerging market currencies, worsening domestic price pressures.

1.4. Real GDP Growth of Key Economies

China

The Chinese economy grew 6.9% in 2017 led by increase in household disposable income and consumption growth and pick-up in global growth that aided increase in exports. The US-China trade war restrained economic growth to 6.0% in 2019 due to a fall in exports and moderation in manufacturing investments due to increased uncertainty. In 2020, China was one of the few major economies to register a positive growth rate, as successful early containment measures resulted in resumption in economic activity from Q2 2020.

Figure 1.3: Real GDP and Real GDP Growth, China, 2017-2027¹



1) Data pertains to each calendar year; Real GDP is measured in constant prices. Base year for calculating Real GDP growth is 2015. Estimates and forecasts start from 2023

Source: International Monetary Fund (IMF) World Economic Outlook, April 2022; Data updated as on 27th February 2023

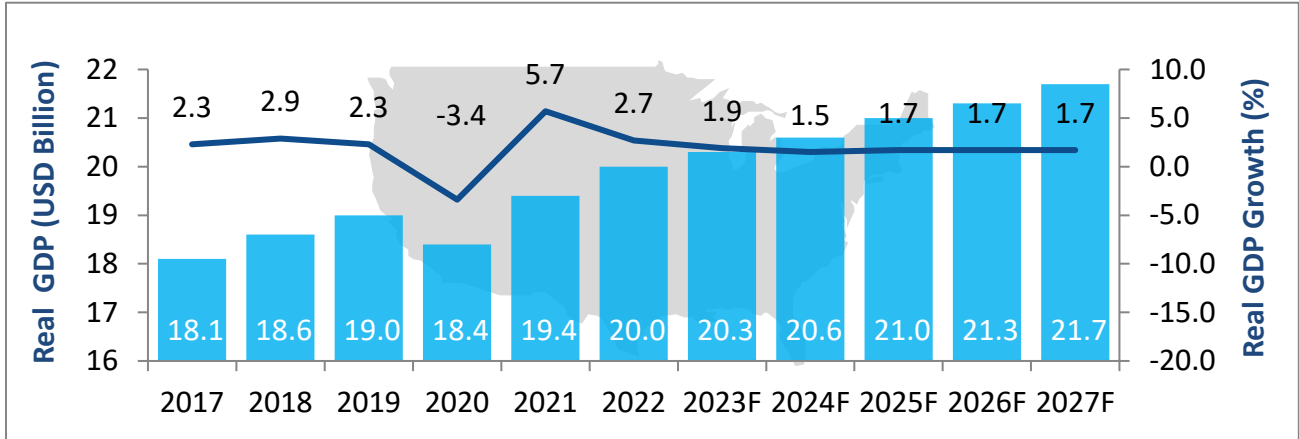
In 2021, China unveiled its medium-term economic growth strategy which focuses on making domestic consumption a key growth driver while cutting reliance on external demand. The strategy also plans to increase domestic manufacturing of high value-added products and enhance supply chain diversification to secure critical components. Due to a slowdown in domestic demand, increased external headwinds to growth in the form of the Russo-Ukrainian war, and sporadic lockdowns on account of the zero-Covid policy, the Chinese economy will expand only 4.4% in 2022. Economic growth is expected to rebound to 5.1% in 2023 and 2024 as both domestic and external economic conditions improve due to lower fuel prices and improving consumption and manufacturing. China's national target aims for an average economic growth of 4.7% between 2021 and 2035 to transition to a moderately developed country. China US Trade war accompanied by a slowdown in China's economy and the impact of the COVID-19 pandemic has resulted in significant

slowdown in China economy and impact on the economic growth. This will have a negative impact on China’s exports eventually.

The United States

Growth slowed to 2.3% in 2019, primarily on account of the US-China trade wars. The economy witnessed 3.4% contraction following the onset of the pandemic, with economic recovery thereafter driven by a combination of strong fiscal stimulus and monetary policy support.

Figure 1.5: Real GDP and GDP Growth, The US, 2017-2027²



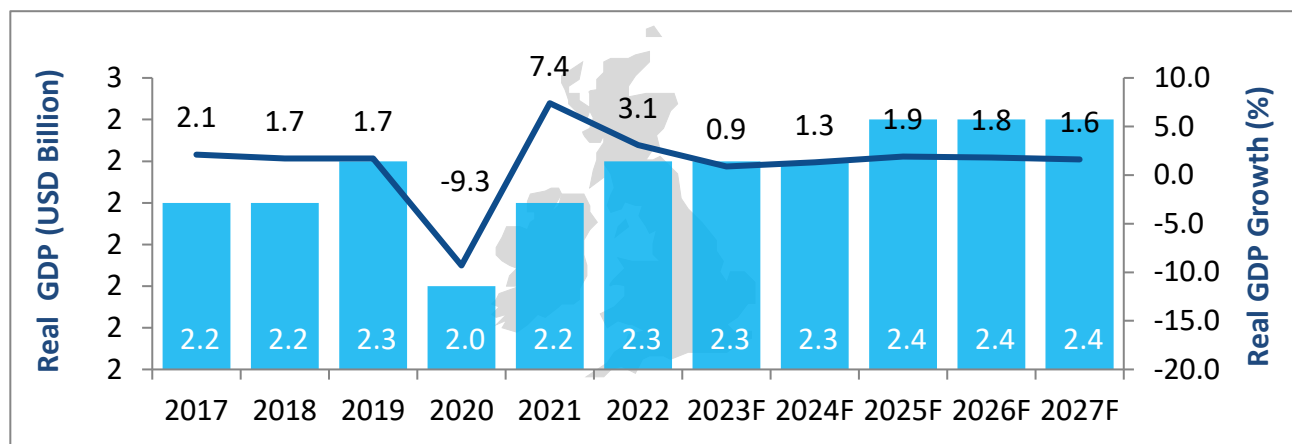
Sources: International Monetary Fund (IMF)- World Economic Outlook, Oct 2022; Frost & Sullivan
 Data is updated as on 27th February 2023; real GDP is measured in constant prices with 2012 base year; estimates and forecasts start from 2023

The US is presently facing record-high inflation levels, necessitating multiple interest rate hikes by the US Federal Reserve. The central bank has already pursued two rate hikes this year, with several more expected over 2022 as it pursues an inflation-targeted approach. Growth had already weakened in Q1 2022 considering COVID-19 resurgence, inflationary pressures, and the Russia-Ukrainian war, with growth to further weaken over 2022 and 2023 given aggressive monetary policy tightening. There is the growing risk that rate hikes could potentially tip the US economy into a recession by 2023 or 2024.

The United Kingdom

The UK economy has been slowing down since the 2016 Brexit referendum which created a lot of investor uncertainty- businesses were particularly concerned about the risk of a no-deal Brexit, although this did not materialize. The UK officially left the EU in January 2020, with a transition period thereafter until December 2020, with subsequent trade and border disruptions and worker shortages negatively affecting the UK economy in 2021. 9.3% growth contraction was registered amidst the pandemic.

Figure 1.6: Real GDP and GDP Growth, The UK, 2017-2027³



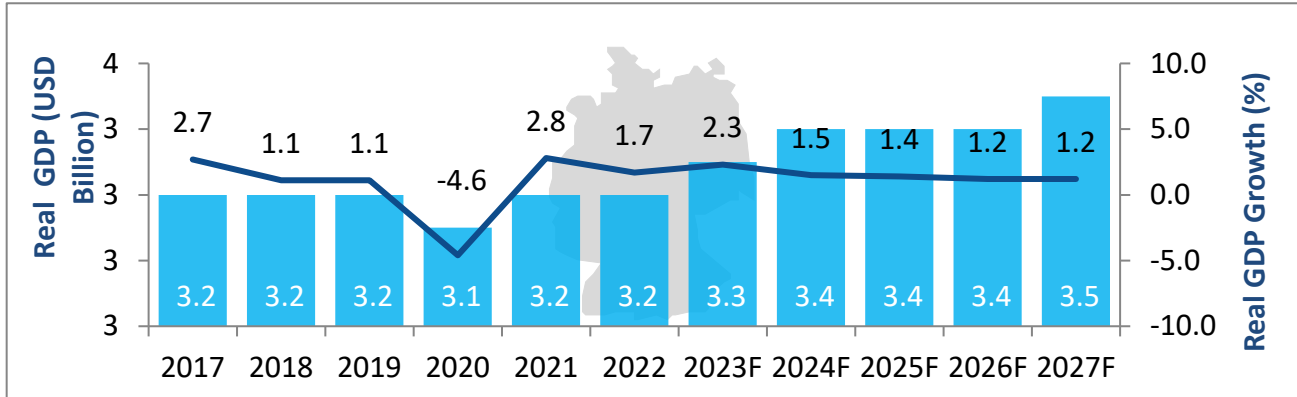
Sources: International Monetary Fund (IMF)- World Economic Outlook, Oct 2022; Frost & Sullivan Data is updated as on 27th February 2023; real GDP is measured in constant prices with 2019 base year; estimates and forecasts start from 2023

The Bank of England has already raised the key interest rate four times since December 2021, but continues to battle very high inflation levels. Present inflationary pressures are being fuelled by a combination of imported food and energy inflation on account of the Russo-Ukrainian war, in addition to rising household energy bills. Energy bills are set to rise further from October 2022 as caps are raised, exerting increasing cost of living pressures for UK households. Growth is expected to slowdown in 2022 and 2023 in light of these factors, before averaging at around 1.8% towards the end of the forecast period. Supportive post-Brexit policies to strike preferential trade deals and attract high value foreign direct investments can help the UK achieve a higher growth trajectory over the forecast period.

Germany

As an export-reliant economy, Germany had been under pressure from the US-China trade war. For instance, Chinese imports from Germany dipped by 37% in 2018 because of the trade conflict, resulting in weaker GDP growth for the European economy that year. Given the manufacturing-intensity of Germany, exposure to slowdown from more recent supply-chain disruptions has been greater; new car sales, for example, shrank by 10.1% in 2021 amidst chip shortages which affected the German automotive industry.

Figure 1.7: Real GDP and GDP Growth, Germany, 2017-2027⁴



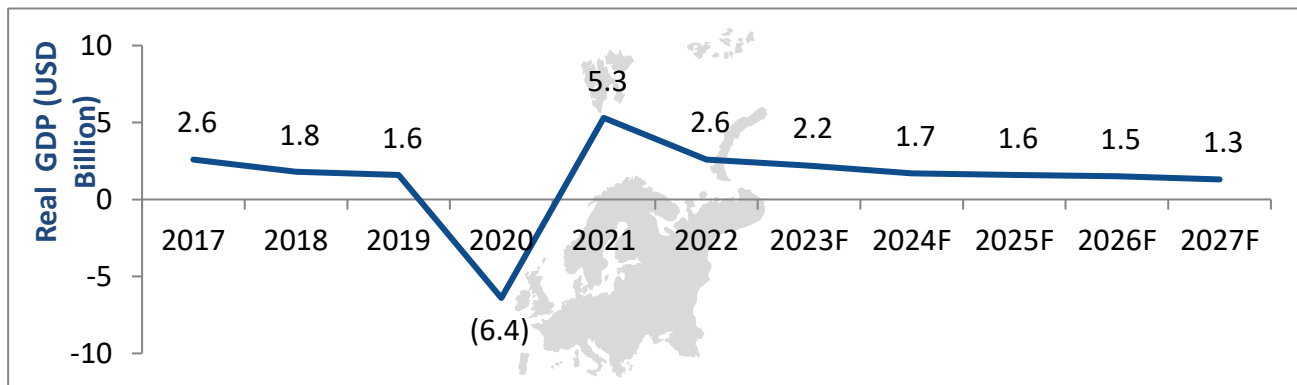
Sources: International Monetary Fund (IMF)- World Economic Outlook, Oct 2022; Frost & Sullivan Data is updated as on May 25th, 2022; real GDP is measured in constant prices with 2015 base year; estimates and forecasts start from 2023

Trade and supply-chain disruptions arising from the Russo-Ukrainian war will exert further stress on the German economy. Adding to this are pressures from Germany's high energy import reliance and resultant susceptibility to energy supply disruptions. On a positive note however, Germany has managed to curtail the share of Russian oil imports from pre-war levels of 35% to nearly 12% at present, as per government indications. With regards to gas supply, the risk of a potential halt in Russian gas supply to Germany would lead to sharp economic slowdown; with gas likely needing to be rationed in this case. Germany has been working to diversify its gas imports, with progress seen in a deal with Qatar. Growth should pick up from 1.7% in 2022 to 2.3% by 2023, assuming a decline in energy prices and some easing in supply-chain disruptions, although the outlook is volatile. For the longer term, higher labour force participation and worker immigration uptick are vital to ensure adequate labour supply and doing business competitiveness for Germany.

Eurozone

The bloc's growth touched a 10-year high in 2017, partially driven by a generous stimulus program of the European Central Bank. Growth thereafter weakened in 2018, with slowdown extending into 2019, on account of factors such as subdued German industrial production and protests in France. The Eurozone economy contracted by 6.4% in 2020.

Figure 1.8: Real GDP Growth, Eurozone, 2017-2027¹



1 Eurozone comprises Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovak Republic, Slovenia, and Spain; data is updated as on May 25th, 2022; estimates and forecasts start from 2023

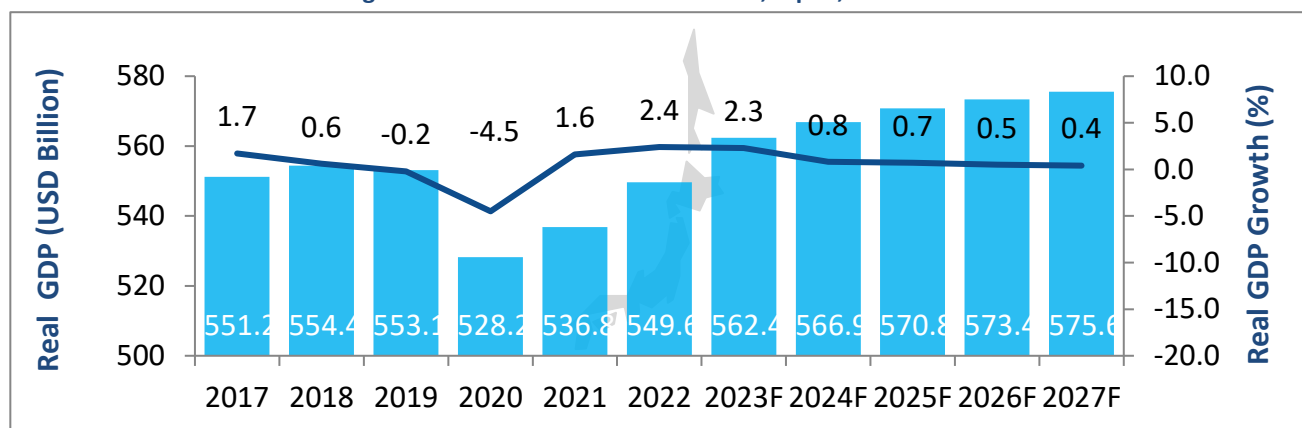
Sources: International Monetary Fund (IMF)- World Economic Outlook, April 2022; Frost & Sullivan

2022 growth forecasts have been revised downwards in light of the Russo-Ukrainian war which is exerting upward pressure on inflation and causing energy market reorientation. 2023 growth will also be weaker than initially projected on this account. If Russia abruptly halts gas supplies to the region, Eurozone growth risks sliding to 0-1% levels in 2022.

Japan

Similar to the German economy, Japan’s export-reliant economy also came under pressures from global trade wars, with Japanese exports exhibiting a declining trend back in 2018 amidst subdued shipments to the US and China. Following 4.5% GDP contraction in 2020, growth recovered to 1.6% in 2021. Economic activity revival in Q4 2021 was however followed by mobility restrictions in Q1 2022 on account of the Omicron variant.

Figure 1.9: Real GDP and GDP Growth, Japan, 2017-2027¹



¹ Data is updated as on May 25th, 2022; real GDP is measured in constant prices with 2015 base year; estimates and forecasts start from 2023

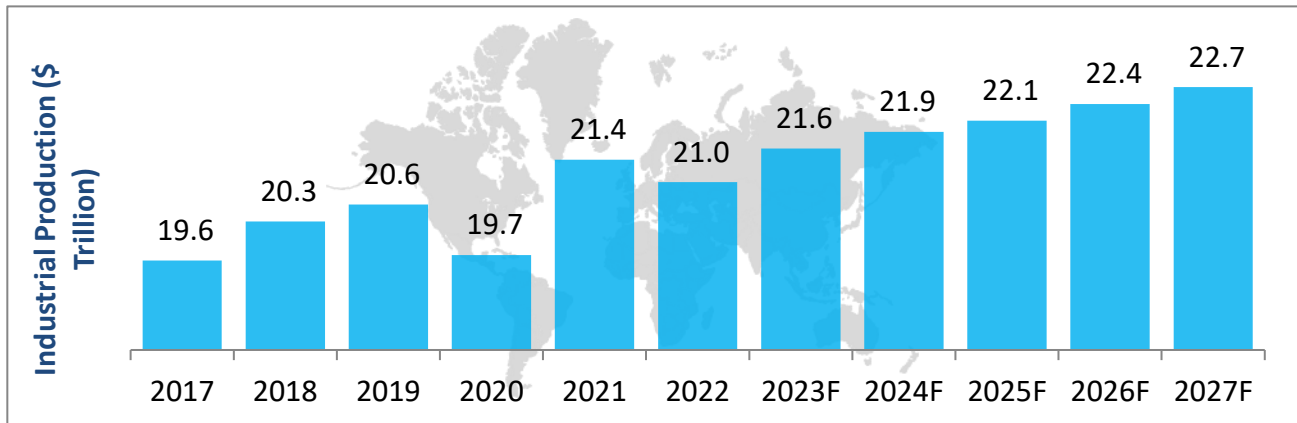
Sources: International Monetary Fund (IMF)- World Economic Outlook, Oct 2022; Frost & Sullivan

Even in early 2022, COVID-19 restrictions challenged the economy. Japan also came under pressure from higher commodity prices which led to growth slowdown in Q1 2022. While inflation just breached the 2% inflation target in April 2022, inflation concerns for Japan are on the lower side compared to other major economies which have seen inflation far outshoot target levels. Japan’s central bank is expected to continue to hold on to ultra-low interest rates, in contrast to the trend of global monetary policy tightening. Demographic trends of a shrinking population size and growing elderly population will be a restraint factor over the forecast period, indicating much needed reforms to boost labour supply.

1.5. Global Industrial Production

Global Industrial production was \$20.6 trillion in 2019. The pace of growth was slowed down to 1.5% in 2019, compared to 3.6% in 2018; the slowdown in growth can partially be attributed to global trade wars which caused supply-chain disruptions and affected export performance. Industrial production contracted sharply in 2020, following onset of the pandemic, registering 4.4% contraction. This contraction came amidst lockdowns and factory closures, trade disruptions, as well as demand-side weakness.

Figure 1.10: Industrial Production, Global, 2017-2027



Data is updated as on 27th February 2023; data is real data based on 2010 US\$; estimates and forecasts start from 2023

Sources: World Bank- Macroeconomic Data (GEM); Frost & Sullivan

In tandem with global economic recovery in 2021, industrial production rose to \$21.4 trillion- much above pre-pandemic 2019 levels. Despite supply-chain disruptions which took hold in 2021, industrial production registered strong growth of 8.6% in 2021. Production levels are expected to decline to an extent in 2022, especially in light of the Russo-Ukrainian war. Monthly industrial production data indicated a decline in industrial production activity in the second quarter, following the invasion of Ukraine. The war is causing significant trade disorder, which will have negative implications for manufacturing output. Additionally, intense energy supply disruptions as a result of the war risk causing sharp industrial slowdown, particularly in Europe. The war in Ukraine has led to significant disruptions to trade and production of energy commodities, exacerbating pre-existing strains in energy markets. To cushion the impact of the current increase in energy prices policy makers in many economies implemented energy subsidies and tax breaks on a large scale, reversing a trend of declining subsidies in recent years. Temporary support to vulnerable groups can be more effective at cushioning the impact of rising energy prices than energy subsidies, since the latter have distortionary effects and can delay the transition to a zero-carbon economy. There are also additional headwinds arising from China's recent lockdowns to control COVID-19 cases. So the current volatile situation across Europe and China will help countries like India to increase their Industrial production and exports. Industrial production will pick up momentum in 2022 with easing of some of the on-going restraints, with production expected to thereafter grow to \$22.7 trillion by 2027.

1.6. Manufacturing as a Share of the GDP

China

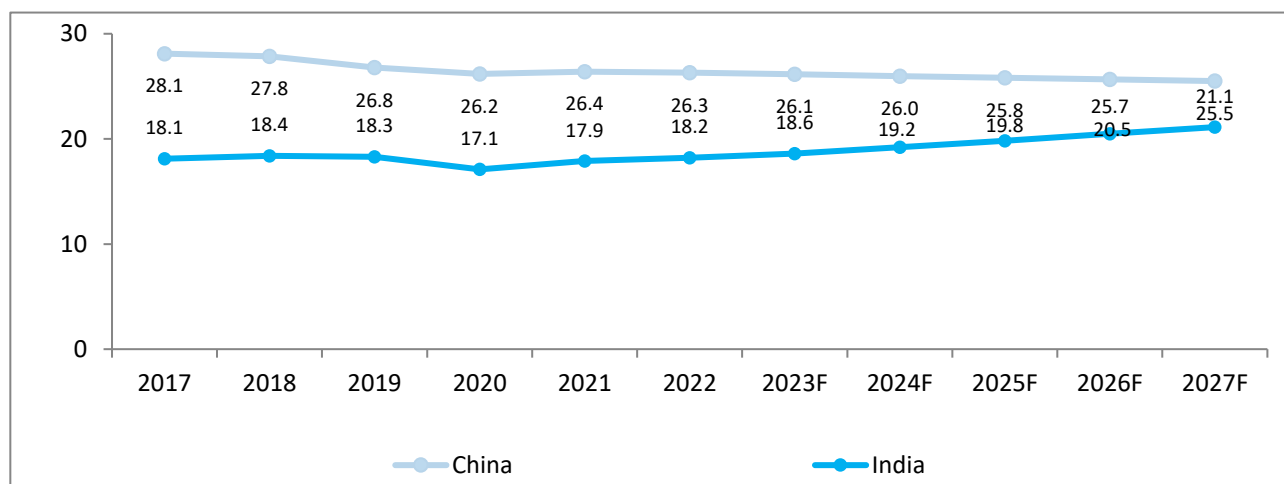
While the share of manufacturing as a percentage of Chinese GDP has been on a constant decline since 2011, it remains a key sector contributing to the country's economic growth. The decline in recent years has been driven by China's focus on economic restructuring that prompted a gradual shift from labor-intensive manufacturing to innovation-driven high-end advanced forms of manufacturing.

Citing China as a promoter of unfair trading practices and intellectual property theft, the United States started imposing trade tariffs on Chinese products from mid-2018, with China retaliating by imposing tariffs on US products. On-going trade wars have had serious implications on the Chinese manufacturing sector, as evidenced by declining exports and relocation considerations by companies in China, more mirrored by tech giants. Notably, in 2019, the share of manufacturing in GDP contracted by over 1 percentage point from 2018.

In 2020, the pandemic-induced national lockdown and the resultant reduction of production brought about a further contraction in the share of manufacturing. Although Chinese manufacturing gained some steam in 2021, industrial activity is likely to remain subdued in the near term amid the Omicron wave, job losses, and curbs due to the Winter Olympics that partially moderated factory output in Q1 2022.

Supported by the "Made in China 2025" (MIC 2025) blueprint that aims to position China as a global leader in high-tech manufacturing by reducing technology imports and by investing heavily in developing indigenous innovation, Chinese manufacturing contribution to GDP is likely to stay around 25.0% over the medium-term. China's zero-Covid policy has made supply chain decentralization a priority for manufacturers who have endured months of disruption. Companies are even looking to move from China altogether to more 'pro-business' countries in Southeast Asia, despite the extra costs.

Figure 1.12: Manufacturing as a share of GDP (%), China, India , 2017-2027



Source: World Bank; Brazilian Institute of Geography and Statistics, Federal State Statistics Service Russia; Ministry of Statistics and Programme Implementation India

- 1) Estimates and forecast start from 2022, except for China. China's 2021 data is an estimate. FY 2017 denotes the period from April 2016 to March 2017. Contribution of India's manufacturing sector has been measured against total Gross Value Added (GVA) at 2011-12 constant prices.

India

India's manufacturing sector has accounted for 17%-18% of the total Gross Valued Added (GVA) over the past decade. In FY 2020, the contribution of the manufacturing sector shrank owing to a global slowdown in global trade resulting in lower manufacturing and exports. In FY 2021, the share of the manufacturing sector improved slightly as contact-intensive services experienced a sharp decline. In FY 2022, increased manufacturing and export of refined petroleum products, gems and jewellery, chemicals, engineering and agricultural goods helped pull up the share of manufacturing as a percentage of the GVA to 18.2%. Over the medium-term, the share of manufacturing is poised to grow driven by production linked incentive schemes across 14+ sectors including pharmaceuticals, textiles, medical devices, auto components, and white goods (electronic items such as refrigerators and television) among others.

Further, government's logistics and infrastructure push is expected to bring down transportation costs for businesses, resulting in higher cost efficiencies for manufacturers. With the UAE FTA¹ already in force from May 2022 and the Australia FTA expected to come into force in H2 2022, Indian manufacturing should be able to maintain its growth momentum. In the first two months of the current fiscal, international manufacturing orders have remained strong, boosting factory output. However, moderation in growth is likely in H2 2022 amid growing headwinds from higher inflationary pressures. Over the medium-term, a combination of logistics cost-efficiencies, manufacturing

¹ Free Trade Agreement

incentives, and increased access to foreign markets should help drive up the share of India's manufacturing to GDP.

Companies contemplating diversifying their dependence on China is a strategy known as "China-Plus-One". Zero-COVID policy, supply chain disruption issues, high freight rates and lead times from China – the confluence of all these factors have resulted in a China+1 strategy for many global companies. The 'China Plus One' supply chain diversification strategy triggered by the global Covid-19 pandemic is creating opportunities for Indian players. Many MNCs are adding new operations in other developing Asian countries like India, Vietnam, Thailand, Bangladesh and Malaysia, and are welcoming new manufacturing opportunities. India stands out as an attractive option because of its strategic location, a large domestic market, skilled labor, low labor costs, etc.

In Europe, many businesses are likely to face the double impact of rising energy costs and a potential decline of consumer spending due to households' increased energy-related expenses. Rising power prices are already impacting operations of electricity-intensive industries. So, the dislocation of industries from Europe to India because of energy prices will help Indian manufacturing.

1.7. Macroeconomic Implications of the Russo-Ukrainian War on Europe and India

Surging Inflation for Europe:

- Similar to the rest of the world, Europe is experiencing imported food and energy inflation, which is fuelling inflationary pressures.
- Eurozone inflation in April 2022, for example, climbed to 7.5% as per Eurostat figures- the highest level since 1997.
- The European Central Bank has started pursuing rates hikes, as has the bank of England.

Evolving Energy Dynamics and Supply Risks for Europe:

- Given Europe's high reliance on Russian oil and gas imports, securing new supply partners and increasing renewable energy production becomes vital to mitigate risks arising from energy supply disruptions.
- Germany has made progress in a Qatar gas supply deal while the EU had proposed to phase-out Russian oil imports over a six month timeframe.
- Countries can also potentially roll-out policy measures to curtail energy demand.

Trade and Supply Chain Disruptions for Europe:

- The EU's high dependence on Ukraine feed crops and Russian fertilizers and resultant trade disruptions pose restraints to regional agricultural production.
- Given that Russia and Ukraine are leading producers of key inputs used in chip production, potential intensification of global chip shortages would hurt European industry.

- These disruptions will also nonetheless promote local growth manufacturing opportunities across Europe.

Energy and Supply Chain Disruptions to Hinder European Manufacturing:

- Russian gas slowdown to Europe will restrain German chemicals production.
- Potential activation of phase 3 of Germany's emergency gas plan will lead to gas rationing for German industry.
- Deeping chip shortages as a result of the war stands to hinder regional automotive production.

Inflationary Pressures for India:

- Inflationary pressures stemming from the Russian war will necessitate more interest rate hikes, thereby affecting consumption.
- India's oil import bill had surged partially driven by higher oil prices due to the war; expected easing in oil prices will help reduce India's import bill.

War is reshaping Défense Trade: The procurement modus operandi in Europe is anticipated to change because of the conflict. Countries like Germany, which have traditionally favoured time-consuming joint military procurement programs, may be more open to accelerated off-the-shelf purchases to improve their dangerously low operational readiness. Germany may have to look at non-traditional military suppliers and diversify its equipment portfolio. The Israeli Défense industry could potentially benefit and could be a favoured supplier, as Israel already leases UAVs to Germany. Another characteristic change can be expected from the Nordic region. Norway and Sweden, which had reduced collaboration on joint procurements, could come together again and embark on collective procurements to improve interoperability of defence equipment against their common foe, Russia. Suppliers that offer solutions that are interoperable and are more suitable for "collective defense" could be well placed to win contracts. Conflicts often cause permanent changes in the demand-supply equation for military hardware and related solutions, as lessons learnt – be they political, economic, or technological – are evaluated. The new procurement equation seems to favour non-traditional suppliers and further diversification of the procurement base.

1.8. Production Diversification Beyond China and Emerging Go-To Manufacturing Locations

Rise of China+1 Strategies:

- China has been losing its competitiveness as a manufacturing powerhouse over recent years, restrained by higher labour costs, prolonged US-China trade wars, and more recently the pandemic.
- China+1 strategies have therefore been gaining momentum, whereby companies maintain or scale down presence in China while simultaneously expanding across other locations.

- A recent survey by the European Union Chamber of Commerce in China and Roland Berger pointed to 23% of firms looking at potentially moving investments outside of China in light of the country's strict COVID-19 policy.

India's Competitiveness as a Go-To Manufacturing Location over China

- India rolled out a production-linked incentive (PLI) scheme in 2020- seen as an initiative to fortify India's manufacturing competitiveness positioning in the context of global supply-chain reorientation. India is targeting to generate new PLI-linked production worth \$520 billion over a five year timeframe.
- In the current pandemic environment, China's strict zero-covid policy and recurrent lockdowns stands in contrast to India's more accommodative policy to tackle the pandemic.
- India's working age population (15-64 years) size is set to expand from 938.6 million in 2020 to 1.04 billion by 2030, while China's shrinks from 988.6 million to 972.5 million during this timeframe, according to projections from the United Nations.
- According to latest available data from International Labour Organization, average monthly earnings in the manufacturing sector stood at \$745.9 in China in 2016 compared to \$192.1 for India in 2020.
- Indian government plan to extend the benefit of the concessional corporate tax rate of 15% till March 2024 for newly incorporated manufacturing companies is set to give India the much-needed competitive edge. The 17% tax rate (including surcharge) for new investment is one of the most competitive globally and India will see a huge benefit from this in the coming years.
- Other measures like production-linked incentives (PLI) scheme, state incentives by way of tax refunds, Capital subsidy(based on investment and employment generation), single window compliances and approval mechanism may push the manufacturing sector growth in India. India's ease of doing business ranking has improved significantly from 142 (out of 190 economies) in 2014 to 63 in 2020.
- Indian government launched the 'Secured Logistics Document Exchange' (SLDE) along with a calculator for Green House Gas (GHG) Emissions with the objective of improving the ease of doing business.
- According to latest forecasts, India is expected to register 7.2% growth in 2022-23, while China only grows by 3.4% in 2022.

Chapter 2: India Macro-Economic Overview



2.1. India - Macroeconomic Trends

Growth Environment and Key Policy Objectives:

Policy stimulus, resumption in economic activity, and improving consumer sentiment are steering the Indian economy back on a sustained growth trajectory following the economic slowdown in 2019 and a sizeable contraction in 2020. In particular, the pandemic resulted in higher unemployment, depressed consumption, and affected industrial output due to stringent mobility restrictions in the first half of 2020 and a severe wave in 2021. Benefitting from a lower base, the Indian economy experienced robust economic growth in 2022. India to witness GDP growth of 6.0% in 2023-24, depending on the trajectory of economic and political developments globally. Economic survey 2022-2023 projects a baseline GDP growth of 6.5% in real terms in FY24.

Policy priorities over the current decade are increasingly focusing on economic vulnerabilities exposed by the pandemic. In particular, recent policy pivots have focused on tackling enduring economic challenges of jobless growth, lower manufacturing competitiveness and high energy import dependence.

To re-invigorate economic growth, government policy has prioritized the development of logistics and infrastructure projects, rolled out production incentives to encourage local manufacturing, and revamped foreign trade policy to stimulate job creation and raise local competitiveness.

Inflation:

In 2022, the inflation rate in India was around 6.7 percent compared to the previous year. Inflation in India is expected to come down from 6.8 percent in the fiscal year ending Mar 2023, and drop to 5.0 percent in the 2023-24 and then drop further to 4.0 percent in 2024-25. As global financial conditions tighten because of surging inflationary pressures, India can witness higher capital outflows, similar to other emerging markets.

Socio-demographic Trends:

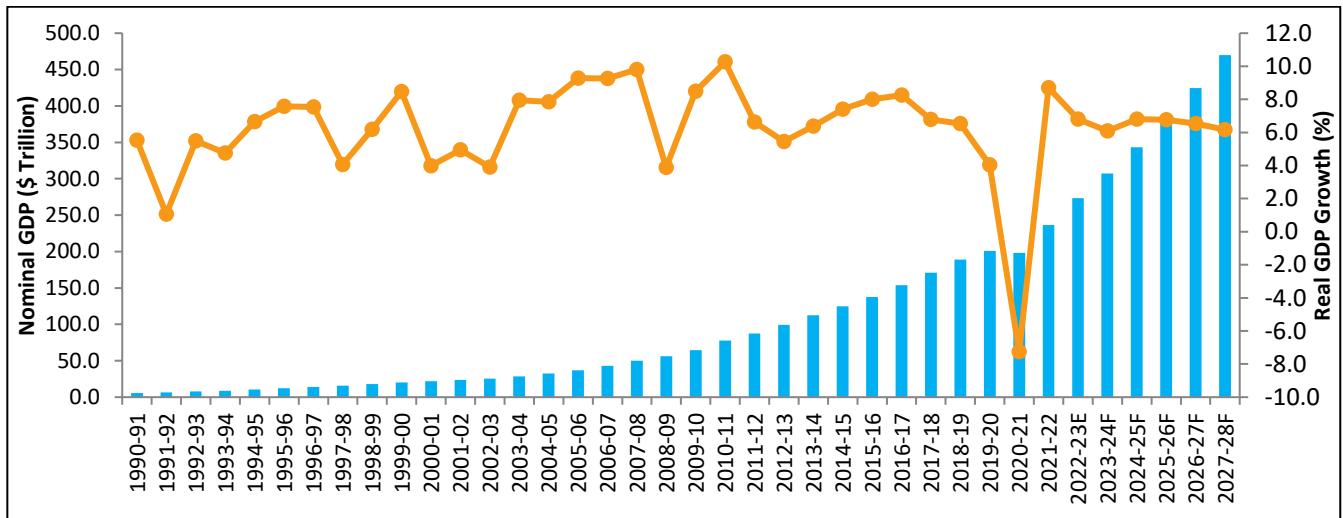
On the socio-demographic front, the Indian economy will witness a burgeoning middle class with over a billion strong working-age population by 2030, more than half of which will constitute the workforce. Rapid urbanization through a push for affordable housing and improved connectivity as well as increasing smartphone penetration and internet access will continue reducing barriers to economic development as financial inclusion improves and access inequity reduces further.

2.2. GDP and GDP Growth

The past two decades have been a high-growth period for the Indian economy, supported by factors such as the new industrial policy and the liberalization of external trade. The decade of 2010 has been noteworthy, with GDP growth accelerating 7.0%. However, for the first time since 2002, India's GDP growth slowed down to 4.0% in 2019–20, constrained by a lackluster domestic demand and a liquidity crisis.

With the onset of the COVID-19 pandemic and subsequent nationwide lockdowns, India experienced a deep recession evident from the GDP growth contraction of 7.3% in 2020-21. India's GDP increased by 8.7% in 2021–2022, despite a partial growth pullback caused by the second COVID–19 wave. Growth was mainly driven by a strong release of pent-up demand following a partial relaxation of the restriction measures.

Figure 2.1: Nominal GDP and Real GDP Growth, India, 1990-91 to 2027-28



Note: Data stands updated as on 27th February 2023. Data is presented for Indian fiscal years. Data until 2010-11 is based on 2004-05 constant prices, with 2011-12 constant prices thereafter. E indicates estimate and F indicates forecast. Nominal GDP data is based on current prices.

Source: Ministry of Statistics and Programme Implementation (MOSPI); International Monetary Fund (IMF) World Economic Outlook Database (WEO) October 2022 and January 2023; Frost & Sullivan

Growth rates for 2022-23 and 2023-24 are estimated to hover around 6.5% on account of slowing global growth, high inflation, and interest rate hikes. In comparison to other emerging countries, the Indian economy is relatively insulated from global spill overs from the Russo-Ukrainian war, attributable to India's sizable domestic market and its relatively smaller exposure to global trade flows.

GDP growth is expected to thereafter normalize to 6.6% by 2027-28. Government's sustainability-driven growth agenda, greater manufacturing sector boost, ongoing structural reforms and large middle-income and young population size are characterised as the notable medium-term growth drivers.

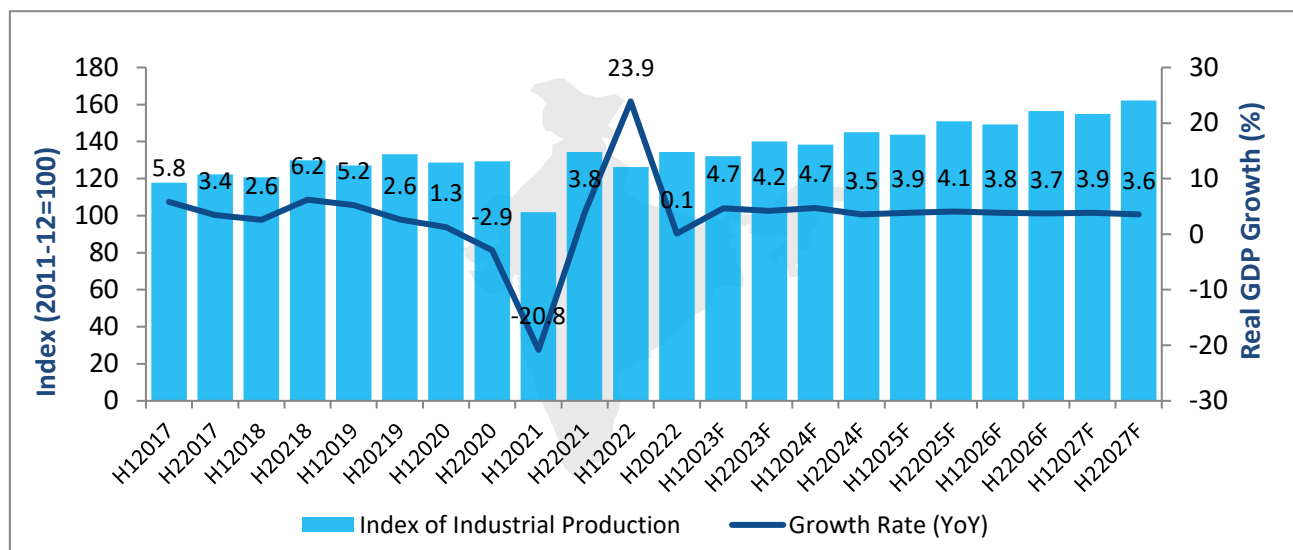
Looking at the nominal GDP trend (Exhibit 1), India is expected to grow from an INR 273.3 trillion economy in 2022-23 to an INR 469.7 trillion economy by 2027-28, with a Compound Annual Growth

Rate (CAGR) of 11.4%. Notably, India is expected to be the third largest economy globally and also to surpass \$ 5 Trillion by 2027 based on nominal GDP values in dollar terms²

2.3. Index of Industrial Production (IIP)

The IIP is a composite index measuring monthly changes in production volumes for a portfolio of key industrial goods including mining, manufacturing, and electricity production during a period of time in comparison to production in the base year of FY 2011-12. Between FY 2017 and FY 2019, the manufacturing index, which assumes a 77% weightage, grew at an average rate of 4.3% driven by increased production of pharmaceuticals, electronics and optical products, furniture, transport equipment, wearing apparel, and machinery and equipment. Electricity production increased at an average rate of 5.5% over the same period.

Figure 2.3: Index of Industrial Production (IIP), India, 2017-2027¹



(1) H1 refers to the first semester of the financial year from April to September; H2 refers to the second semester from October to March; For instance, H12017 is the six-month period from April 2016 to September 2016 and H22017 is the six month period from October 2016 to March 2017. The base year for the IIP is FY 2011-12. Estimates and forecasts start from FY 2023

Source: Reserve Bank of India, Ministry of Statistics and Programme Implementation

As economic growth slowed in FY 2020 and the economy experienced a sizeable contraction in FY 2021 due to the pandemic, the IIP shrank 0.8% and 8.4% respectively, with the manufacturing index falling 1.6% and 9.6% over the same period. For the 12 month period from April 2022 to March 2023 industrial output registered a growth of 5.5%.

² IMF; Frost & Sullivan

Factors Impacting Industrial Production

- **Current Macroeconomic Environment:**

In FY 2023, higher input prices due to supply disruptions and increased fuel costs on account of the Russo-Ukrainian war can moderate growth in the IIP, especially as consumer sentiment will also be restrained because of high inflationary pressures and likely rate hikes by the RBI. Moreover, coking coal shortages are likely to dampen production in the pulp and paper, cement, aluminium and steel and engineering industries in the short-run until global prices ease or domestic output is ramped up to meet the surge in demand.

As global trade moderates in 2022, primarily due to disruptions on account of the Russo-Ukrainian war, Indian manufacturing exports may see limited growth from a robust FY 2022, which saw merchandise exports surpass \$400 billion for the first time. Further, projected increase in interest rates by the RBI, resulting in a one percentage point in the interest rate to 5.0% by end-2022, can moderate the pace of new investments in capacity expansion.

On the upside, a number of manufacturing incentive schemes starting in 2020 and imposition of moderate tariff on capital goods imports from 2022 will increase demand for locally manufactured alternatives. Moreover, heavy capital spending by the government on infrastructure and connectivity projects is expected to generate backward and forward linkages in the form of increased demand for construction material and labour and lowered logistics costs which can boost domestic manufacturing competitiveness.

- **Socio-demographic Factors and Consumption Growth:**

Consumer spending across India amounted to over 22.2 trillion rupees by the end of fourth quarter of 2022. This was a decrease from the consumer spending noted at the beginning of the year. Since having declined in 2020 due to the COVID-19 pandemic and the lockdown period, consumer spending across the country made a sizable recovery rapidly in spite of forecasts predicting this revival to occur during the second half of 2021.

Sustained economic growth as well as government's employment push in the form of manufacturing, logistics, and infrastructure development will support broad-based growth in consumer spending over the medium-term. Moreover, India's working age population will surpass 1 billion, nearly half of which comprise the workforce, driving consumption growth. Rising household disposable incomes along with the influence of cultural trends such as increasing share of nuclear families will push up demand for housing, household items, as well as appliance and electronics items. Growing internet access as well as smartphone penetration in rural areas is also expected to drive e-commerce sales and help small and medium-sized manufacturers scale sales through online marketplaces.

India's merchandise exports recovered strongly from the pandemic-induced collapse and registered positive growth in the current financial year. Merchandise exports have registered highest ever

annual exports of USD 447.46 billion with 6.03% growth during FY 2022-23 surpassing the previous year (FY 2021-22) record exports of USD 422.00 billion. Sharp recovery in key markets; increased consumer spending; pent up savings and disposable income due to announcement of fiscal stimulus by major economies; global commodity price rise and an aggressive export push by the government have bolstered exports in 2022-23.

2.4. Tailwinds for Growth in Manufacturing in India

2.4.1. Union Budget 2022-23: Custom Duty and Tariff Reform

To complement the Make in India strategy and several production linked incentive schemes aimed at enhancing domestic manufacturing, the Union Budget 2022-23 proposes custom reform and duty rate changes. In particular, concessional rates in importing capital goods and project imports for various sectors such as power, fertilizers, textiles, leather, footwear, and food processing will be phased out gradually over the next 2-3 years with the imposition of a moderate tariff of 5% - 7.5%. This is in line with the objectives of the National Capital Goods Policy, 2016 which aims to double the local production of capital goods by 2025. While exemptions of advanced machineries not locally manufactured will continue being in place, new exemptions for inputs such as specialized castings, ball screws, and linear motion guides will be introduced to aid domestic producers.

Tariff exemptions on more than 350 items across agricultural produce, chemicals, fabrics, medical devices, and drugs and medicine will be phased out with a gradual hike in tariff levy until 2025-26. Tariffs and customs rates will be simplified for chemicals, textiles, and metals to minimize disputes and several concessional rates will be incorporated in the Customs Tariff Schedule instead of disparate notifications. For electronics manufacturing in particular, a graded rate structure has been proposed to encourage domestic manufacturing of wearable devices, hearable devices, and smart meters. Duty concessions will be continued for transformer parts of mobile phone chargers, camera lens, and other items.

Custom duty on critical chemicals including methanol, acetic acid, and heavy feed stocks for petroleum refining will be reduced while the basic custom duty (BCD) for sodium cyanide will be increased from 7.5% to 10%. Capital goods required for renovation, modernization, or maintenance of a fertilizer plant will be dropped from tariff exemption and attract 5% BCD from 1st April 2023. Specific agricultural implements will also be dropped from tariff exemption and attract a BCD of 2.5% from 1st April 2023. To incentivize exports, exemptions on items such as embellishment, trimming, fasteners, buttons, zipper, lining material, specified leather, furniture fittings and packaging boxes used by bonafide handicraft, textile, leather garments and footwear exporters will be retained.

2.4.2. Other Manufacturing Drivers

Production Diversification Beyond China and Emerging Go-To Manufacturing Locations:

China has been losing its competitiveness as a manufacturing powerhouse over recent years, restrained by higher labour costs and prolonged US-China trade wars. The onset of the pandemic

prompted further reorientation of production and supply-chain approaches. China+1 strategies, for example, have been gaining momentum, whereby companies maintain or scale down presence in China while simultaneously expanding across other locations. South Asia and Southeast Asia particularly saw gains during the trade war period, with companies indicating shifts to locations such as India, Philippines, Vietnam, Thailand, Bangladesh and Malaysia.

With limited gains from the trade war, India rolled out a production-linked incentive (PLI) scheme in 2020- seen as an initiative to fortify India's manufacturing competitiveness positioning in the context of global supply-chain reorientation. During the earlier stages of the pandemic, the Japanese government had extended incentives to encourage Japanese firms to relocate production from China to India, Bangladesh, or Southeast India, with India looking to enhance Japan's engagement under the PLI scheme. India is targeting to generate new PLI-linked production worth \$520 billion over a five year timeframe.

China's zero-covid policy and recent lockdowns will further spur diversification beyond China, with reports already indicative of the same. A recent survey by the European Union Chamber of Commerce in China and Roland Berger pointed to 23% of firms looking at potentially moving investments outside of China in light of the country's strict COVID-19 policy.

Production Linked Incentive Schemes:

Over the course of the last two years, the government has introduced manufacturing incentives for more than 13 categories including electronics, auto components, semiconductors, pharmaceuticals, textiles, and drone manufacturing among others. Respective schemes offer 4%-6% incentives on incremental turnover over a 5 year period for selected companies.

Automobiles and Auto Components PLI Scheme:

The PLI scheme for Automobiles and Auto Components was notified in September 2021 and closed for applications on 9th January 2022. The scheme will be implemented over a period of five years from FY 2022-23 with benefits valid for 5 consecutive years. Fiscal year 2019-20 is to be deemed as the Base Year for calculation of eligible sales under the scheme. The scheme approved investment of Rs. 74,850 crore, with Rs. 45,016 crore received from applicants under the Champion OEM Incentive Scheme and Rs. 29,834 crore under the Component Champion Incentive Scheme.

A detailed definition of the two sub-schemes is as under:

1. Champion OEM Incentive Scheme³:

A sales value linked scheme applicable on Battery Electric Vehicles and Hydrogen Fuel Cell Vehicles of all segments and any other Advanced Automotive Technology vehicles prescribed by MHI⁴ depending upon technical developments.

³³ Ministry of Heavy Industries (<https://pib.gov.in/PressReleasePage.aspx?PRID=1757651>)

⁴ Ministry of Heavy Industries

2. Component Champion Incentive Scheme:

A 'sales value linked' scheme, applicable on pre-approved Advanced Automotive Technology components of all vehicles, CKD/SKD kits, Vehicle aggregates of 2-Wheelers, 3-Wheelers, passenger vehicles, commercial vehicles and tractors including automobile meant for military use and any other Advanced Automotive Technology components prescribed by MHI depending upon technical developments.

Table 2.1: Minimum New Domestic Investment Conditions (Rs. Crore) for different Schemes

Cumulative new domestic investment to be achieved	Champion OEM (Except 2W & 3W)	Champion OEM 2W & 3W	Component Champion	New Non-Automotive investor(OEM) company or its Group company(ies)	New Non-Automotive investor (Component) company or its Group company(ies)
Upto or before March 31, 2023	300	150	40	300	80
Upto or before March 31, 2024	800	400	100	800	200
Upto or before March 31, 2025	1400	700	175	1400	350
Upto or before March 31, 2026	1750	875	220	1750	440
Upto or before March 31, 2027	2000	1000	250	2000	500

Table 2.2: Incentive Slabs for the Champion OEM and New Non-Automotive (OEM) Investor Company

Determined Sales Value (in Rs Crore)	Incentives (%age of Determined Sales Value)
<=2,000	13%
> 2,000 to 3,000	14%
> 3,000 to 4,000	15%
> 4,000	16%
Cumulative Determined Sales Value of Rs 10,000 Crore over 5 years	Additional 2%

Table 2.3: Incentive slabs for Component Champion and New Non-Automotive (Component) Investor Company:

Determined Sales Value (in Rs Crore)	Incentives (%age of Determined Sales Value)
<=250	8%*
> 250 to 500	9%*
> 500 to 750	10%*
> 750	11%*
Cumulative Determined Sales Value of Rs 1,250 Crores over 5 years.	Additional 2%
Battery Electric vehicles & Hydrogen fuel cell vehicles components	Additional 5%

**Multiplied by a factor of 0.9 in the fifth year for eligible sales relating to Internal Combustion Engine (ICE) vehicle components*

Revamped Foreign Trade Policy:

India is accelerating trade talks with a number of advanced economies including the UK, Canada, and the European Union to tap into China+1 strategies amid growing importance of supply chain diversification. In April 2022, India signed a free trade agreement with the UAE, its first major trade deal since 2011.

The trade deal with UAE aims to boost bilateral trade in goods to \$100 billion over the next five years from \$60 billion in 2022. Labour-intensive sectors including gems and jewellery, textiles and garments, leather and farm products, medical devices, engineering products, and automobiles will benefit from enhanced access to the UAE market.

India and Australia also signed an interim free trade deal in April 2022 which is likely to double bilateral trade from \$27 billion in 2022 to \$50 billion over the next five years and benefit Indian manufacturing through the availability of cheaper raw materials such as steel, aluminium, and textiles besides enhancing market access.

New Export Opportunities Due to Geo-political Tensions:

Over the medium-term, policy pivots and diversification efforts in Europe can benefit Indian manufacturers through closer economic ties with the European Union and UK. Against the backdrop of a revamped trade policy and disruptions due to the war, bilateral trade talks between the European Union and India have regained traction with the launch of the Trade and Technology Council in April 2022. The alliance is set to enhance cooperation on 5G, artificial intelligence, climate modelling, and health technology and facilitate greater trade.

Following trade and financial sanctions since March 2022, Russian demand for over 50 Indian export items such as food products, pharmaceuticals, home furnishings, ceramics, and industrial chemicals has increased, giving rise to a \$2 billion export opportunity in FY2022.

Infrastructure & Logistics Push:

To complement the domestic manufacturing drive, the government has undertaken the construction of several multimodal logistics parks and connectivity projects throughout the country. The government aims to trim logistics costs from 14% of the GDP in 2021 to about 9% of the GDP over the next three years to boost domestic export competitiveness. To finance a spate of infrastructure and connectivity projects, the Union Budget 2022-23 has allocated Rs. 7.5 trillion (\$101.4 billion) for capital expenditure, an increment of 35% over the previous year. Major projects being undertaken over the current fiscal include contracts for the implementation of 4 multimodal logistics parks, launch of new rail-logistics services for small farmers and MSMEs⁵, and construction of 25,000 km of highway network.

Lower Labour Costs:

In comparison to several other emerging markets including China, India continues to have lower labour costs owing to a moderate cost of living, readily available semi-skilled labour supply, and one of the lowest minimum wages in the world. Indian labour reforms, expected to be implemented in the next fiscal year, are likely to benefit the industry through greater employer autonomy. The new labour code raises the threshold for layoffs without government approval from 100 workers to 300 workers and enables firms to directly hire fixed term employees without a cap on contract renewal, independent of third-party contractors. India has also launched several reskilling initiatives since 2016 including the set-up of 15,000 Industrial Training Institutes and rural-youth training programs to increase labour productivity.

India had the second lowest nominal wages in comparison to several emerging markets including Vietnam, Indonesia, Tanzania, and Brazil as of 2018, with an average monthly nominal wage of \$192.2. Only Bangladesh had lower monthly nominal wages in comparison to India, with the average nominal wage being 21.5% less in 2017.

Table 2.4: Country-Specific Nominal Wages¹

Country	Reference Year	Monthly Nominal Wage (Local Currency)	Monthly Nominal Wage (USD)	Country	Reference Year	Monthly Nominal Wage (Local Currency)	Monthly Nominal Wage (USD)
Brazil	2018	2,213	605.7	Qatar	2018	11,121	3,055.2
Tanzania	2015	403 729	202.7	Turkey	2018	3,960	820.2
Hong Kong	2018	16,488	2,103.5	KSA	2015	6,413	1,710.1
Bangladesh	2017	12,016	149.4	Indonesia	2018	2,829,130	198.7
Vietnam	2018	57,67,750	255.2	India	2018	13,143	192.2

⁵ Medium and Small Enterprises

1 Wages sourced from the report are in Local Currency Units. To convert to USD, World Bank's Official exchange rate (Local Currency Unit (LCU per US\$, period average) is used for respective reference years.

Source: International Labour Organization (ILO) Global Wage Report 2020-21; World Bank Indicators

Advanced Technology and Machinery Use:

Between 2015 and 2022, India moved up from the 81st position to the 40th position on the Global Innovation Index buoyed by its ability to translate costly innovation investments into high-quality output. India continues to hold the record for over-performing on innovation relative to its development level for the 11th year in a row. While India ranks among the top 30 economies under the market sophistication and knowledge and technology output pillars of the Index, its performance on institutions, creative outputs, and infrastructure remains underwhelming. Government initiatives including the logistics and infrastructure push, universal internet access plan for all villages, and institutional reforms to strengthen the domestic business environment over the medium-term will further augment India's innovation capabilities. India can thus be expected to break into the top 35 economies led by improvement in performance along the infrastructure, creative outputs, human capital and research, and institution pillars of the GII index by 2026.

Indian manufacturing of auto, electronics, clothing, footwear, and medical equipment among others is increasingly integrating smart solution including AI-enabled preventive maintenance, 3D printing or additive technology, and data-driven decision-making to enhance production efficiency. Further, according to the World Bank, India is a leading innovation player in biotechnology, pharmaceuticals, and automobile parts and assembly. Moreover, Indian manufacturers are known to use quality equipment and production tools including Japanese machinery to meet quality standards.

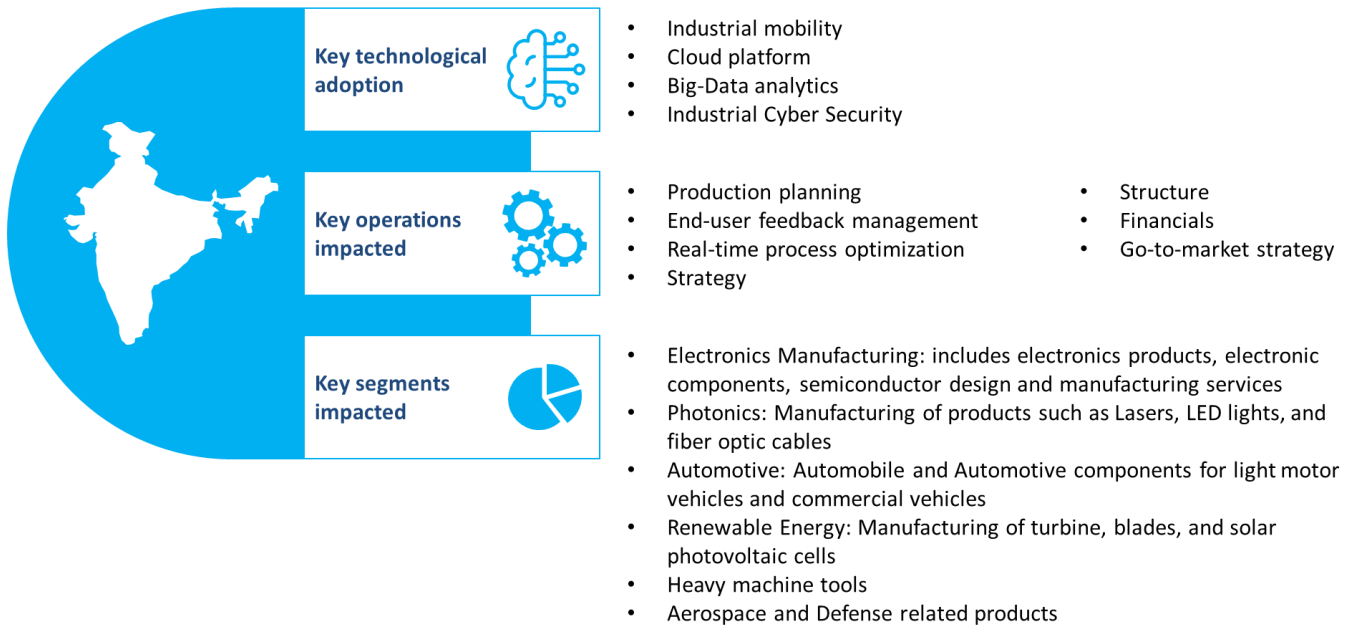
The launch of six national technology innovation platforms in 2021 will further strengthen integration of advanced technology in manufacturing and accelerate adoption of Industry 4.0. The platforms will provide expert guidance and facilitate industry collaboration to accelerate R&D in key manufacturing technology solutions. Additionally, the government has launched several Smart Advanced Manufacturing and Rapid Transformation Hubs (SAMARTH) since 2019 to raise awareness and increase adoption of Industry 4.0, particularly among SMEs.

According to NASSCOM⁶, the Indian manufacturing industry spent \$5.5-\$6.5 billion on digitalization initiatives in FY 2021. Moreover, over 66% of Indian manufacturers are expected to integrate advanced digital solutions in their business models by 2025 resulting in digital technologies accounting for nearly 40% manufacturing tech spend. Over the medium-term, a confluence of policy push and accelerated private sector adoption is expected to increase the uptake of smart manufacturing technologies and raise domestic competitiveness.

⁶ NASSCOM. (<https://community.nasscom.in/communities/industry-40/india-industry-40-adoption-case-mature-manufacturing-digitalization-2025>)

2.5. Industry 4.0 in Manufacturing

Figure 2.4: Factories of Future – An Important Transition in the Manufacturing Sector



Source: Frost & Sullivan

Industrial processes are often dangerous and difficult to monitor, particularly if it requires traveling long distances or entering hazardous environments. Due to this, companies are increasingly turning to automated solutions to improve safety, efficiency, and productivity.

Industrial automation is increasingly popular—and often necessary—for modern industrial facilities. Some of the advantages of increasing industrial automation include:

Analytics Collection - Computerized and smart devices can collect more data from the facility and the details of production. This allows facility managers to learn about error rates, production rates, energy usage, and other factors that will help devise efficiency plans.

Improved Product Quality - When the fabrication process is automated, each unit of production becomes more standardized. Automated processes better adhere to design specifications within tight tolerances and offer superior repeatability from part to part.

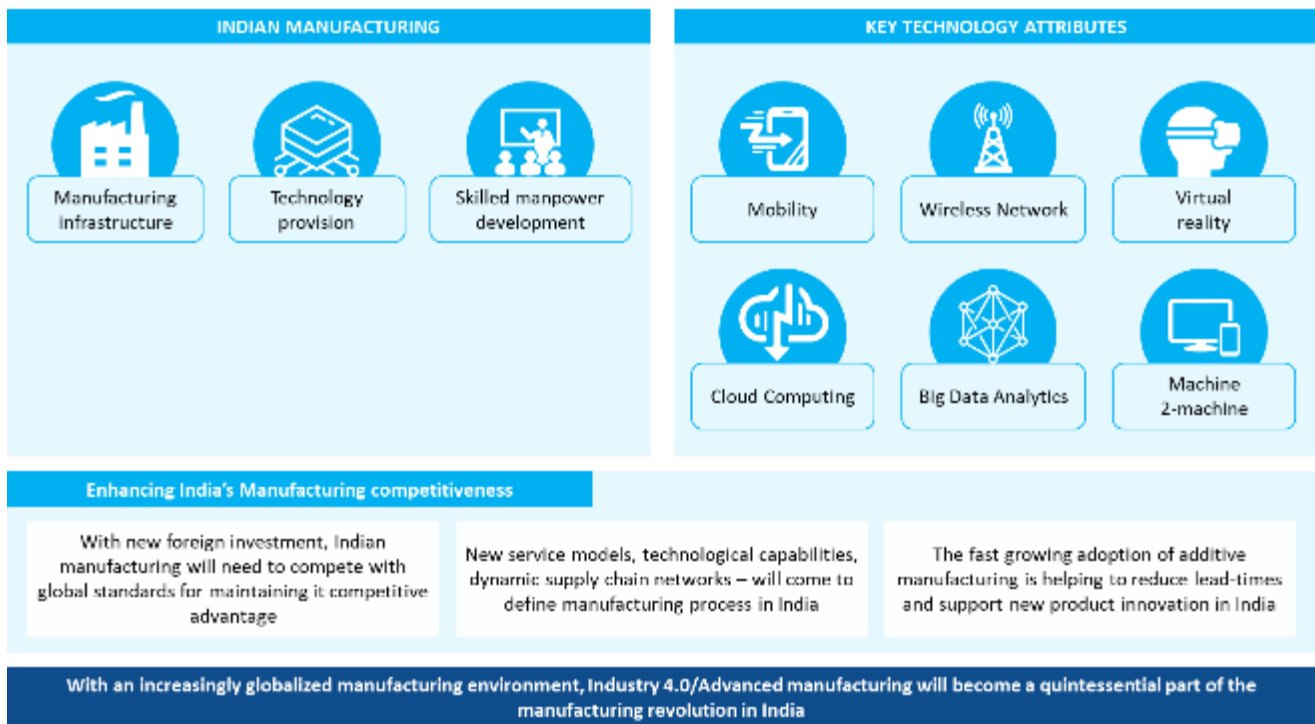
Increased Safety - In automated processes, humans shift to the role of a supervisor rather than an operator. This reduces the risk of injury on the production floor because employees have less exposure to potentially toxic materials or dangerous processes.

More Flexibility and Capacity - Automated production facilities can run 24/7 or adopt more dynamic schedules to meet demand.

More Productivity with Manufacturing Automation - Automated processes are typically faster than human capabilities or more simply mechanized processes. Automated machinery operates faster with a reduced rate of error.

Reduced Operational Costs- Smart devices and automated machinery run self-diagnostics and alert human operators about potential malfunctions, streamlining maintenance and repair.

Figure 2.5: Interweaving the concept of Industry 4.0 - Key elements which can enable advanced manufacturing in India



Source: Frost & Sullivan

Due to globalization, Indian enterprises have to achieve higher international product quality benchmarks and focus on improving efficiencies, automating processes, and investing in IoT initiatives. These will increase their global competitiveness and attain economies of scale in their respective markets. Government bodies partner with major emerging economies to increase bilateral trade as well as introduce amendments to the Foreign Trade Policy to simplify trade regulations. The government is aligning India's trade policies with the World Trade Organization (WTO) requirements to augment trade integration with nations in South Asia, Europe, and Africa.

Participants in the IoT sphere are expected to move investments from IoT to IIoT in the next 2 to 3 years, with newer start-ups eyeing innovative manufacturing use cases. With the advent of 5G and edge solutions, IoT will evolve to solve the problems of key verticals such as engineering, automotive, transportation, food production, power, oil and gas, and other types of manufacturing. Enterprises are demanding cloud-based IIoT platforms to optimize workflows, assist in asset performance management, and conduct industrial control such as predictive maintenance. IIoT is set to offer

innovative solutions for industrial digital transformation while creating newer revenue models for IoT vendors.

2.6. India - State of IOT in Manufacturing sector

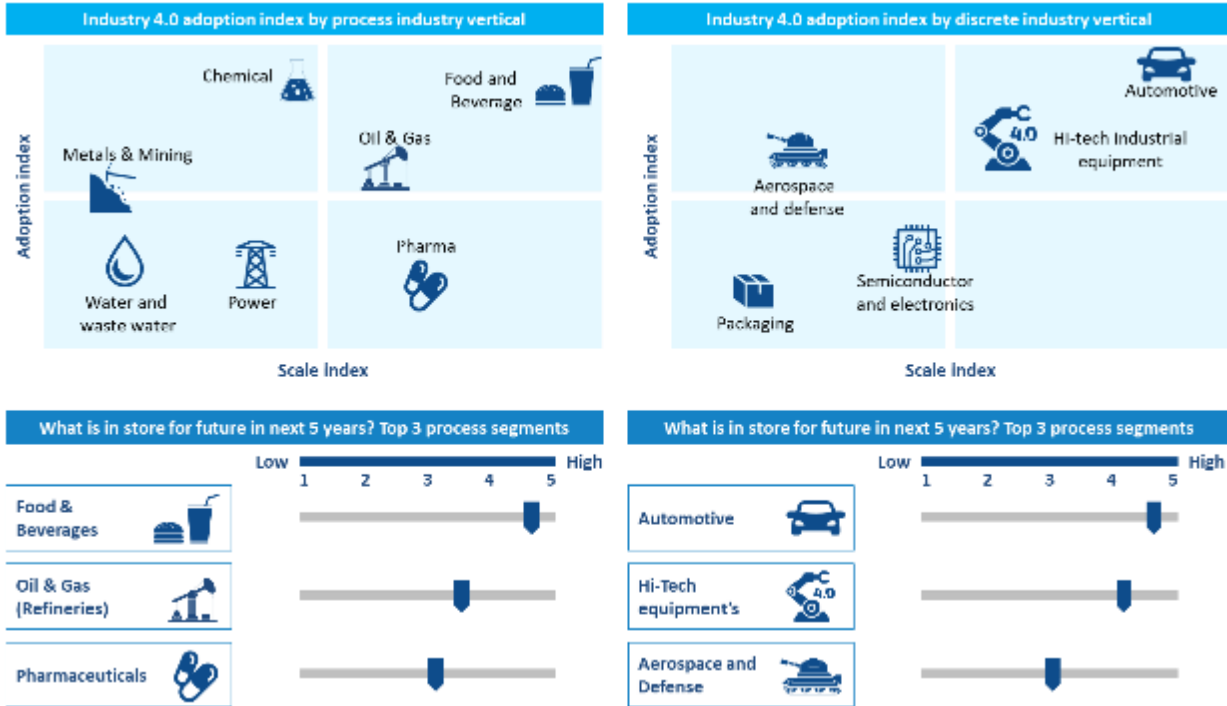
Figure 2.6: IIoT in Manufacturing, Sector Emergence, India, 2021



Source: Frost & Sullivan

IIoT in the Indian manufacturing sector is bound to grow due to initiatives like 'Make in India', which will eventually strengthen the country's manufacturing prowess. Convergence of operational technology and information technology is one of the major trends identified to gather useful data. The merging of IT (information technology) and OT (operational technology) will open up new platforms for large data management, offer analytical solutions promptly, and open up new applications. Energy, automotive, power, and FMCG (fast moving consumer goods) will be leading adopters of industrial automation and connected (IoT) technologies within the Indian manufacturing sector in the short to medium term.

Figure 2.7: Industry 4.0 Adoption Index by Industry, 2021-2027



Source: Frost & Sullivan

Food processing, agro chemicals, electronics, industrial machinery, iron and steel, auto parts, and leather and footwear, are among the 12 industry sectors identified earlier with potential for import substitution and boosting exports

IoT is considered the best fit in realizing the full capability of digital twins. IoT provides end-to-end visibility throughout a product life cycle and invaluable operational intelligence to decision-makers for predictive maintenance. Vendors are exploring ways to use IoT and AI to create digital twins to support enterprises in using IoT data for product innovation and product management, from product conceptualization to realization. A digital twin can strengthen IIoT software and platforms and will most likely become a vital pillar in connected manufacturing in the near future.

The pandemic has accelerated digital transformation in manufacturing companies in India. They are keen to deploy IoT solutions to acquire capabilities such as remote monitoring, predictive maintenance, and automation to reduce human intervention and implement business resiliency.

Chapter 3: Global Engineered Goods Sector



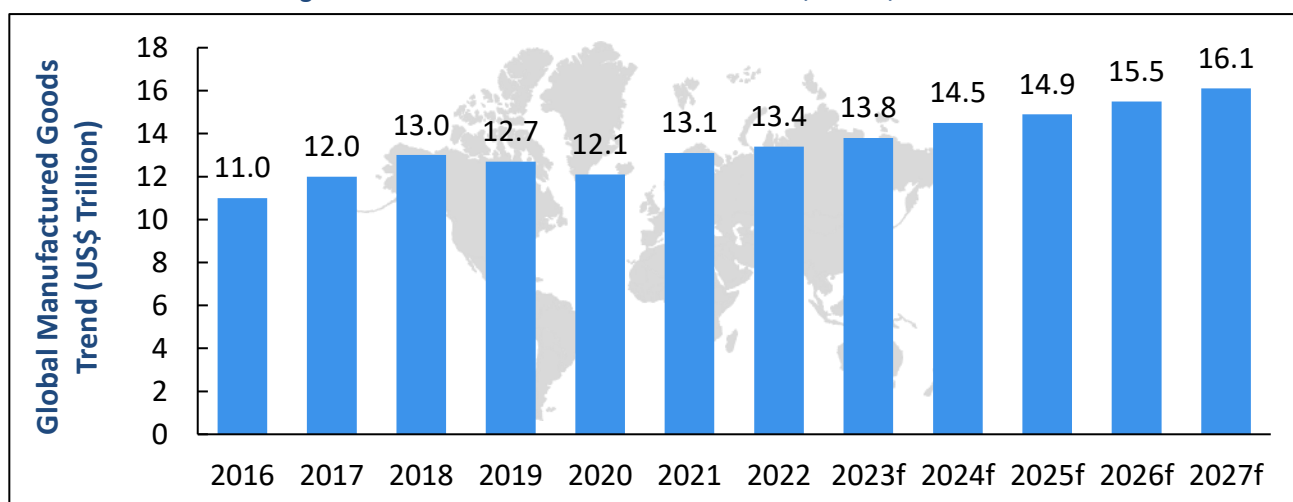
3.1. Engineering Goods Sector: Definition

The Engineering Goods sector comprises of metal products, industrial machinery and equipment, automobiles and its components, transport equipment, bicycles, medical devices and renewable equipment. Engineering Goods sector includes goods from various industries like Automobile, Railways, Aerospace, Textile, Healthcare and many more.

3.2. Global Manufactured Goods Trend

The Global Manufacturing Goods Output is expected to grow from US\$ 13.1 Trillion in 2021 to US\$ 16.1 Trillion in 2027 at a CAGR of 3.5%. The output was severely by the pandemic and the current geopolitical situation with rising commodity prices along with supply chain bottlenecks.

Figure 3.1: Market Size of Manufactured Goods, Global, 2016-2027F



Source: WTO, Frost & Sullivan Analysis

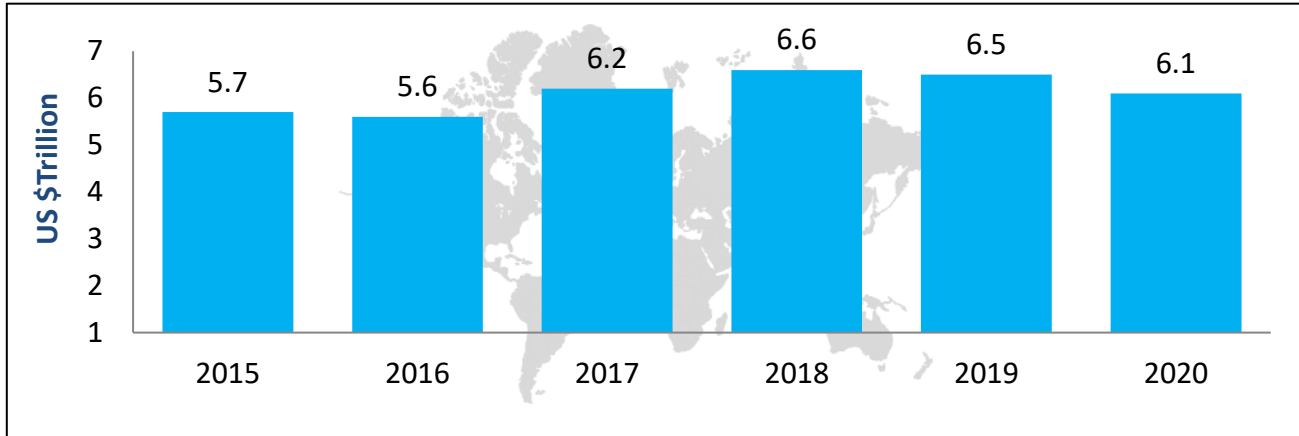
Table 3.1. Summary - Global Engineered Goods Sector - Key End-user Segment Market Size and Growth rate

End-user Segment	Market Size -2020 (\$Trillion)	CAGR (2015-2020)	CAGR (2021-2027) – Est.
Machinery and Transport Equipment Manufacturing	6.1	1.4%	2.5%
Automotive Equipment Manufacturing	1.32	0.4%	1.6%
Telecommunication Equipment Manufacturing	0.64	-2.0%	1.5%
Electronic Goods Manufacturing	1.2	5.4%	6.0%
Others	2.85	1.7%	2.0%
Total	12.1	2.4%	3.5%

Source: Frost & Sullivan Analysis

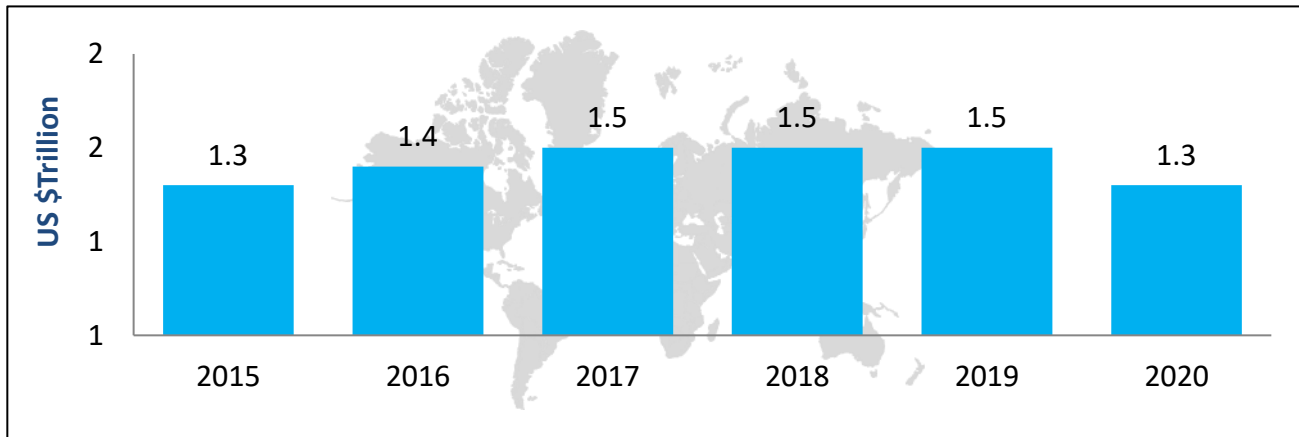
3.3. End-User Industry Trends

Figure 3.2: Global Machinery & Transport Equipment Manufacturing, 2015-2020



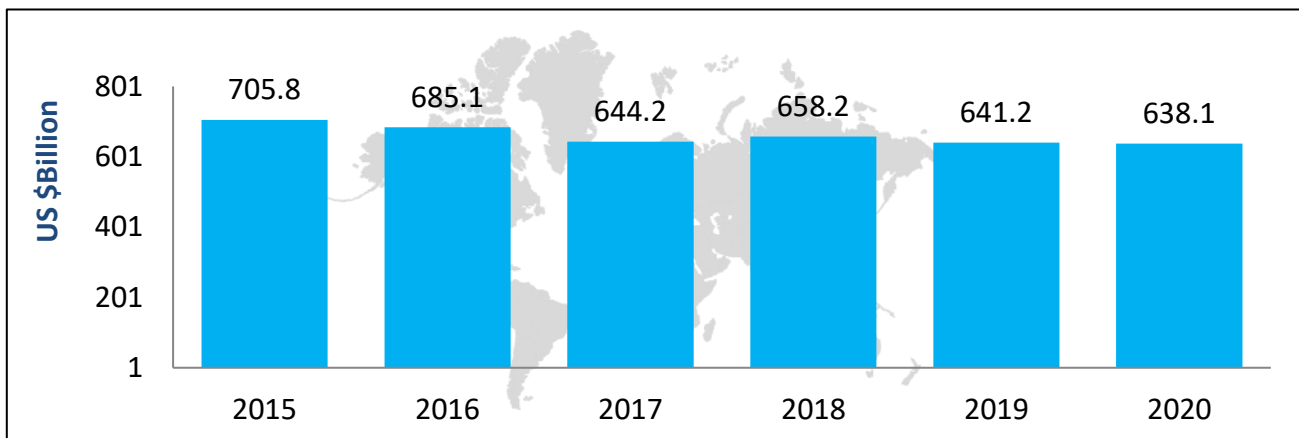
Source: WTO Statistics, Frost & Sullivan Analysis

Figure 3.3: Global Automotive Equipment Manufacturing, 2015-2020



Source: WTO Statistics, Frost & Sullivan Analysis

Figure 3.4: Global Telecommunication Equipment Manufacturing, 2015-2020



Source: WTO Statistics, Frost & Sullivan Analysis

Impact of Russia Ukraine war on Automotive Sector:

The Russo-Ukrainian war severely disrupted the automotive value chain and prompted OEMs and suppliers to defer or discontinue trade with Russia. Several OEMs in Europe and Eastern Europe have paused or slowed their production due to a lack of parts from Ukraine-based suppliers. Production halt and auto parts supply shortage are the immediate effect of this crisis, and supply chain issues and raw material shortages are expected in the coming weeks. OEMs, including Toyota, Ford, Volvo, Jaguar-Land Rover, General Motors, and BMW, have ceased export operations to Russia, with many of them suspending Russian joint ventures in response to the invasion. Russia is a major supplier of key metals & minerals, and export sanctions have severely impacted commodity demand and prices.

Due to the shortage in auto parts supply, such as wiring harnesses, OEM production facilities in Germany and Eastern Europe took a hit in production. Supply of inventory to other markets pulling out of Russia, a minor market, could help OEMs generate the lost revenues. Revenue derived by OEMs from Russia is less than 2% of their global revenues

Ukraine war has sparked another supply chain crisis, just as pandemic-related disruptions had started to ease. Europe depends on Russia, Ukraine and Belarus for its energy imports, but also for some chemicals, oilseeds, iron and steel, fertilizers, wood, palladium and nickel, amongst others. Especially the energy dependency is a vulnerability now that Russia is demanding ruble payments for its exports. It is unlikely that Europe would be able to fully replace Russian gas in the short term, whilst most of the Russian oil and solid fossil fuels could be replaced. Besides energy goods, disrupted supply of pig iron and several other iron and steel products, nickel and palladium will likely have the largest impact on EU industry. EU supply chains could also be distorted via war-related production disruptions in third countries. The EU could face challenges in importing e.g., electronic circuits from third countries, as these require inputs such as nickel and neon gas sourced from the warzone. Germany and Italy are relatively vulnerable to the crisis because of their relatively large industrial sectors, strong reliance on Russian energy, and in case of Italy strong reliance on Russia and Ukraine for certain iron and steel imports and gas in its total energy mix.

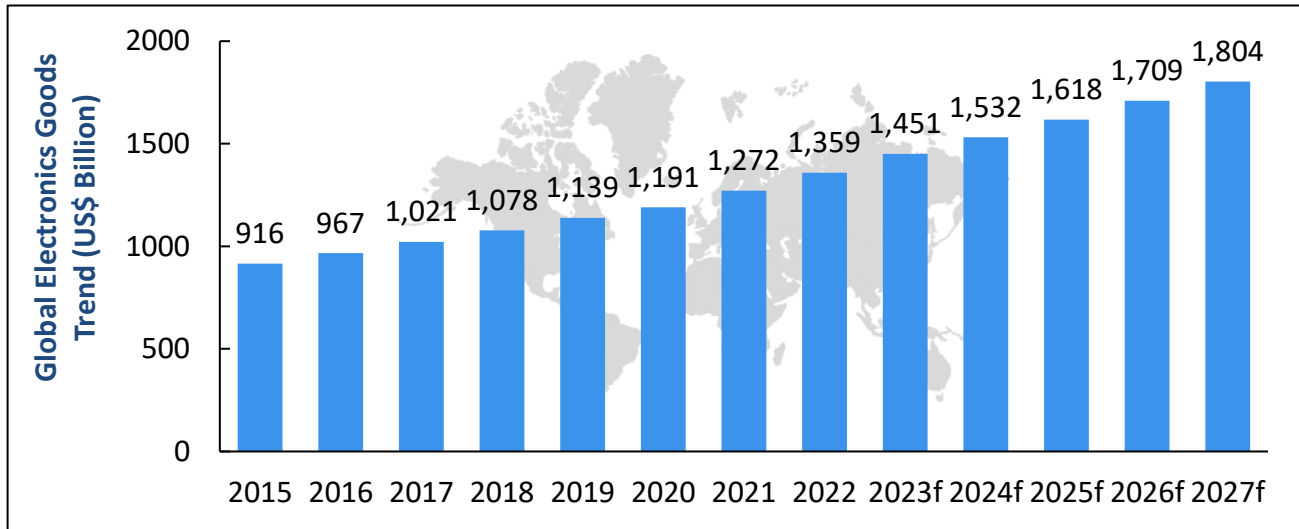
3.4. Emerging Market Dynamics – Electronics Parts Machining

The global electronic products market reached a value of nearly \$1,191.2 billion in 2020, having increased at a compound annual growth rate (CAGR) of 5.4% since 2015. The market is expected to increase from \$1,191 billion in 2020 to \$1,532 billion in 2024 at a rate of 6.5%. The electronic products market is expected to grow from \$1,532 billion in 2024 to \$1,804 billion in 2027 at a CAGR of 5.6%.

Growth in the historic period resulted from rise in disposable income, increased popularity of audio and video broadcasting, increased internet penetration, low interest rate environment, high investments and increasing usage of televisions. Factors that negatively affected growth in the

historic period were volatile metal prices, changes in consumer preferences, and rising costs and shortage in electronic components supply.

Figure 3.5: Global Electronics Goods Manufacturing, 2015-2027(F)



Source: Frost & Sullivan Analysis

Going forward, development of smart cities, innovations in electronic products such as 4G and 5G, growing demand for wireless audio devices and smart TVs, increase use of electronic devices, rising demand for electronic components in display devices, increasing adoption of internet of things (IoT) and increasing demand for smart home products are expected to drive the market. Shortage in semiconductors, changing regulations, and the coronavirus pandemic are major factors that could hinder the growth of the electronic products market in the future.

The rapid pace of innovations in electronics technology is stimulating consistent demand for newer and faster electronic products and applications. Technological development is key for attracting both consumers and business users for either replacing or upgrading the older products with advanced versions. Digital technologies such as the internet of things (IoT) and latest communication technologies such as 5G are expected to aid in the development of innovative electronic products. Increasing use of next-generation mobile networks, such as 4G and 5G will increase demand for integrated circuits thus driving the growth of the electronic products market. All these infrastructure upgrades are expected to increase the CNC Machine Center demand in the next 5 years.

The market for CNC Machining Centers is expected to grow as there are several trends in the industry favoring this market. Many Industries are moving towards industry 4.0 and automation of their production line. And market players are looking for more precision oriented machine. These trends are increasing the demand for CNC Machines in the market.

Key Challenges:

Global Engineering goods sector has seen couple of challenges in the recent years with drastic disruption in supply chain, intense shortage in labour and rising commodity prices. All these changes have put the sector in immense stress.

The pandemic combined with the current geopolitical tension between Ukraine-Russia has caused a huge disruption to the supply-chain globally further tightening the bottleneck resulting in huge inflation in prices. The increase in raw material cost is due to the rising crude oil prices and sanctions on Russia the cost of transportation of goods have also increased dramatically.

The US - China trade war and the latest pandemic situation in China is causing all the western companies to look for alternatives to China. Countries like Vietnam, India, Taiwan and Europe have been an attractive to some extent. The western countries seem to have realized the strategic importance of domestic production capabilities and are now focusing of localization and diversifying their supply chain. Many global companies have also taken steps to localize part of their production

3.5. Capex Investment Impact

The increasing Capex investments across the key sectors (Electronic Goods, Telecommunication, Automotive Manufacturing, Machinery and Transport equipment Manufacturing) will increase the equipment demand. This will have a multiplier effect and increase the machining Centers requirement to manufacture the various precision equipment. It is estimated global manufactured goods sector will grow at a CAGR of 3.5% from 2021-2027. The machining Centers market growth is expected to be around 3X ($3.5 \times 3X = \sim 10\%$) – from the global manufactured goods sectoral growth rate.

With the increase in Capex investments of around \$ 200 billion YOY across key sectors (cumulative investment), is expected to support the global machining Centers market and propel the 10% CAGR growth between 2021-2027.

Chapter 4: India Engineered Goods Sector



4.1. Overview of the India Engineering Goods Sector

The Engineering Goods sector in India is the largest and most diversified industrial manufacturing sectors. It is a strategically important sector to the economy as the output drives a broad base of industries acting as a critical input.

The sector accounts to 3% of the total GDP of India and the sector contribute nearly 27% of India's total exports and is the largest foreign exchange earner for India. The sector has seen a lot of push from the government through various policy initiatives in a vision to realize Make in India project.

Table 4.1. India Engineered Goods Sector - End-user Segment Market Size and Growth rate

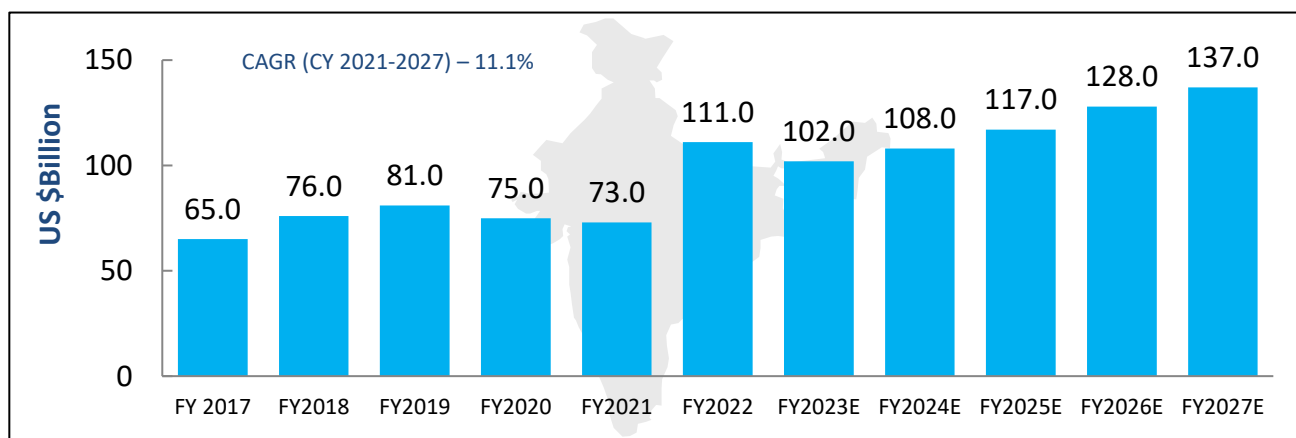
End-user Segment	Market Size -FY2022 (\$ Billion)	Forecast CAGR (FY 2023-2027)
General Engineering	87.7	3.9%
Automobile	36.1	4.4%
Industrial Machinery & Electrical Machinery	50.6	4.5%
Ships	6.4	4.7%
Aerospace	2.0	6.8%
Medical	3.0	6.5%
Railways	0.7	4.2%
Other Engineering Sectors	20.8	3.5%
Total	207.3	4.2%

Note: The above values are estimated based on considering local manufacturing consumption and Imports

Source: Frost & Sullivan Analysis

4.2. Growth in Engineered Goods Exports from India

Figure 4.1: India's Engineering Goods Export, 2017-2027



Source: Engineering Export Promotion Council of India (EEPC), Frost & Sullivan Analysis

Due to the pandemic India witnessed a drastic slow down in engineering export in FY20 and FY21 by -6.9% and -2.9% respectively. Post this period once the pandemic intensity slowed down India's exports has seen a dramatic growth from US\$ 73 Billion in FY21 to US\$ 111 Billion in FY22 which is a

52% increase from the previous year and 37% higher than the pre-pandemic levels of FY19. India's engineering exports also surpassed the target of US\$ 107 Billion set for FY22. And for the first time the monthly exports have crossed the US\$ 11 Billion mark in march to reach US\$ 11.13 Billion which was a 19.7% increase from US\$ 9.29 Billion in previous year. India is expected to reach US\$137 Billion of engineering goods export by the end of FY27.

4.3. Engineered Goods Exports from India – Regional/Country wise Analysis

In FY22, the total export value was estimated to be worth US\$ 111 Billion. Top 12 countries contribute to nearly 51.4% of the overall engineering goods exports worth around US\$ 52 Billion in FY22. USA is the largest engineering goods export destination for India with exports worth \$US 15.3 Billion exported in FY22 and this contribute to nearly 15% of the overall engineering goods exports. This is followed by China, UAE, Italy and Germany.

Table 4.2: India's Engineering Goods Export by Top 12 Countries (US\$ Millions)

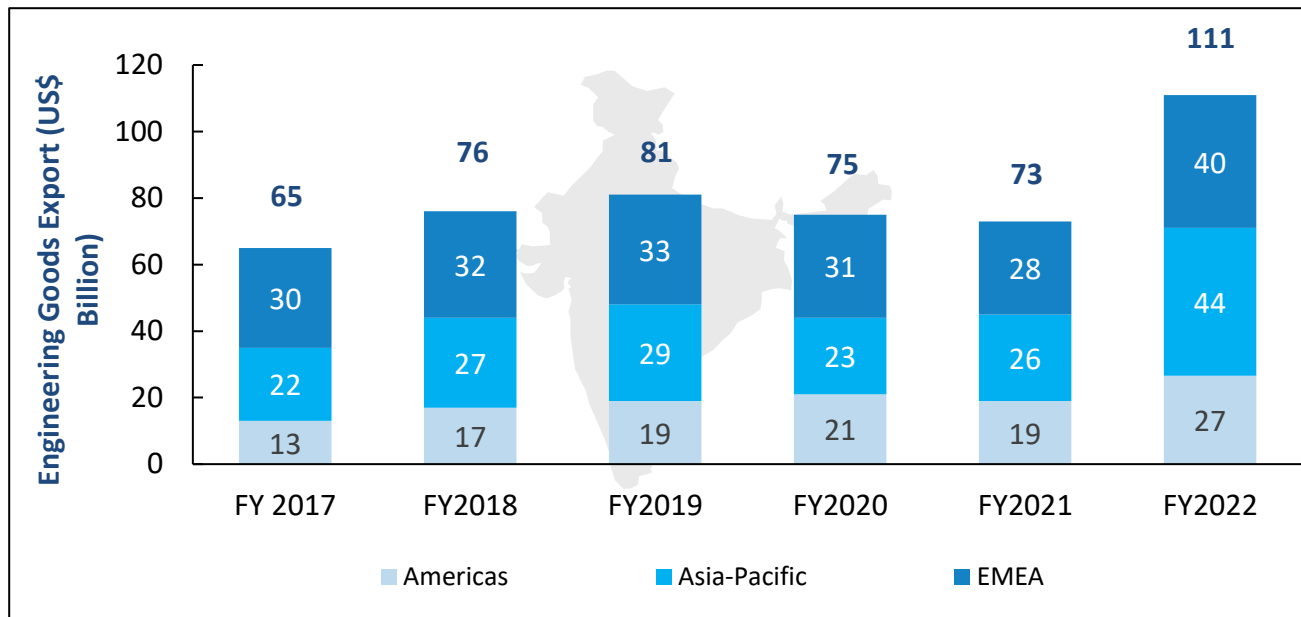
Country	April-February (2020-21)	April-February (2021-22)	Growth Rate (%)
USA	10078.8	15346.4	52.3
China	4314.1	5154.6	19.5
UAE	2891.0	5039.0	74.3
Italy	1648.7	3725.0	125.9
Germany	2539.2	3473.6	36.8
Nepal	2122.3	3166.4	49.2
Turkey	1057.2	3021.5	185.8
South Korea	1766.8	2794.6	58.2
UK	1698.7	2732.7	60.9
Bangladesh	1835.1	2628.1	43.2
Mexico	1760.0	2504.1	42.3
Singapore	2479.4	2441.9	-1.5

Total Engineering Exports to Top 12 Countries	34191.3	52027.9	52.1
Total Engineering Exports	67421.2	101079.3	49.9
Share of Top 12 Countries	50.7%	51.4%	0.7

Source: Engineering Export Promotion Council of India (EEPC)

India's engineering exports recorded 33.31% percent YoY growth in February 2022 by climbing up to USD 9.4 billion from USD 7.05 billion in February 2021. Exports during April-February 2021-22 stood at USD 101.7 billion, registering 49.9% growth over the same period last year. In April – February 2021-22, share of engineering in total merchandise export was 26.94% 31 out of 34 engineering product panels witnessed positive YoY growth during February 2021. Only 'Ships, boats and floating structures', 'Project Goods' and 'Industrial Machinery like Boilers, parts, etc' conceded decline in YoY exports during February 2022. Export to all the regions grew YoY in February 2022 other than Sub-Saharan Africa. India's engineering imports recorded a positive growth of 7% during February 2022 by increasing to US\$ 9.40 billion. Negative import growth was witnessed by engineering goods sector comprises metal products, industrial machinery and equipment, automobiles and its components, transport equipment, bicycles, medical devices and renewable equipment.

Figure 4.3: Engineering Goods Export By Region, India, 2017-2022

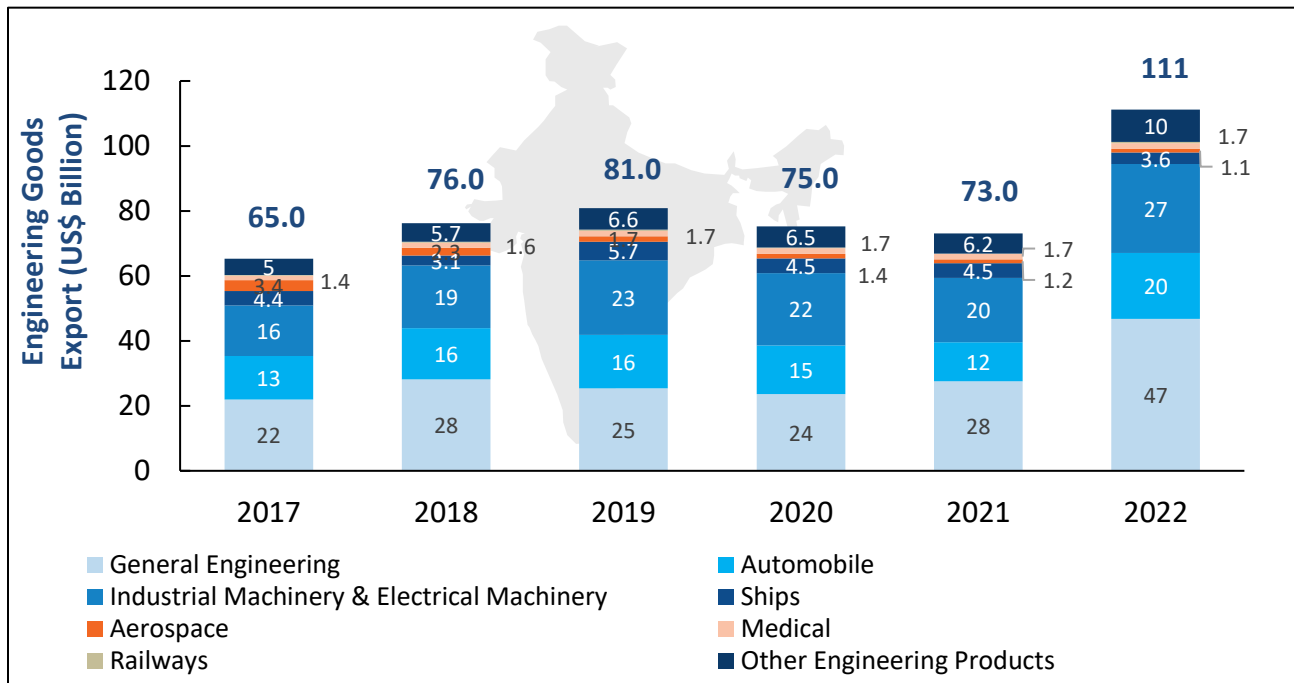


Source: Engineering Export Promotion Council of India (EEPC), Frost & Sullivan Analysis

USA was the largest importer of Indian 'Industrial machinery' during April- February 2021 in India's global import of the product group. Thailand and Germany were the two immediate followers of USA. South Africa, Mexico and Nigeria were top three importers of India's Automobiles during April-February 2021 in India's global exports respectively over the same period last fiscal. During April-

February 2021 USA, Germany and Poland were the three top importers of Indian Electrical Machinery & Components. USA, France and UK were the top three importers of India's 'Aircrafts and Space crafts' during April- February 2021 in India's total global exports of the product followed by Singapore and Germany. UAE, Singapore and Sri Lanka became the largest importer of ships, boats and floating structures followed by Malaysia and Indonesia. While for the auto components' product group, USA remained the top importer in April- February 2021 followed by Germany, Bangladesh, Brazil and Turkey. Industrial machinery, auto and auto components also had registered noteworthy export figures during February 2022 as well as in April – February 2022.

Figure 4.4: Engineering Goods Export by Category, India, 2017-2022



Source: DGCI&S, Frost & Sullivan Analysis

India, on its quest to become a global superpower, has made significant stride towards developing its engineering sector. The Government has appointed Engineering Export Promotion Council (EEPC) as the apex body in charge of promotion of engineering goods, products, and services from India. India exports transport equipment, capital goods, other machinery/equipment, and light engineering products such as castings, forgings, and fasteners to various countries of the world.

Indian Engineering Goods market has grown significantly in the last decade. And the government has taken a special interest and considers it as a strategic industry for the long-term interest the country. They have taken several policy initiatives to attract foreign investment and leading global players into the Indian market.

4.4. Key Government Schemes impact on the Sector

A) PLI:

Indian Engineering Goods market has grown significantly in the last decade. And the government has taken a special interest and considers it as a strategic industry for the long-term interest the country. They have taken several policy initiatives to attract foreign investment and leading global players into the Indian market.

Indian government has allowed 100% FDI through the automatic rule and has initiated incentive schemes such as PLI (Production Linked Incentive) scheme aiming to help and encourage companies to setup production in India.

The implementation of the PLI scheme will lead to a potential capital expenditure (capex) of Rs 2.5-3 lakh crore over the scheme period and will account for 13-15 % of average annual investment spending in key industrial sectors over the next 3-4 years.

PLI will spur green investments in India, with (nearly) 55 % of the scheme expected to be green, in sectors such as auto for electric vehicles/fuel cell electric vehicles, solar photovoltaics, and automotive cell company (ACC) batteries. The incentive-to-capex ratio varies among sectors is particularly attractive for mobile phones, electronic components, telecom equipment, and IT hardware, which have high dependence on imports across value chains and relatively lower domestic base

Following are some of the Incentive Schemes initiated by the government:

- In September 2021, the Indian government announced a PLI scheme for automobiles and auto components worth Rs. 25,938 crore (US\$ 3.49 billion). This scheme is expected to bring investments of Rs. 42,500 (US\$ 5.74 billion) by 2026.
- In September 2021, the government announced its PLI scheme of Rs. 10,683 crore (US\$ 1.4 billion) for textiles, specifically aimed at boosting production of man-made fiber (MMF) fabric, MMF apparel and technical textiles.
- In October 2021, the Department of Telecommunications (DoT) approved 31 proposals totaling an investment of US\$ 447 million over the next 4.5 years, as part of the PLI scheme for telecom and networking products manufactured in India.
- In August 2021, the government introduced a PLI scheme post liberalization of the drone industry with a scheme outlay amount of Rs. 120 Crores.
- The Production Linked Incentive Scheme (PLI) Promoting Domestic Manufacturing of Medical Devices and Production Linked Incentive Scheme for Pharmaceuticals (PLI 2.0) worth Rs. 18420 Crores have been introduced to provide an impetus to India's vision of becoming a global manufacturing hub for medical devices.

The government has introduced a Production-Linked Incentive (PLI) Scheme worth Rs. 63222 Crores in Specialty Steel for Enhancing India's Manufacturing Capabilities and Enhancing Exports.

In the renewable sector the government has taken major initiative to build the country's manufacturing capabilities in the solar PV modules space worth Rs 24,000 Crores.

The Production Linked Incentive Scheme worth Rs. 6,238 Crores for White Goods (PLIWG) proposes a financial incentive to boost domestic manufacturing and attract large investments in the White Goods manufacturing value chain.

All these incentives will drive the machine tool industry as the government is paving a path for India to become a Global Manufacturing Hub. This will encourage more investments mainly Capex across Engineered goods sector.

B) Make in India

Make in India is an initiative by the Government of India to make and encourage companies to develop, manufacture and assemble products made in India and incentivize dedicated investments into manufacturing. This policy approach was to create a conducive environment for investments, develop a modern and efficient infrastructure, and open up new sectors for foreign capital. The initiative targeted 25 economic sectors for job creation and skill enhancement and aimed "to transform India into a global design and manufacturing export hub.

"Make in India" had three stated objectives:

- To increase the manufacturing sector's growth rate to 12-14% per annum.
- To create 100 million additional manufacturing jobs in the economy by 2022.
- To ensure that the manufacturing sector's contribution to GDP is increased to 25% by 2025

The Government has taken several initiatives in order to reach these goals. It allowed a 100% FDI in the automatic route for several sectors like the Automotive Industry. In line with the Make in India, individual states too launched their own local initiatives, such as "Make in Odisha", "Tamil Nadu Global Investors Meet", "Vibrant Gujarat", "Happening Haryana", and "Magnetic Maharashtra" India received US\$83.5 billion FDI in FY 2021–22. The state level initiatives is expected to increase the engineered good exports.

4.5. Capex Investment Impact

The increasing Capex investments across the key sectors (Automotive, Aerospace, Medical, Industrial Machinery) will increase the equipment demand. This will have a multiplier effect and increase the machining Centers requirement to manufacture the various precision equipment. It is estimated India manufactured goods sector will grow at a CAGR of 4.6% from FY 2023 -2027. The machining Centers market growth is expected to be around 3X ($4.2 \times 3X = \sim 12\%$) of India manufactured goods sectoral growth rate.

With the increase in new Capex investments of around \$ 10 billion YOY across key sectors (cumulative investment), is expected to support the India machining Centers market and this will drive ~12% CAGR between FY2023-2027.

Chapter 5: Global Market for Machining Centers for Engineered Goods



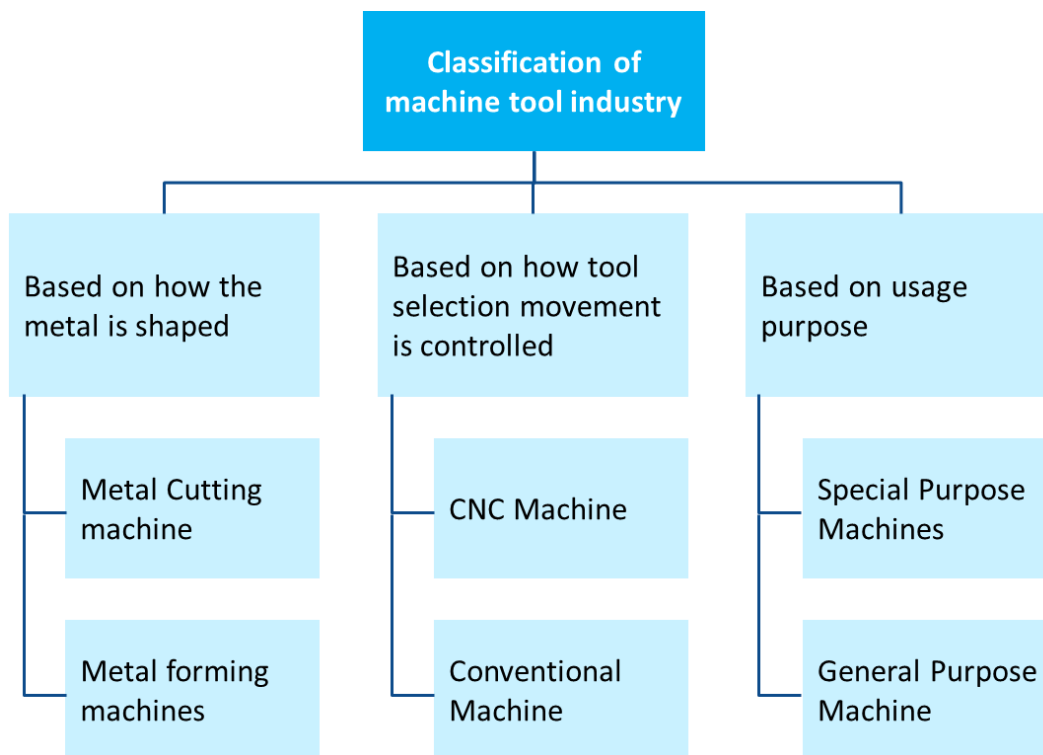
**GLOBAL MARKET FOR MACHINING
CENTERS FOR ENGINEERED GOODS**

5.1. Machine Tool Industry Overview

Machine tools are used to cut and shape metals and other materials based on the specifications of a product. They provide an effective and efficient method of manufacturing critical components with ease and accuracy.

Machine tools can be broadly classified by three ways on basis of how the workpiece is being shaped, how the tool is operated and based on the usage as follows.

Figure 5.1: Global Market- Classification of Machine Tool Market



Market Dynamics: Key Market Drivers:

The growing manufacturing industry is expected to propel the growth of the machine tools market going forward. The technological advancements in machine tools, such as multi axis and robotic arm, are some of the major factors driving the growth of the machine tool industry globally.

Primary industry users like automotive, aerospace and defense, railways, capital goods, and consumer durable sectors have a high demand for machine tools. The automotive industry is adopting the integration of technologies such as AI, IOT, robotics, etc., which will serve the demands of the end users. Major efforts are made to upgrade engine technologies to meet the fuel efficiency mandates and NCAP rating globally. This will further add to the re-tooling of the existing machining solutions.

1. Industrial Automation

The rise in demand in the industrial automation acts as one of the major factor driving the growth of machine tool market. The increase in demand for high productivity, high quality and reduced cycle time has a positive impact on the market.

2. Integration of CAM

The surge in integration of Computer-Aided Manufacturing (CAM) in machine tools for declining the time required for manufacturing workpieces further influence the market. The Computer-Aided Manufacturing (CAM) ensure hassle-free production of micro components escalate the growth of the market.

5.2. CNC Machines Classification

CNC Machines can be segmented based on their operations into:

CNC Mills:

These machining centers use computer controls to cut varied materials. They are able to translate programs consisting of specific number and letters to move the spindle to various locations and depths. Used to make 3D prototypes, moulds, cutting dies, printing plates and sights.

CNC Lathes:

They cut metal that is often turning at fast speeds. CNC lathes are able to make fast, precision cuts using indexable tools and drills with complicated programs. Normally, they cannot be cut on manual lathes. They often include 12 tool holders and coolant pumps to cut down on tool wear.

Turning Centers:

Turning Centers are capable of executing many different types of lathe cutting operations simultaneously on a rotating part.

CNC Grinder:

Grinding metal process uses a coated wheel that removes metal to create a part. Through the years, grinding was done on a manual machine, but with the advent of CNC technology, the grinding process has advanced.

CNC Drilling:

Drilling is commonly used for mass production. The drilling machine (drilling press) is used to create or enlarge holes. Drilling machine for different jobs.

Bench drill: For drilling holes through raw materials such as wood, plastic and metal
Pillar drill: A larger version that stands upright on the floor. As the bench drill, it can be used to drill larger pieces of materials and produce bigger holes.

CNC Boring:

Process of enlarging an existing hole or internal cylindrical surface. This can be accomplished on a lathe or a machine tool specifically designed for the process, such as a horizontal boring machine.

5.3. CNC Machining Centers - Overview

The CNC machine center is an advanced manufacturing machine tool that can perform a variety of machining operations with high precision, high quality, and high surface finish. A CNC machine center can perform drilling, milling, and lathe operations.

CNC machine tool center was developed which allowed Milling, lathing, and drilling operations on a single machine tool which allows one machine to perform a greater variety of machining needs. These machine tool centers are operated by a computer through a sequential program of machine control instructions using G-code and M-code. The program can be written by a person or, far more often, generated by graphical computer-aided design (CAD) or computer-aided manufacturing (CAM) software.

The CNC machining centers can be broadly categorized into

- a) Vertical machining center (VMC)
- b) Horizontal machining center (HMC)
- c) Universal machining center (UMC)

a) Vertical machining centers (VMC)

Vertical Machining Center (VMC) is a machining center in which the spindle axis and the rectangular worktable are set vertically, which is suitable for processing workpieces with high accuracy and precision, even with multiple procedures and complex shapes. The spindle cartridge is mounted in a housing that moves vertically which is known as the z-axis and the workpieces of VMC are usually mounted on top of its table and perform standard 2.5 or 3 axis machining operations, using a 3D Cartesian coordinate system for its motion. It is utilized primarily as a metal cutting machine that is useful in cutting or shaping steel, aluminum, and other hard materials in a precision formed or machined surface. Aside from these, it can also be used for milling, boring, drilling, carving, engraving, tapping, thread cutting, and more operations. It is used in various end-user industries such as aerospace, automobile, defence, electronics etc.

b) Horizontal Machining Centers (HMC)

A horizontal machining center (HMC) is a machining center with its spindle in a horizontal orientation. This machining center design favors uninterrupted production work. One reason for this is that the horizontal orientation encourages chips to fall away, so they do not have to be cleared from the table. More significantly, the horizontal design allows a two-pallet work changer to be incorporated into a space-efficient machine. To save time, work can be loaded on one pallet of a horizontal machining center while machining occurs on the other pallet. It is used in various end-user industries such as aerospace, automotive and metal fabrication.

c) Universal Machining Center (UMC)

The universal machine center is similar to a horizontal machining center, but the spindle shaft can be continuously tilted from a horizontal position to a vertical position under computer control. The universal machine center consists of five or more axes that allow the top surface of the workpiece to be mounted on a horizontal machining center so that different sides of the workpiece can be machined in one unit. It is used in various end-user industries such as die and mold, aerospace, and automotive.

5.4. Conventional Machine Vs CNC Machine

The precision manufacturing industry relies heavily on computer-numerical control (CNC) machining, including operations that once used engineer-operated equipment like routers, shaping machines, vertical millers and center lathes. Manufacturers of many types of industries choose CNC machining because it provides efficient, expedient, and precise production capacity ideal for creating large quantities of items normally produced with a grinder, router, center lathe, or shaping machine.

In manual lathing, there must be a skilled technician for every machine, while with CNC machining, one skilled person can operate several machines. CNC machining can produce a broad range of metal components used across many industries use due to their accurate, consistent and complex cuts. Some examples of these industries are aerospace, automotive, electronics, firearms, hospitality, manufacturing, metal work, military, production and transportation. CNC machining grew popular due to its ability to produce detailed and precise results in enormous quantities by using computers.

5.5. CNC Machining Centers - Global Technology Trends

1. Increasing trend of manufacturing as a service

Manufacturing as a service (MaaS) has made inroads into the CNC sector in recent years, and this trend will continue in 2022. It is accomplished using networked resources. The expense of maintaining and operating the CNC equipment is shared among the service's subscribers. MaaS allows businesses to be more flexible, productive, and cost-effective. Companies will seek out additional supply chain networks via MaaS as a result of COVID-19's impact.

2. Longer machine life with IOT

Across global market, IoT adoption has risen this year as a result of increased need caused by social alienation and mask-wearing. During the pandemic, the ability to monitor remotely and use sensors to determine where a machine is in its lifespan became even more important. The application of sensors has expanded as more sensors have been installed on equipment around the machine shop floor. Sensors can now be used in drill presses, milling and turning machines, lathes, and other machinery. These sensors, in turn, continuously monitor the machine's many components, generating a large amount of data. Predictive maintenance can be made easier with this knowledge. CNC machines, like any other machine, require routine maintenance. Equipment has traditionally been maintained on a regular basis; The equipment downtime can be reduced by using IoT sensors.

3. Digital twinning technology

In 2023, digital twins have become more widespread. Many companies have launched Manufacturing Intelligence Software which creates a virtual twin of the real-world machine, allowing it to prevent errors and reduce setup times. This new feature allows machinists to discover and avoid the 5-axis singularity point, allowing NC programming to be optimized.

4. Increasing penetration of Multiaxis machines

Factory use of 5-axis machines has become increasingly cost-effective. It is well-known for its ability to rotate smoothly around the X and Y axes. However, in 2019, the 6-axis machine was introduced, which improved efficiency and speed by adding an additional spin around the Z-axis. As a result of the increase, cut times are faster and more items are produced in a shorter amount of time. Cutting time can be reduced by up to 75% with a 6-axis CNC milling machine.

5. Simulation and optimization software

Through simulation, verification, and optimization software, advancements in CNC machinery technology save firms time and money by minimizing scrap and lowering damage to machining Centers. Several firms offer these software packages, some with novel and distinctive features, but most with the same basic capabilities. Simulating the machining of a new part, checking tool paths to avoid crashing and accidents, and improving production are all possible with these software tools.

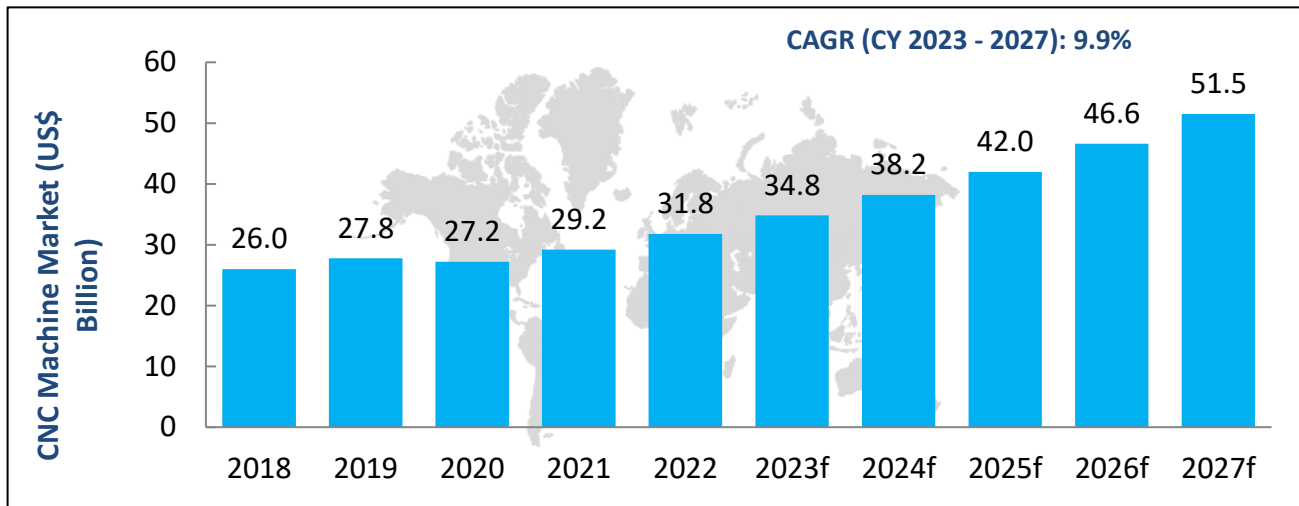
5.6. Global CNC Machining Centers Market

The global CNC machining Centers market was ~\$29.2 billion in 2021. The global CNC machining centers market is estimated to be ~\$51.5 billion by 2027. This market is majorly driven by global automotive and heavy industries manufacturers, who are embracing automation and advanced software solutions to meet their customers' needs. In addition, shortage of skilled labor, working hour limits, and labor costs are on the rise. Thus, there is a rapid growth in the demand for automated precision machines.

On the other hand, market growth is projected to be hampered by the soaring prices connected with the purchase of these devices, as well as the costs associated with their maintenance. In addition,

the computer numerical control (CNC) machining Centers market is expected to face challenges till 2024 in shortage of Semiconductor used in CNC machines and fluctuations in raw material costs.

Figure 5.2: Machining Centers Market, Global, 2017-2027F



Source: Primary Research, Frost & Sullivan Analysis

Global CNC Machining Centers Market is expected to grow at CAGR of 9.9% from 2023-2027. The market recovered well in 2021 due to increased machine orders across the industries, notably from Europe, Asia Pacific, and North America. In 2021, the market recorded positive growth owing to the pent-up demand and backlog orders resulting from the pandemic. This trend will continue over the short term to meet backlogs from 2020. However, the worldwide shortage of semiconductors and rising steel prices & logistics costs are expected to hinder the sales revenues of OEMs, a trend that is expected to continue till 2023.

The increasing demand for automotive/ auto ancillaries, industrial manufacturing, medical devices, replacement of low precision/ manual machines, components in the aerospace and defense industry is expected to drive the market growth over the forecast period. Also, the growing demand for five-axis mill machines and ultra-precision machines required to address the needs for EV productions are anticipated to drive the growth.

COVID 19 Impact on the Market and Rebound

The pandemic has a negative impact on the machining center market in 2020. Several governments had imposed strict lockdown and social isolation, which almost halted manufacturing and production for several weeks globally. Moreover, the suspension of the import as well as export of critical raw materials and components, which disrupted the global supply chains in early 2020. Disruptions in manufacturing units have stopped the production of horizontal machining equipment, thus negatively impacted the market growth. In 2021 the market return back to normal and industry achieved positive growth in 2021.

CNC Vertical Machining Centers drives the future market growth

The CNC vertical machining centers market is driven by the rising demand for fabricated products. In addition, the growing focus toward additive manufacturing is anticipated to boost the growth of the CNC vertical machining centers market during the forecast period. Over the past decade, there has been significant growth in the demand for buildings, cars, and heavy machinery across the world. This resulted in an increase in the demand for fabricated products such as stamped metal parts, building products, fasteners, and heavy equipment. To meet the growing demand for fabricated products from end-users, fabricated products manufacturers are integrating CNC vertical machining centers as they facilitate easy tool changing and produce superior quality products. Therefore, the rising demand for fabricated products is expected to fuel the growth of the global CNC vertical machining centers market during the forecast period.

CNC Horizontal Machining Centers

The Global CNC Horizontal Machining Center market growth is attributed to the growing demand for CNC horizontal machining centers from various end-use industries such as automotive and aerospace. In addition, the increasing demand for high-precision machining is also contributing to the market growth.

Application areas:

Automotive: The use of CNC horizontal machining center in automotive is mainly for engine blocks and cylinder heads. It is also used in other auto parts such as transmissions and driveshafts. The benefits of using this machine in automotive are that it helps to reduce the cycle time and lead time. In addition, it also offers superior quality and dimensional accuracy.

Aerospace: The aerospace industry is one of the major users of CNC horizontal machining centers. The complex shapes and sizes of aircraft parts require high-precision machining that can be achieved with these machines. In addition, the need for lightweight and durable aircraft parts has led to an increase in the use of advanced materials such as composites, which can also be machined using CNC horizontal machining centers.

5.6.1. Key Growth Drivers

Rising Focus on the Development of Multifaceted Machining Centers to Propel Market

Several manufacturers are aiming to develop multifaceted tools owing to their rising demand from various industries for addressing multiple operations. The latest 5-axis technology is also resulting in an ever-increasing demand for hassle-free procedures during the production of complex parts. Multifaceted machining centers are multifunctional. They include high precision, custom finishing, and improved efficiency. The designers, at present, are focusing on developing the multifaceted machining centers. All these factors are likely to increase the Machining Centers Market revenue across the globe during the forecast period.

New developments within Automotive Segment (Electric Vehicles) drives the machining Centers market growth

Automotive industry is one of the major end-use markets for machine tools for manufacture of a wide range of individual vehicle parts. Automobile sales and consequent production trends thus determine demand for a range of automotive parts and components, which in turn spurs opportunities in the machining centers market. The increasing demand for commercial vehicles from the developing economies, such as India is expected to result in the growth of automotive segment in the near future.

Rising Demand for High Precision Machinery to Boost Growth of Market

The surge in demand for high precision machinery from various industries including aerospace, defense and medical sector is expected to result in the increased demand for the machining Centers market. Furthermore, the rising demand for critical components from the robotic sector is resulting in the high demand for the machining center market. The increasing industrial automation is expected to result in the growth of industrial robot's revenue which in turn is expected to drive the machining center market growth. The ever-increasing demand for complex parts from the aerospace industry is further resulting in the growth of machining Centers. The increasing demand for general machinery from various other industries, such as Food & Beverages, Construction and Pharmaceutical is expected to increase the machining centers market size in the near future.

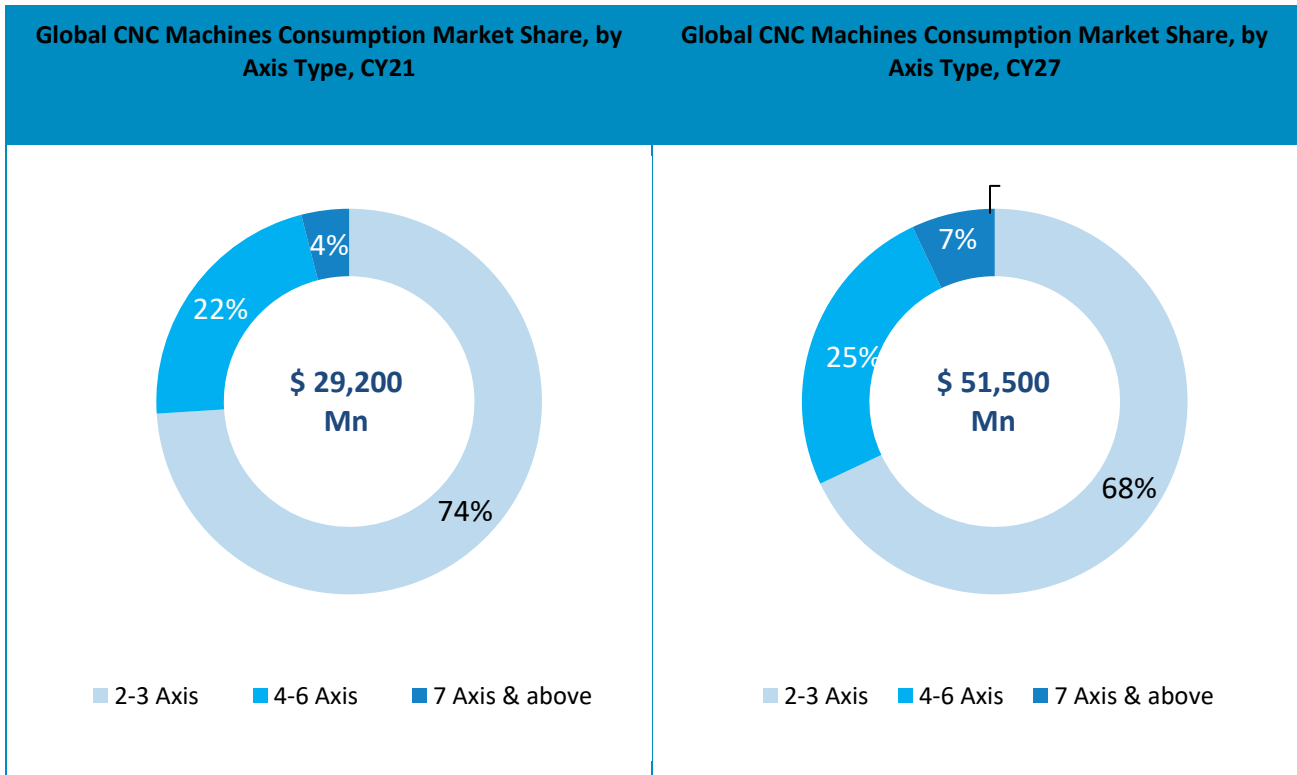
5.6.2. Global Machining Centers Market – Axis Types

2-3 Axis Machining Centers

2-3 axis CNC machines commanded the highest market share (74%) in 2021, owing to their cost advantage over 4 & 4+ Axis machines. Further, this segment is expected to continue its domination during the forecast period. This segment is expected to grow at a CAGR of 8.4% between 2021-2027.

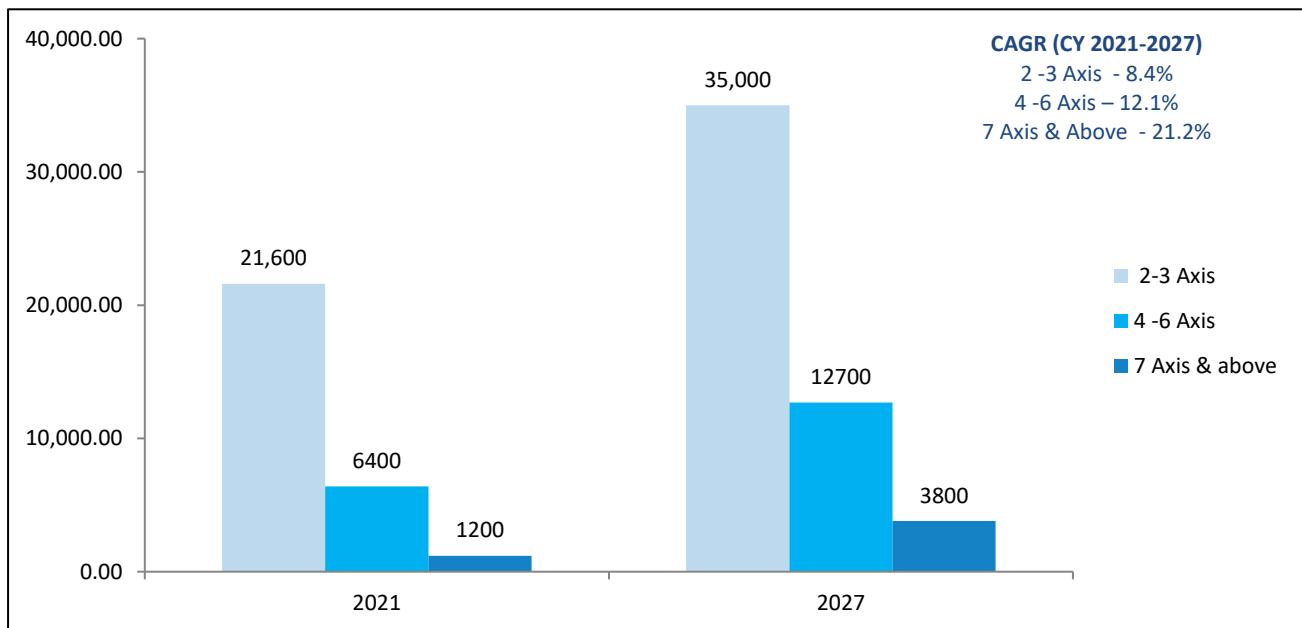
A 2 axis CNC machine is a computer numerical control machine that has two axes of movement which are typically the x-axis and the y-axis. It can be used to create a variety of parts and objects with precise accuracy. The 2-axis machine can cut and drill machine parts. 2-axis CNC machining is widely used in many industries, such as the automotive industry (producing parts for engines, transmissions, and other components), the aerospace industry (aircraft engines, landing gear, etc.), the medical field (producing parts for medical devices, such as pacemakers, hearing aids, and artificial joints), and consumer electronics production (parts for televisions, stereos, DVD players, and digital cameras). 3-axis machines are ideal for simple tasks that do not require intricate detailing or depth. As such, it is one of the most preferred techniques for creating mechanical parts for automation. Additionally, it is used for cutting sharp edges, boring, milling slots, tapping, and drilling holes. 3-axis machining is still one of the most widely used techniques to create mechanical parts, and can be used for automatic/interactive operation, milling slots, drilling holes, and cutting sharp edges. But the share of 2-3 Axis machines is expected to decline due to increasing preference of using 4+ axes machines across different user segments.

Figure 5.3: Global CNC Machining Centers- Market Split by 2-3 Axis vs. 4-6 Axis vs.7 Axis

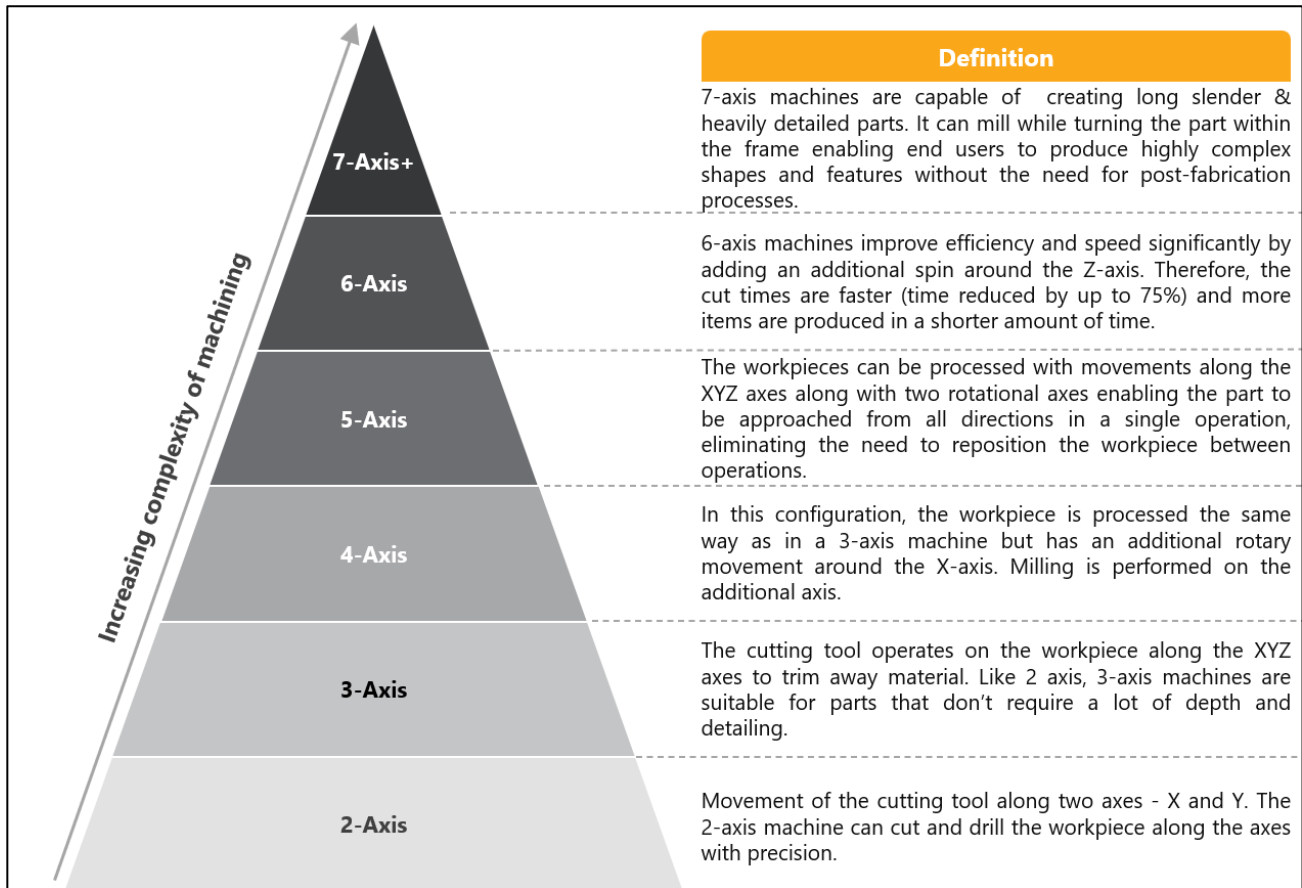


Source: Primary Research, Frost & Sullivan Analysis

Figure 5.4: Global CNC Machines Consumption Market Size, by Axis Type, CY21 – CY27(Values in \$Mn)



Source: Primary Research, Frost & Sullivan Analysis



4-6 Axis Machines

On the other hand, the 4 -6 axis segment commanded second highest market share (22%) in 2021. This segment is expected to improve its market share by growing with a faster CAGR of around 12.1% between 2021-2027. This is attributed to the increasing demand for precision manufacturing in the automotive, defense and aerospace industry.

4-axis milling involves the same process involved in 3-axis machining, where a cutting tool is used to remove material from the workpiece to create the desired shape and contour. However, in four-axis machining, milling is performed on the additional axis. 4 axis machines used in multiple industries, including Technology Research, Teaching, Hobby Prototype Building, Advertising Design, Creating Art, Medical Equipment Creation, etc.

A 5-axis CNC machining center is a versatile and multifaceted machine which enables a part to be approached from all directions in a single operation, eliminating the need to reposition the workpiece between operations. A 5-Axis machine allows a rotation/movement of the cutting tool in 5 'planes' or directions. This facilitates more nuanced and complex cutting functions with a degree of precision and exactitude which are crucial for highly complex industrial engineering across industries including aerospace, defence and high-end automotive.

In addition to this, it allow the production of various complex parts in more convenient manner. The coordinated motion enables the manufacturing of several complex elements more efficiently because their configurations are drastically reduced, higher cutting speeds are reached, more efficient tool paths are generated, and better surface finishes are possible. Using the 5-axis technology instead of the conventional 3-axis one, a lower number of configurations is necessary to create a part with complex geometry.

6-axis CNC machine can create complex shapes and improve machining capabilities. Several industrial use cases have reported a 75 % reduction in production time when using a 6-axis machine. The aerospace industry relies on 6 axis CNC machines due to its high demand for highly complex and expensive parts, usually made from very solid material. Aircraft wings can sometimes reach up to 24 meters (80 ft) in size, requiring the use of some specialized 6-axis machines. Military aircraft also contain components that require the precision of 6-axis CNC machines. 6-axis CNC machines are also relied on by the automotive industry for their ability to quickly produce high-quality components.

7 Axis and Above

The 7+ axis segment commanded 4% market share in 2021. This segment is expected to improve its market share by growing with a faster CAGR of around 21.2% between 2021-2027. This is attributed to the increasing demand for precision manufacturing in the Medical and aerospace industry at the global level.

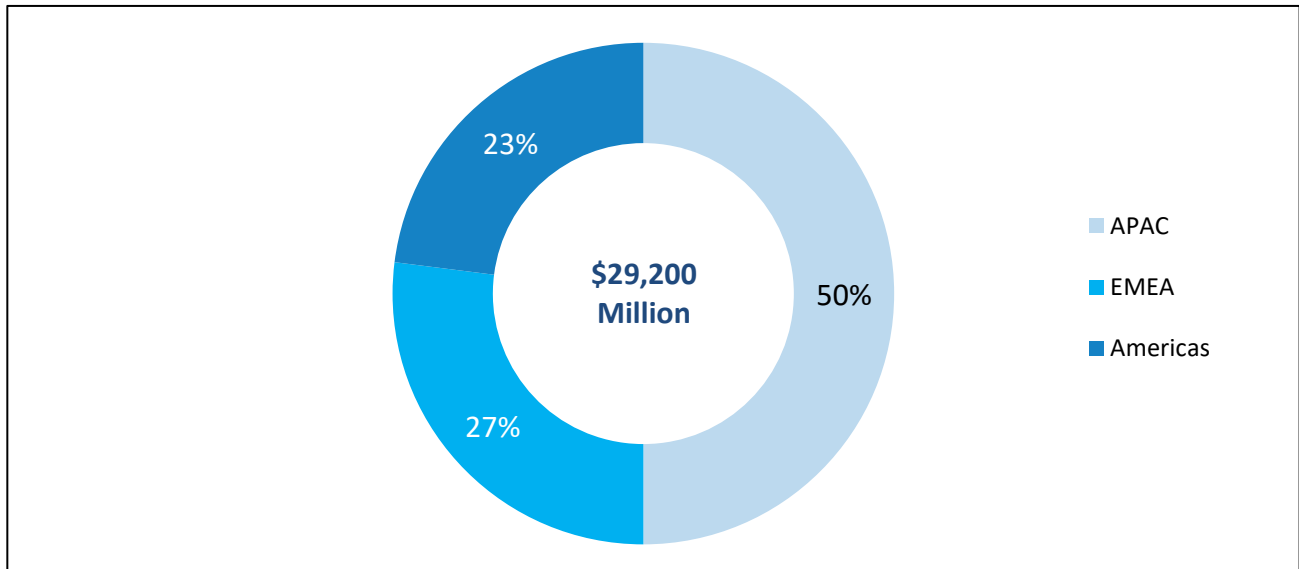
7-axis CNC milling machines can create long slender, and heavily detailed parts. This high degree of movement imparts greater accuracy to the finished product without the need for post-fabrication processes. Due to the ability of a 7-axis CNC machine to mill while turning the part within the frame, end users produce extraordinarily complex shapes and features. A 7-axis CNC machine is especially useful in the aerospace and military industries.

The 9-axis CNC combines a 4-axis lathe and 5-axis milling machining. This traditionally involves a 5-axis CNC milling machine to complete surface machining, and a 4-axis lathe to complete internal machining. The 9-axis CNC is so highly capable, it can complete a fully-finished product in a single fixturing. Common applications for 9-axis machines include implantable medical devices, complex aerospace parts, surgical tools, and dental implants.

As India aims to establish itself as a production hub, aligning with the Make in India initiative, these high precision stages find applications in various crucial processes within semiconductor manufacturing.

5.7. CNC machining Centers- Market Split by Regions/ Countries

Figure 5.5: CNC Machining Center Consumption Share, by Region CY21 (%)



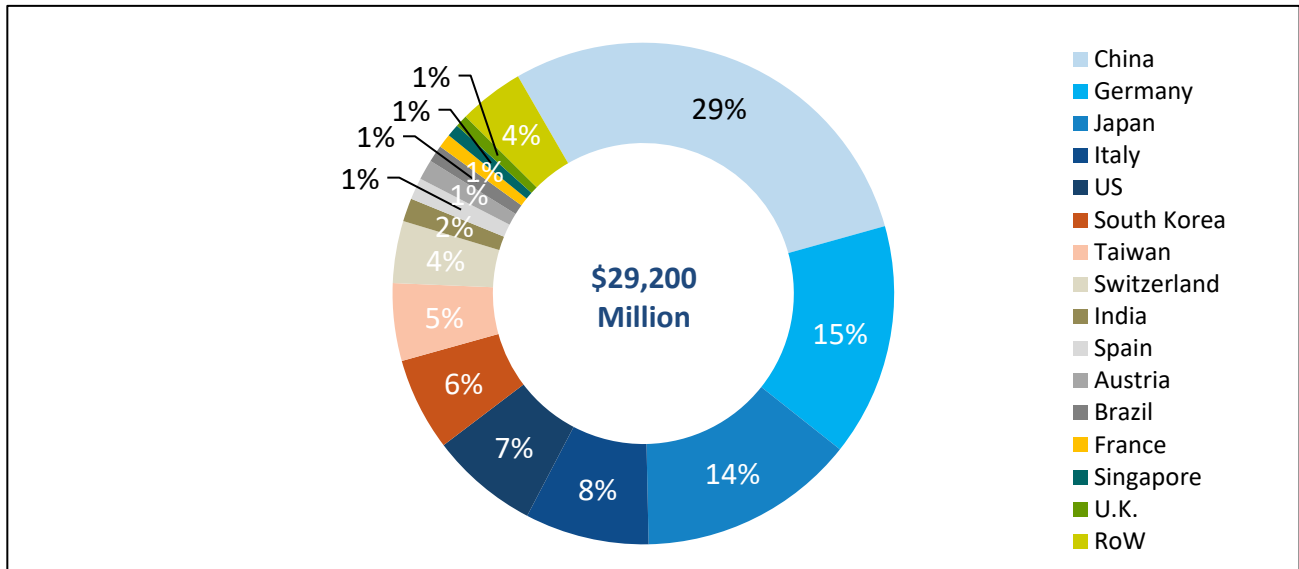
Source: Primary Research, Frost & Sullivan Analysis

The largest machine center market share is estimated to be held by Asia Pacific. In the near future, the growing automotive and aerospace markets in developing nations like India, Vietnam, and Thailand are likely to fuel demand for machining centers. Furthermore, the increase in construction activity has increased the demand for several types of construction machinery.

The APAC region is followed by the EMEA. In EMEA, the growing inclination for automation, as well as the aggressive adoption of innovative technologies such as computer-aided manufacturing (CAM) and CNC procedures, is likely to increase demand for CNC machines. More, companies are also encouraged to pursue R&D operations as a result of research funding schemes launched by various governments in partnership with universities, ensuring higher market growth potential.

In America automation is a primary factor impacting CNC machining operations. In recent years, it has grown in importance, and this tendency will continue in 2022. Positive outcomes will help the trend gain traction as more manufacturers study what automation can achieve for CNC machining.

Figure 5.6: CNC Machining Center Production Share, by Country CY21 (%)

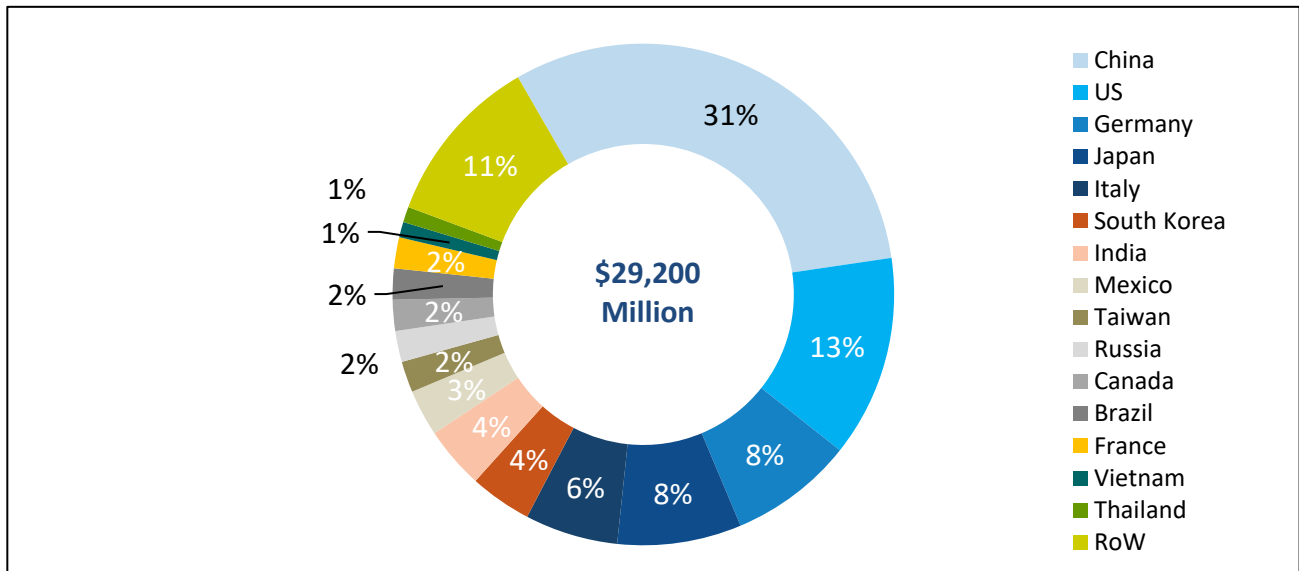


RoW: Rest of the World

Source: Primary Research, Frost & Sullivan Analysis

With a cumulative share of more than 70% China, Germany, Japan, Italy, and the US remained the leading producer of CNC machines in the year 2021. Western Europe was maintaining its market share consistently due to considerable number of players available in the region.

Figure 5.7: CNC Machining Center Consumption Share, by Country CY21 (%)



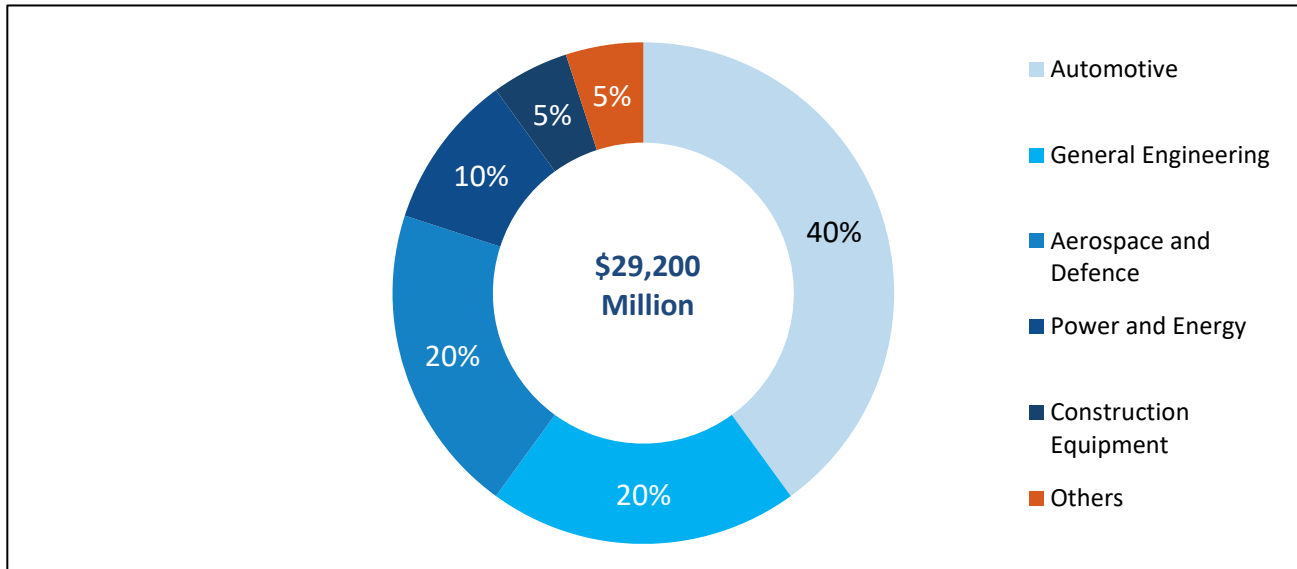
RoW: Rest of the World

Source: Primary Research, Frost & Sullivan Analysis

In 2021, China remained the leading consumer of the CNC machining center. This is due to high CNC demand from its world's largest manufacturing clusters of computers and automobiles. Further, numerous government efforts, such as the Chinese government's "Made in China 2025," have resulted in an increase in the machining centers' market income in this region.

5.8. CNC machining Centers- Market Split by End-User

Figure 5.8: CNC Machining Center Production Share, by End User CY21 (%)



Note: E refers to estimate

Source: Primary Research, Frost & Sullivan Analysis

Automotive industries hold the largest share in the CNC machines market by the end user due to the speedier manufacture of accurate and highly efficient parts. After the advent of Artificial Intelligence in CNC machines to improve their performance, the usage of CNC in automotive has undergone revolutionary changes. With AI in CNC machines, the machine will be able to self-diagnose the defect with the aid of AI software, potentially saving several hours of machine downtime. Furthermore, the significance of CNC automotive in self-driving automobiles is critical. CNC automotive has been producing higher output than previously once AI was introduced into the CNC.

In addition to automotive, CNC is the most adopted technology in the aerospace sector as well. CNCs are better at dealing with complicated interpolated motion in automated aerospace assembly than programmable logic controllers (PLCs). Complex aircraft alignment tooling, robot control, additive machining, fiber placement, tape laying, and 5-axis machining are the major factors increasing the adoption of CNC technology in the aerospace industry.

Similarly, the power & energy industry also relies extensively on CNC tools for its precise applications. Many firms who develop parts for the energy industry are rethinking their manufacturing processes considering the near-unprecedented rise of both sources of energy and a wide-open competitive market. Most shops now use CAD/CAM software and sophisticated CNC machines, but the hugely successful ones will focus on machining optimization. Additionally, CNC is playing a key role in manufacturing components of green energy equipment such as solar panels, hydropower, and windmills among others, which again boosts the demand for CNC machines across the globe

Along with this, industries such as medical, construction equipment, general engineering, and the railway sector are also some of the major end-users of CNC machines, due to their high precision

and cost affordability. Globally, industries are adopting CNC machines over other conventional machines due to these reasons and hence expected to witness lucrative growth in the coming future.

5.9. Key Trends in the Sector

5.9.1. Multi-Task Machine VS Single Task Machines

A multitasking machine is a machine equipped with an automatic tool changing function (including turret type which can perform multiple types of machining such as milling, turning, and grinding without changing the workpiece setup. In most cases, at least two machine tools, such as a lathe and a machining center, are required to finish a single part from material to finished product, but a multitasking machine can complete all these processes with a single machine. But in a Single task machine can only perform one function such as milling, turning or grinding thus requires the work piece to go through many machines to produce the final product.

Key Advantages of Multi-Task machines:

- **Consolidation of processes and reduction of labour costs**

If a multitasking machine is not used, it is necessary to use several machines to produce a finished product from a material, and each time it is necessary for a worker to install, remove, and transport the material.

With a multitasking machine, all of these tasks are performed by a single machine, eliminating the need for workers to attach and detach materials or move materials between processes. Once materials are set, they are ready to be finished, reducing the burden on workers.

- **Space Saving**

Since there is no need to have several machine tools for different processes, the number of machines can be reduced, and the factory space can be effectively utilized. The production capacity of the entire factory can be increased.

- **High Quality**

In terms of machining accuracy, it is said that accuracy deteriorates as the number of mounting and dismounting operations increases and positioning during mounting is important. In the past, it was necessary to install and remove materials for each process, which could lead to slight deviations. However, by machining with a single multitasking machine, it is possible to eliminate the installation and removal processes that can cause a decrease in machining accuracy and maintain uniform accuracy of the finished product.

Globally there is an increase in usage of multi-task machines. It is expected the growth is almost twice in the next 5 years when compare to the single task machines.

5.9.2. Precision Machining in Industry 4.0

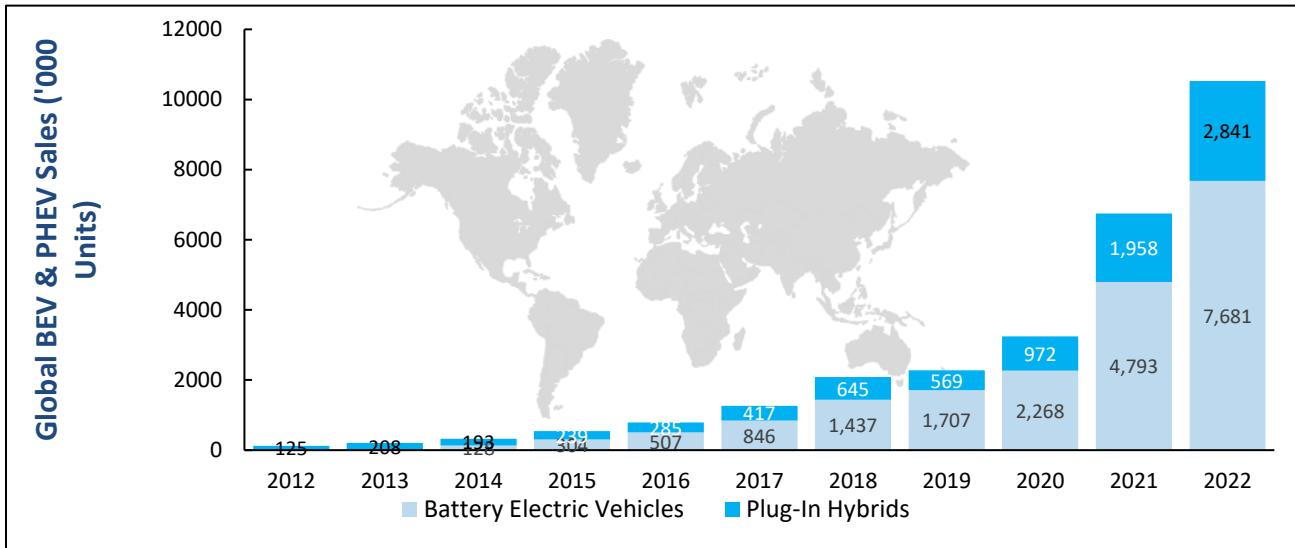
The fourth industrial revolution is integrating innovative technologies with production and manufacturing processes. CNC machines in Industry 4.0 will be equipped with sensors to monitor and respond autonomously as needed. Machines will be able to self-diagnose issues through analysis of system performance and analytics. In this way, Industry 4.0 presents many opportunities and challenges. Many small parts used in various industries favor precision CNC machining. The most important reason for using precision machining is to produce complex parts with higher precision and accuracy. These parts can be used in the production of a wide range of industries, including electronics, automotive, aerospace and medical. CNC machining can be used to create more desirable surface finishes and tolerances than with additive manufacturing. Two process technologies that have been cornerstones for medical component manufacturers are five-axis machining and Swiss turning.

Traditional manufacturing techniques and machine tools are not always reliable. Downtime increases costs, including production, labor, and maintenance costs. Industry 4.0 facilitate preventive maintenance in the machining Centers. Tracking performance and real-time data allows manufacturers to better prepare for equipment malfunctions or errors. Data collected from IoT sensors and platforms can also help more effectively inform operations. Smart meters can be installed to efficiently manage the flow of energy, or equipment could be automated or powered appropriately to reduce environmental and resource impact.

5.10. Emergence of Electric Vehicles – Impact to Machining Centers Market

Global EV sales have remained high. In 2022, a total of 10,5 million new BEVs and PHEVs were delivered, representing a +55% increase over 2021. However, the regional growth pattern is changing. EV sales in the United States and Canada climbed by 48% year on year, despite a sluggish overall light vehicle market that fell by 8% in 2022 y/y. Indonesia (from 1k to 10k), India (+223% to 50k, practically all BEVs), and New Zealand (+151% to 23k, for a 20% market share) were the fastest growing markets. EV supply and use are currently rapidly moving throughout the global south. Growing demand for low emission commuting and governments supporting long range, zero emission vehicles through subsidies & tax rebates have compelled the manufacturers to provide electric vehicles around the world. This has led to a growing demand for electric vehicles in the market. Countries around the world have set up targets for emission reductions according to their own capacity.

Figure 5.9: Global BEV & PHEV Sales, Global, 2012-2022



Source: EV Volumes, Frost & Sullivan Analysis

Global EV market growing at a compound annual growth rate (CAGR) of 23.1% during the forecast period 2023 to 2032.

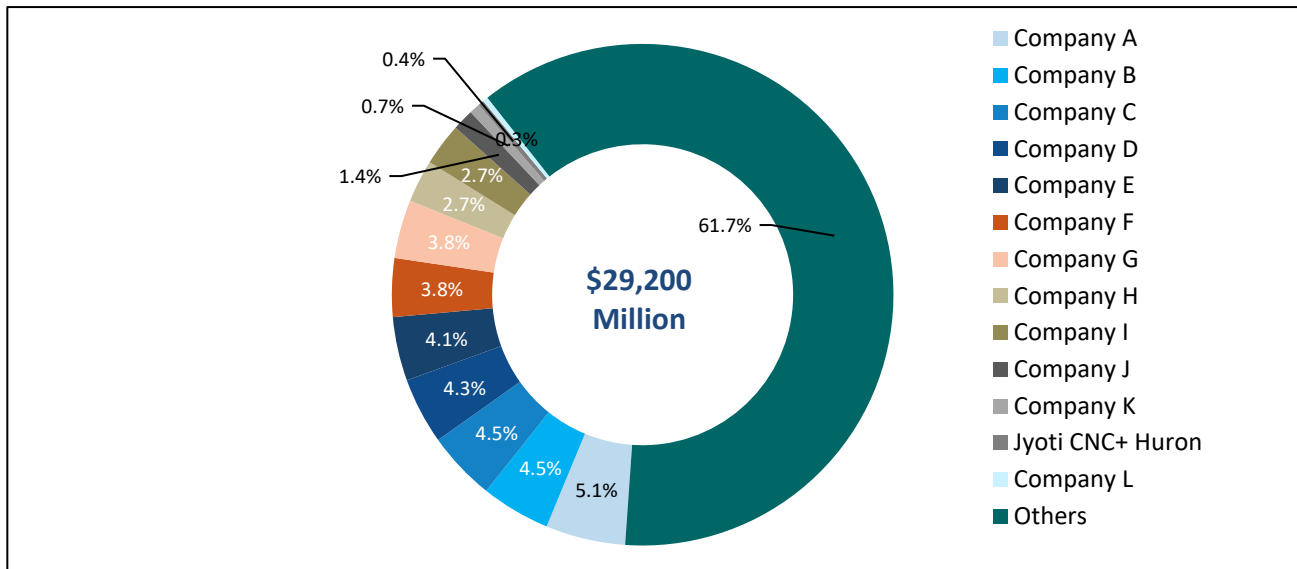
Increasing investments by governments across the globe to develop EV charging stations and Hydrogen fueling stations along with incentives offered to buyers will create opportunities for OEMs to expand their revenue stream and geographical presence. The EV market in Asia Pacific is projected to experience steady growth owing to the high demand for lower cost efficient and low-emission vehicles, while the North American and European market are fast growing markets due to the government initiatives and growing high-performance Passenger vehicle segment.

5.11. Global Electronics Market

The global electronics industry has evolved tremendously over the last 60 years. Global demand for the electronics industry is created by emerging and multiple disruptive technologies. The overall electronics market is inclusive of electronics products, electronics design, electronics components, and electronics manufacturing services. Traditionally a strong growth market, however, the market contracted by 3.4% in 2020, owing mostly to a decline in private expenditure triggered by the COVID-19 pandemic. The global electronics industry was valued at USD 2,288 billion in CY2020 and grew to USD 2,494 billion in CY2021. As per Frost & Sullivan’s analysis, the industry is expected to grow at a CAGR of 4.9% to reach USD 3,168 billion by CY2026. Some of the critical factors driving this growth are increasing disposable income, improved acceptability of audio and video broadcasting, higher broadband penetration, the inclination of the youth towards next-gen technologies, emergence of e-commerce, rising demand from rural markets, etc.

5.12. Global - Key players and their market share

Figure 5.10: Global CNC Machines Market Share, by Key Players 2021 (%)



Source: Company Website, Annual Report, Filings, Primary Research, Frost & Sullivan Analysis

The global CNC machine market is highly fragmented, with a limited number of leading manufacturers. Some of these suppliers include Company A (5.1%), Company B (4.5%), Company C (4.5%), Company D (4.3%), Company E (4.1%), Company F (3.8%), Company G (3.8%), Company H (2.7%), Company I (2.7%), Company J (1.4%), Company K (0.7%), Jyoti CNC + HURON) (0.4%), and Company L (0.3%). The Top 13 manufacturers contribute 38.3% of the global CNC machine market share. These companies achieved their market position due to their wide product portfolio, global presence, strong customer base with a high retention ratio, and ability to innovate.

Huron (Jyoti CNC):

Jyoti CNC is one of the leading manufacturer of CNC machines globally with a 0.4% market share in Fiscal 2021. Jyoti CNC has acquired 160 years old and French machine tool giant Huron Graffestaden S.A.S. at Strasbourg, France in 2007. Huron has 1,00,000+ installations of CNC machines across the globe since its inception. Jyoti – Huron have strong global network and have presence in more than 65 countries across 5 continents. Huron is reputed across Europe for its state of art 5 axis machining centers. Huron is considered as a pioneer for 5 axis machining technology. Huron produces a wide range of milling and turning solutions dedicated to machining by chip-removal. These machines are catered to the aerospace, defence and other high end engineering industries. The rich clientele comprises of reputed companies like Boeing, Airbus, NASA, BMW, Volkswagen, Daimler Chrysler, Fiat, Toyota, Volvo etc. The acquisition strengthened the product portfolio of Jyoti in terms of range offering and technology and enriched Jyoti to become one of the most sophisticated technology leader across the globe.

Huron's current range aims to satisfy the most varied requirements. The "All-in-One" concept meets the expectations of their most demanding customers. From small vertical centers to large-sized

machines with their palletizing system, Huron is focusing towards enabling customers to enjoy a complete production tool at a particularly low productivity cost.

Chapter 6: India Market for Machining Centers for Engineered Goods



**INDIA MARKET FOR MACHINING CENTERS
FOR ENGINEERED GOODS**

6.1. India's Machine Tools Industry - Overview

The machine tool industry is a fundamental pillar of Indian engineering's industrial sector. Machine tools are widely utilized by businesses in a variety of applications, including die molding, component production, aircraft, shipbuilding, electricals and electronics, healthcare, and consumer durables. According to Gardner's World Machine Tools Output Survey, the Indian machine tool industry ranks 10th in terms of output and 8th in terms of consumption. Also, it is a component of the capital goods industry, which accounts for 12% of the manufacturing sector, and it represents a huge multi-disciplinary field with multiple end-use application sectors.

In India, machine tools, accessories/attachments, subsystems, and components are manufactured by around 1,000 units in the machine tools sector of which, around 25 are large-scale units, which contribute to over 70% of the turnover, and the rest is contributed by the MSME sector.

India machine tools market is expected to witness steady growth for the next five years. Rise in adoption of precision engineering to achieve high accuracy in complex manufacturing process is a major factor contributing to the growth of the automotive industry. Launch of Make in India intended to boost the domestic manufacturing sector with relaxation in taxes and other benefits is supporting the expansion of manufacturing sector. Rising demand for bulk industries to cater the needs of rising population and increasing adoption of conventional systems in construction sector is driving the market.

Based on technology, market is divided into CNC machines and conventional machines. CNC machines segment holds the major market share for the forecast period. Increasing demand from the manufacturing industries for innovations to increase the productivity of products is fostering the machine tools market. The growth of manufacturing sector is increasing the demand for CNC machines. Advancement in CNC technology is making the machines compact and equipped with automatic tool changers. Automation of CNC machines have increased the productivity drastically and eliminates the chances of human error. CNC machines use a single machine to carry out multiple operations. Based on end user industry, market is categorized into automotive, electrical & electronics, railways, consumer durables, government & defense, among others. Automotive industry is expected to dominate the market share for the next five years. Continuous advancements in automotive industry to upgrade the engines and satisfy the fuel efficiency standards. Increasing demand for different kind of vehicles is fostering the demand for machine tools market.

6.2. Impact of Automation/ Industry 4.0

In India, automation or Industry 4.0 solutions in large-scale industries, automation is surging. For instance, currently, in India 5,000 to 6,000 robots are built every year compared to less than 100 robots per year 15 years ago. Further, according to research commissioned by NASSCOM and Capgemini on the Indian Industry 4.0 scenarios, the domestic manufacturing industry spent between USD 5.5-6.5 billion on Industry 4.0 solutions in the 2020-21 fiscal year, accounting for half of all tech

investment by Indian manufacturers. The automotive, electronics and electrical, chemicals, and pharmaceutical industries contributed significantly to this investment. The survey also stated that owing to "financial and leadership restrictions," micro, small, and medium-sized firms (MSMEs), who account for one-third of all Indian manufacturing and half of all exports, are failing to scale up Industry 4.0 solutions.

Industry 4.0 is changing the CNC machining

Industry 4.0 is the latest in industrial revolution and it is changing how CNC machine shops run on a day-to-day basis. With all the smart technology and integrated software available, quicker turnaround times and decreased downtime all result in increased productivity. Data collection and analysis from sensors and other instruments help CNC shops test out new products or study product use. With the application of Industry 4.0, Data helps inform CNC machine shops and manufacturers to make better products and allows business owners to examine their supply chain management process and delegate tedious tasks to the machines.

Industry 4.0 basically refers to a more complex manufacturing setup that includes IIoT (Industrial Internet of Things) that monitors and measures manufacturing processes and reacts autonomously to errors. This ability helps CNC machines self-diagnose problems and correct errors in the manufacturing process faster than employees can detect and respond to errors or diagnose the reason for machine malfunction.

For the industry specific example, the medical products industry demands perfection in manufacturing processes because life depends on fail-safe components. CNC machines and Industry 4.0 technology together ensure the production of high-quality components for medical devices. CNC and CAM (Computer Aided Manufacturing) machines are a combination that produces top quality, flawless products, regardless of the industry a manufacturer serves.

6.3. Key Technology Trends

1. More axes for greater cost-savings

Traditional CNC machines feature linear motion in three axes. Typically, a fourth-axis rotary is mounted to the machine table, and the part is mounted to the face of the fourth-axis rotary. This makes 4-axis machines well-suited for manufacturing medical devices and parts with complex geometries. Finally, 5-axis machines represent the pinnacle of milling ability. These machines enable micromachining and are capable of producing extremely detailed cuts at unmatched speeds. They consist of three linear axes and two rotational degrees of freedom. While 4- and 5-axis CNC machines have been commercially available for a number of years, they have only recently become financially accessible to many manufacturers in India.

¹ Source: Cybernetik Technologies, Tol

2. Increased Investments in Automation

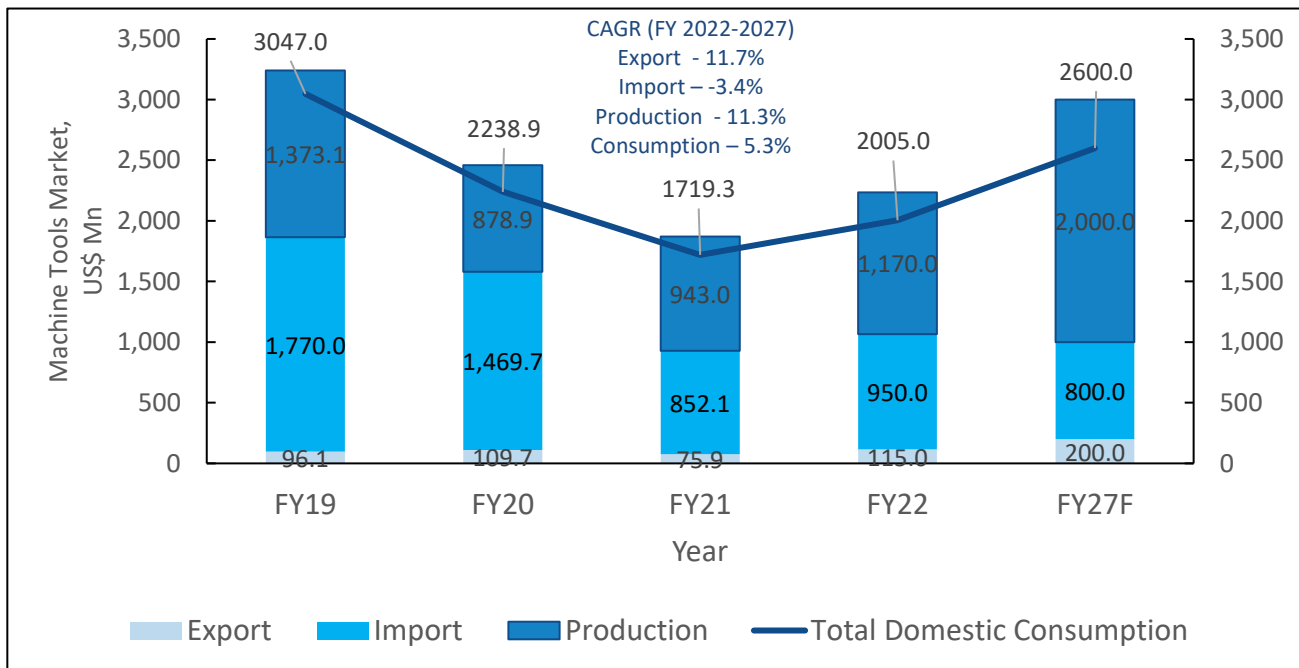
Automation is another factor influencing CNC machining operations. It has been gaining importance in recent years, and that trend will continue in 2022. As more manufacturers investigate what automation could do for CNC machining, positive results will help the trend gain prominence. One company offers a camera-controlled robotic cell used to automatically load or unload CNC machines. Customers can then install additional stations to handle turning, measuring, and marking.

3. Digital Twins for CNC Machining

Players in various industrial sectors are using digital twins to gather more insight into the performance of their machines and processes. Digital twins are generally much more representative of the respective objects than simulations. One CNC trend to watch out in future at the global level involves using digital twins during the set-up process to avoid production surprises. This trend is nascent stage in India. This technology will help organized players in the Indian industry to support their growth in the long term.

6.4. Machine Tools Industry Forecast

Figure 6.1: India's Machine Tools Production, Domestic Consumption Market , Import, Export Market Value, FY19- FY27 (\$ Million)



Source: Indian Machine Tool Manufacturers' Association, Frost & Sullivan Analysis

The machine tools production market in India is expected to increase significantly between FY2022 and FY2027 at a CAGR of 11.3%. The machine tool industry is a strategic industry determines the manufacturing competitiveness in important sectors such as automobiles, heavy electrical

equipments, defence, aerospace and consumer goods and other sectors. With an increased need for better productivity, improved precision and accuracy, and low-cost manufacturing solutions, computer numerically controlled (CNC) machine tools will be in more demand in the future. The machine tool industry is key to the government's flagship 'Make in India' and 'Skill India' initiatives, given that it makes the machines required for the manufacturing sector. The imports is expected to decline in the forecast period due to increasing competitiveness of local players in the Indian market.

6.5. CNC Machining Centers Vs Conventional Machines

The precision manufacturing industry relies heavily on computer-numerical control (CNC) machining, including operations that once used engineer-operated equipment like routers, shaping machines, vertical millers and center lathes. Manufacturers of many types of industries choose CNC machining because it provides efficient, expedient, and precise production capacity ideal for creating large quantities of items normally produced with a grinder, router, center lathe, or shaping machine. It is expected that this trend is going rise even further in the coming years as shift to industry 4.0 has speeded by in recent years. And the inflow of FDI and Government initiatives will also augment this trend.

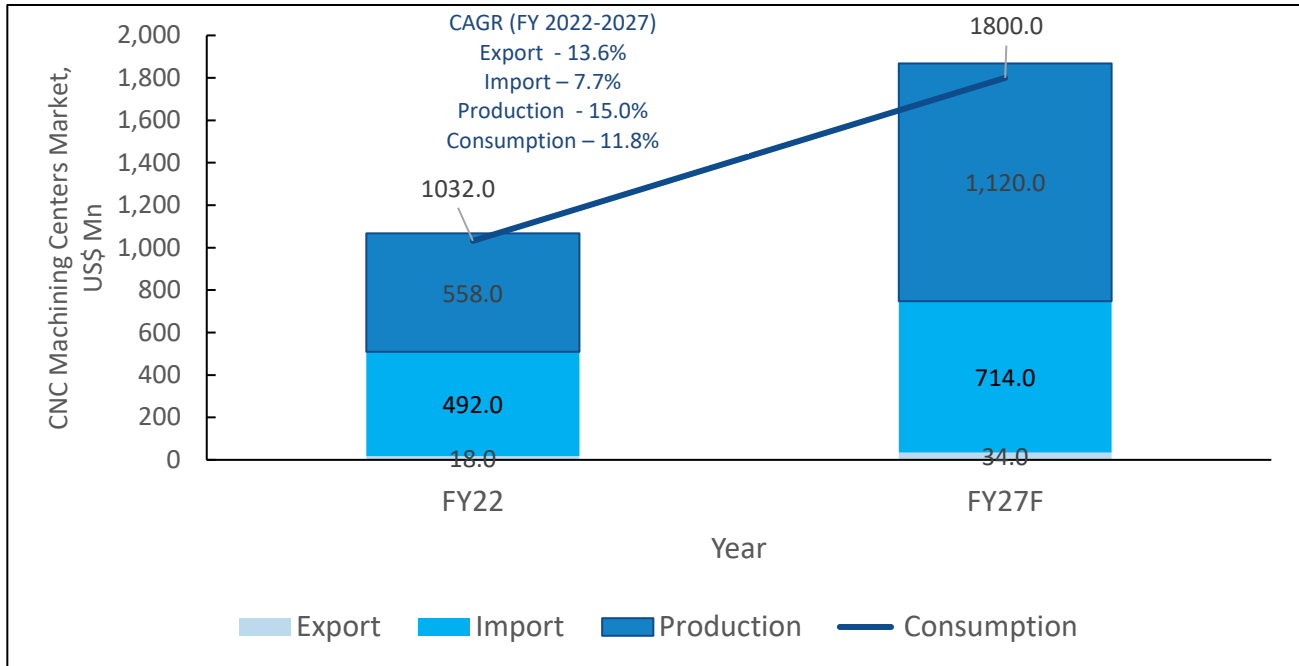
India's machine tools industry witnessed a gradual transition from manual/ conventional machines tools to CNC machines. This is evident from the replacement of conventional machines with CNC machines in many of the machine shops in our country. Owing to this most of the manufacturers of machine tools have switched over to the production of CNC machines from conventional machine tools. Currently, CNC machines constitute a major portion of machine tools manufactured. More, New businesses in the field of manufacturing are also starting with a CNC machine. In addition, technology has enabled us to produce CNC machines at affordable or less costly than conventional machines.

In terms of market share (in terms of value), CNC machining centres have a revenue of \$1032.0 million and hold a 68% market share. Other traditional machines, such as manual lathes and non-automated machinery, have a revenue of \$486.0 million and hold a 32% market share.

6.6. India – CNC Machines Industry size

Driven by demand from important customer categories such as automobiles and consumer durables, and aerospace, the industry is evolving toward increasingly advanced CNC machines. Machine tool makers must develop capabilities to meet this demand, and investments in this area may pay off eventually.

Figure 6.2: India's CNC Machining Centers Production, Domestic Consumption Market , Import, Export Market Value, FY22- FY27E (\$ Million)



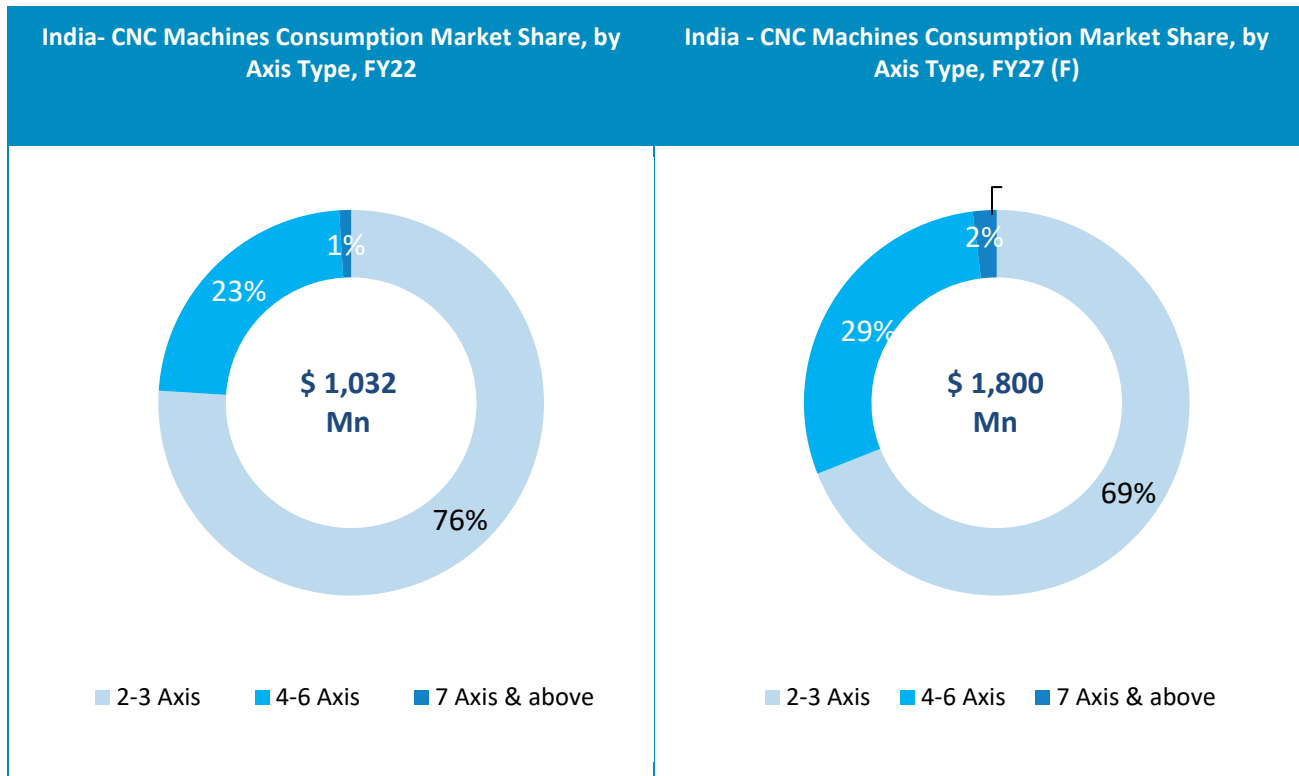
Note: E refers to estimate Source: Indian Machine Tool Manufacturers' Association, Primary Research Frost & Sullivan Analysis

In the past 4 years, the Indian industry experienced, more than 50% of CNC machines being imported for one of the highest contributing applications i.e., metal cutting (Over 80% of the total CNC machine market). This is majorly contributed by Japan and Germany with the share of 45% in total imports. The other major nations contributing to Indian imports are Taiwan, Italy, Korea, and China. Increased imports can be attributed to a gap in the demand-supply of CNC Machines. According to a primary participant, over 60% of domestic CNC Machines are catering to the Indian automotive industry. This has created a demand-supply gap for other end-users, thereby pushing their reliability on imports. In addition, the high proportion of imports is also due to the scarcity of special/ specific-purpose machine tools in India, as Indian manufacturers are majorly focused on low-medium range machine tools.

6.7. Simple Machines vs. Complex machines and trends

India's CNC consumption is dominated by the 2-3 Axis CNC machines, owing to their low cost as compared to 4+ axis machines. However, the need for precision manufacturing in automotive, defense, and aerospace is expected to drive the demand for more modern technologies that are required by the rising complexity of the job. Thus, 2 to 3-axis lathes machines with a Y-axis and sub-spindles were preferred in the past 5 years.

Figure 6.3: India CNC Machines Consumption Market Size, Market Split by 2-3 Axis vs. 4-6 Axis vs.7 Axis&above



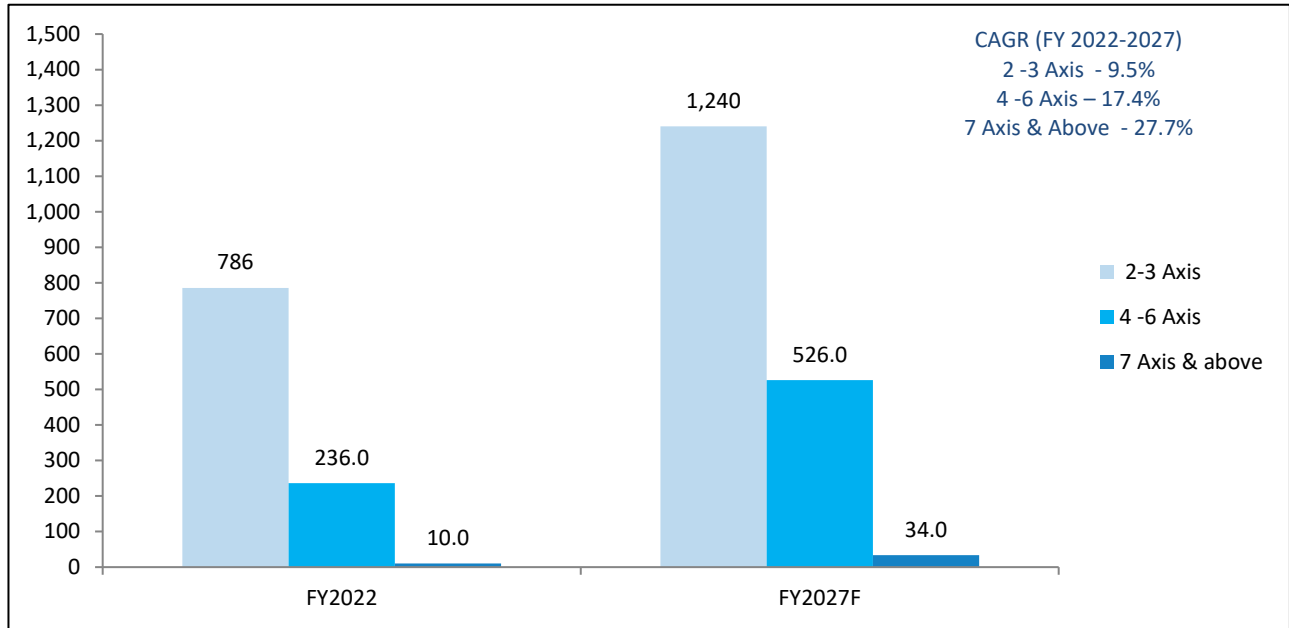
Note: E refers to estimate

Source: Primary Research, Frost & Sullivan Analysis

4+ axis machine tools, often called high-end CNC Machines, are huge or have a high level of precision. The local demand for such high-end machine tools is always significantly smaller than the overall demand as they are expensive and cannot be easily afforded by SMEs in India.

2-3 axis CNC machines commanded the highest market share (76%) in FY2022, owing to their cost advantage over 4 & 4+ Axis machines. Further, this segment is expected to continue its domination during the forecast period. This segment is expected to grow at a CAGR of 9.5% between FY 2022-2027. The market share of this segment is expected to decline due to increasing preference of 4 axis across end customers.

Figure 6.4: India CNC Machines Consumption Market Size, by Axis Type FY22– FY27F (Values in \$ Mn)



Source: Primary Research, Frost & Sullivan Analysis

On the other hand, the 4 -6 axis segment commanded second highest market share (23%) in FY2022. This segment is expected to improve its market share by growing with a faster CAGR of around 17.4% between FY2022-2027. This is attributed to the increasing demand for precision manufacturing in the automotive, defense and aerospace industry in India. The market share is expected to increase from 23% to 29% from 2022-2027. Further, from 2022 onwards, the machine tool industry anticipates that CNC fabricators and shops will shift their focus to six-axis CNC technology, which will be perfect for high-precision manufacturing of parts such as automotive components or aerospace components that require the utmost accuracy conceivable. Manufacturers of such high-end machine tools must consequently obtain sufficient numbers from the worldwide market through exports to remain viable.

The 7+ axis segment commanded 1% market share in 2021. The product is in nascent stage. This segment is expected to improve its market share by growing with a faster CAGR of around 27.7% between FY2022-2027. This is attributed to the increasing demand for precision manufacturing and the increasing Capex investments in Medical and aerospace sector in India. It is expected increase in manufacturing/ usage of 7+ axis is expected to improve the market share of large and organized players in the domestic market.

Jyoti CNC intends to be able to capitalize on its expertise in producing CNC machining centres of up to 5 Axis to take advantage of the estimated 12.10% and 17.40% growth in 4-6 Axis machining centres between Fiscal 2022 and Fiscal 2027, globally and in India, respectively.

CNC Machine Functions

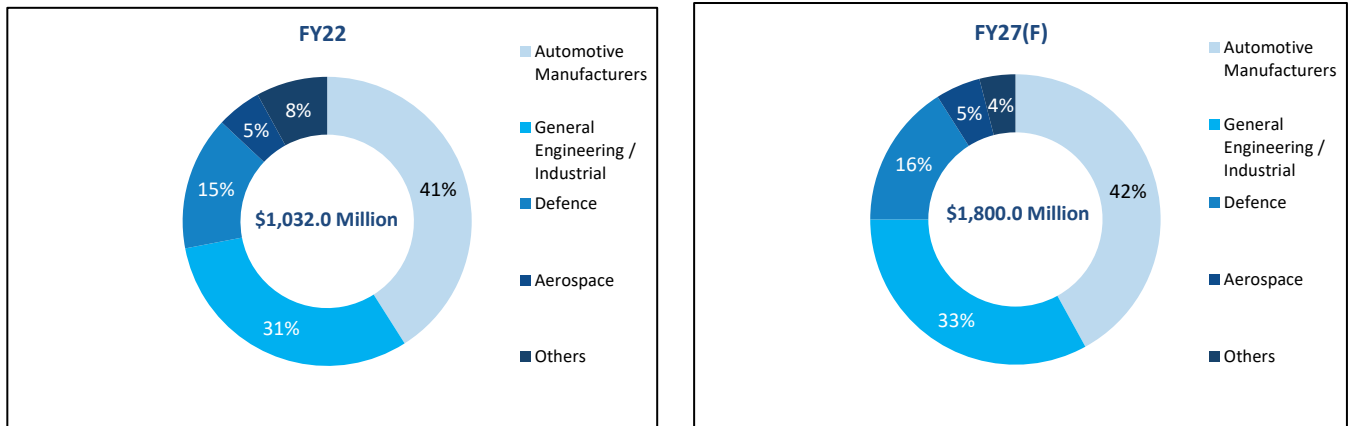
In India, metal cutting accounts for a sizable portion of the CNC machine market. More, metal cutting machine tool demand has increased in recent years due to end customers such as the auto sector and auto component industry. Some of the leading OEMs in the metal cutting CNC machine segment include Ace, BFW, Batliboi, HMT, Jyoti CNC, Lakshmi Machine Works, and Lokesh Machines, and TAL manufacturing solutions.

On the other hand, the metal forming industry serves as the core manufacturing machinery provider for consumer durables, electronics, and automobile industries. Aerospace, power, construction, railways, heavy transportation, office furniture, instrumentation industry, steel industry, forging, and structural engineering are some of the other industries driving demand for metal forming machinery.

There are no big OEMs in the metal forming machine tools market. Many manufacturing companies, on the other hand, are developing innovative technologies to help the metal forming segment grow. Hydroforming is always being researched and developed by the industry in order to produce better dies and components, reduce cycle times, and increase process controls and repeatability.

End-User Industries

Figure 6.5: India's CNC Machines Consumption Market Value, by End User FY22 Vs. FY27F



Note: E refers to estimate

Source: Primary Research, Frost & Sullivan Analysis

Increased demand for highly productive, automated CNC machines has come from the growth of the Indian manufacturing industry. The demand for sophisticated components is increasing in industries such as automotive, agriculture, defense, general engineering, aerospace, and others.

In 2022, the automotive industry is expected to be the leading consumer in the Indian CNC Machines market. In this industry, each element of the production process needs high performance. As a result, several machining processes are used by automotive firms to produce various components such as body sheets, windcreens, door panels, and various interior and exterior components. Furthermore, automotive component manufacturers currently manufacture with precision. Many facilities are equipped with powerful five-axis CNC simultaneous machines and innovative CAD/CAM software.

The industrial segment accounted for 31% market share in FY2022. The industrial segment is inclusive of general manufacturing industries that include packaging, electronics, medical, Construction and agricultural equipment manufacturing and other general industries. The rapid growth in the industrial sector, notably the metalworking and semiconductor manufacturing industries, is projected to drive growth in India.

6.8. Impact of EV on Machining Centers Market

As per the Union Ministry of Road Transport and Highways' data, the total registered EV volumes of all the segments when combined stood at 3.13 lakh units in 2021. It further states that registered EV sales crossed the one lakh mark in just two months in 2022. Adding to it, NITI Aayog's study states that the country is targeting for a 30% market share in the EV market by 2030. All these statistics are indicative of the fact that India is gradually inching towards the EV revolution. According to a recent estimate, India's electric vehicle (EV) market, which includes EV two-wheelers and three-wheelers, is predicted to develop at a CAGR of 90% to reach \$150 billion by 2030. The Indian electric car sector is expected to grow at a 90% CAGR. Between 2020 and 2025, the Indian electric car market will develop at a CAGR of 44.5%. Government legislation, falling battery prices, and increased consumer awareness will propel the market.

Electrification is going to have negative impact on the machine tool industry as Electric vehicles have about 60% less metal removal volume compared to the combustion engine. The value creation potential for machine tool manufacturers is decreasing. Due to this there is going to be higher reuse rate for these machines in the automotive sector, but this is compensated by the increasing precision requirements and CNC requirement in the electronics division of EVs. Automotive Segment to Grow Notably Owing to Increasing Demand for Commercial Vehicles

In terms of application, the market is fragmented into transport machinery, automotive, precision engineering, general machinery, and others (energy, electrical, etc.). Amongst these, the automotive segment is set to exhibit immense growth backed by a rise in the demand for commercial vehicles in the emerging countries, such as India. The segment had generated 41.8% Machining Centers Market share in 2018. According to numerous sources, in 2017, the automotive industry showcased a year-on-year growth of more than 9.5% in India. Additionally, the governments of many countries are taking initiatives to promote the usage of electric vehicles. The Government of India, for instance, has shortlisted 11 cities to deploy electric vehicles for public transportation under the 'Electric Vehicles in India' and 'Faster Adoption and Manufacturing of (Hybrid)' schemes.

Precision engineering, on the other hand, is anticipated to be one of the fastest-growing segments in the coming years. This growth is attributable to the rising demand for highly accurate and top-quality critical components from the medical and aerospace sectors. Besides, there is an increasing demand for those machines that are capable of manufacturing products with high critical tolerance.

The transport machinery segment is expected to grow notably owing to the rising rate of trade worldwide.

6.9. Make in India initiative in the defence sector – Impact on Machining Centers Market

In a major push towards Aatma Nirbhar Bharat in the defence sector, the central government come out with the new defence production and export promotion policy which will lay down the way ahead for strengthening defence production within the country and help in their export to friendly foreign countries. The Union Defence Ministry has decided to earmark around 64 % of its modernisation funds under the capital acquisition budget for 2021-22 — a sum of over Rs 70,000 crore — for purchases from the domestic sector. With this initiative key precise defence equipment's are expected to manufacture in India which will boost the machining Centers market growth in India. In addition to this the country's defence exports have grown by 325% in the last five years and exuded confidence that India will not only achieve its export target of ₹ 35,000 crore by 2024-25 but will also become a net exporter of defence equipment. The focus on increasing defence exports is expected to invest in high end CNC machineries and this will propel the machining Centers market growth.

6.10. Electronics market in India

Electronics is one of the fastest-growing industries in the country. The total electronics market (domestic electronics production and imports of finished goods) in India was valued at INR 9,263 billion (USD 124 billion) in FY22, expected to grow at a CAGR of 18.4% to reach INR 21,540 billion (USD 289 billion) in FY27. The landscape of the industry is changing significantly, and revised cost structures have shifted the focus of multinational companies in India.

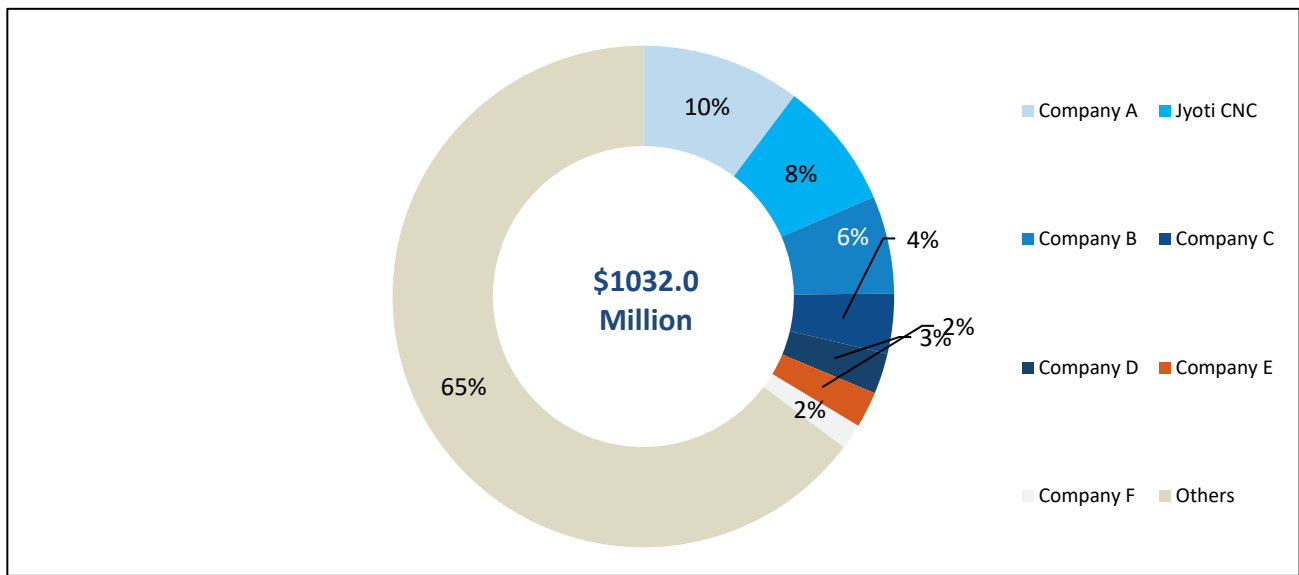
The Indian mobile phone market consists of both feature phones and smartphones. India is one of the fastest growing smartphone markets in the world with a CAGR of 7.3% between FY17 and FY22 in volume terms (113 million smart phones in FY'17 to 160 million smart phones in FY'22). The smartphone market was growing at a healthy rate till FY'20 but stagnated in the last two financial years, first due to Covid and then because of supply side issues such as shortage of chipsets. Experts believe that once supply side issues are sorted by the end of Q1FY'23, Indian smartphone market will get its mojo back and grow at a CAGR of 13-15% till FY'26. The introduction of 5G will aid in this growth. However, inflationary pressure on consumer's purse will remain a concern for the later part of this year. Feature phone market, on the other hand, will remain flat or grow at less than 1% CAGR over next 3 – 4 years. Increasing utility of smart phones due to digital payment regime and IOT related applications, availability of new features at affordable prices and increasing disposable income of the Indian consumers will be the key driving factors for smart phone adoption in the coming years.

6.11. Key players in India and their market share

In India, the CNC machine market is highly fragmented, with a wide range of small, medium, and big providers, as well as foreign and regional competitors. Increased investments in R&D and deployment of high-tech solutions in machine tools have resulted from the intense competition among vendors.

Jyoti CNC is the second-largest CNC manufacturer in India and one of the world's top producers of metal cutting CNC machines, accounting for approximately 8% of the domestic market for CNC machines in Fiscal 2022. The leading players have a manufacturing presence in India.

Figure 6.6: India's CNC Machines Consumption Market Share, by Key Player FY 2022 (%)



Note: E refers to estimate

Source: Company Website, Annual Report, Filings, Primary Research, Frost & Sullivan Analysis

6.12. Product Portfolio Comparison and Benchmarking

Jyoti CNC is a supplier of one of the widest portfolios of CNC machines in India. Jyoti has a wide product portfolio consisting of series of CNC Turning Centers, CNC Turn Mill Centers, CNC Vertical Machining Centers, CNC Horizontal Machining Centers, CNC Vertical Line Machines and High-tech CNC 3 axis and 5 axis machining centers. Jyoti have a strong presence across the CNC metal cutting product range, from entry level machines (the 2 and 3 axes machines) to the high-end machine categories (simultaneous 4 and 5 axes machines). They offer their customers a choice of 24 products in over 81 variants for both turning and milling applications making us a one-stop-shop for all metal cutting requirements.

Jyoti CNC is one of the leading CNC machine manufacturing companies globally as well as in India with presence across the CNC metal cutting machinery value chain. When compared to other competitors, Jyoti's machines caters to all key segments - Automobile, Aerospace, Allied Machinery, Agriculture, Die & Mould, Jewellery, Medical Equipment, Plastic Machineries, Power and Textile Machinery. Jyoti is having technology centers at Rajkot, and has its sales and service branches in all the major cities of India. Jyoti is having technology centers at Rajkot, and has its sales and service branches in all the major cities of India.

A few factors that can be attributed to Jyoti CNC's success is its ability to spot opportunities ahead of competition, investments in R&D and new product development, backward integration, track-record of customer service and the value for money delivered by its machines. For e.g., Jyoti anticipated the potential of 5-axes machining technology which led to the Huron acquisition, launched MTX 300, a multi-tasker machine. Jyoti CNC is a prominent manufacturer of 5-Axis CNC machines in India. It offers one of the most diverse portfolios of CNC machines in India.

Jyoti leads the industry 4.0 in CNC Automation and manufacturing with 7th SENSE. Jyoti CNC offers solutions suited for transition towards Industry 4.0 including '7th Sense' solutions. 7TH SENSE is a highly automated solution capable of processing the most sophisticated operations in the industry. Jyoti introduces 7th SENSE an i4.0 solution capable of performing mundane and repeat tasks independently allowing humans to focus on the outcomes of these operations. 7th SENSE gives a quick overview of current tasks, completion stages, and other insights allowing humans to spend less time on measuring efficiency and productivity of the machine.

7th Sense is the next generation's industry 4.0 tool that redefines the conventional PPC model to plan, produce, Complete.

Features like a virtual machine screen that displays an updated status of the process, intelligent navigation to reduce errors, and various smart reports that gives smart analysis of the processes and outcomes leaving little for interpretation by humans. SEVEN also has a dashboard that gives a quick overview of current tasks, completion stages, and other insights allowing humans to spend less time on measuring efficiency and productivity of the machine .

Various reports & analysis with customized dashboard can be achieved for

- Live Machine Health Monitoring
- Machine Health Alarms Logs
- Machine Health Analysis
- Tool Management
- Intelligent Machine Management
- Productivity Monitoring
- Daily Production Virtualization & Visualization
- Live Production Monitoring

- Live Machine Monitoring
- Virtual Machine Screen
- Current Event Monitoring
- Live Breakdown Alarms
- Live OEE
- Reports

7th Sense is based on majorly by 3 different modules

Productivity with live monitoring, Scheduling & Reports

- Master Modules & Features
- Machine Management
- Part Master Management
- Shift Management
- Production Scheduling Tool
- Daily Production Virtualization & Visualization
- Daily Task Manager
- Planned Downtime Management
- Reports
- Live Production Monitoring
- Live Machine Monitoring
- Virtual Screen
- Alarm Logs
- User Management(operator, Supervisor etc.)

Health Monitoring and alerts with embedded sensors:

Spindle

- Spindle Bearing Temperature
- Spindle Head Stock Temperature
- Spindle Vibration
- Spindle Load
- Spindle Power Utilization
- Spindle Run Hours

Hydraulics

- Hydraulic Pressure Status

- Hydraulic Oil Level Status
- Hydraulic Oil Temperature

Coolant

- Coolant Flow Pressure
- Conveyor Coolant Level

Pneumatics

- Pneumatic Pressure

Lubrication

- Axis Lubrication Oil Level
- Axis Lubrication Pressure
- Gear Box Lubrication Temperature
- Gear Box Lubrication Oil Level
- Gear Box Lubrication Filter Obstruct

Electrical

- Electrical Cabinet Temperature

Tool Management

- Tool Life & Load Monitoring
- Tool Management
- User Management with customized table for Tool Life & Load Monitoring.
- Sister tool library management and linkage with tool life management.
- Tool Management with individual machine for users.
- Better accessibility of tools on floor by tool manager/tool store user.

Table 6.1: Jyoti: CNC Turning /Turn Mill Centers Functional Capabilities by Applications

Product	Model	Aero-space	Agri-culture	Auto-mobile	Diamond & Jewellery	Die-Mould	General Engineering	Infra-structure	Medical	Oil & Gas	Power	Pumps & Valves	Railways	Tele-comm
CNC Turning With Linear Tooling	DX 60; DX 100		•	•			•							
CNC Turning/ Turn-mill Centers	DX 200 3/4/5/7/12, NVU Series, DX 250/350		•	•			•		•			•		
CNC Large Turning Centers	DX 500 1000/1250/2000, DX 750 1250/3000							•		•			•	

High Precision Turning/ Turn-mill Centers	AX 200 M/MY/MSY AX 300 M/MY/MSY				•		•					•			
CNC Turning Centers with Automation	DXG 100 DXG 100i			•											
Twin Spindle Twin Turret with Gantry	TS 120			•											
Heavy Duty Vertical Turning Lathe	VTL 400/ 500/750		•				•	•		•			•		
Inverted Turning Lathe	AT/ATM 160			•										•	
Vertical Shaft Turning	VST 160			•								•			
Oval Turning Lathe	I-SECT			•											

Source: Frost & Sullivan Analysis

Jyoti has three different plants located at GIDC, Metoda, RAJKOT – Gujarat, equipped with world class infrastructure like state of art machine shops with latest and technologically advanced plant and machineries, Assembly Shops, Foundry, Sheet Metal, Paint shop and other allied infrastructure. Jyoti – Huron has a strong sales network internationally at ASEAN countries, Argentina, Austria, Australia, Azerbaijan, Bangladesh, Belarus, Brazil, China, Czech Republic, France, Germany, Great Britain, Hungary, Italy, Middle East, Netherland, Portugal, Russia, Slovakia, South Africa, Sri Lanka, Spain, Switzerland, Tunisia, Turkey and USA.

Table 6.2: Jyoti: CNC Vertical Machining Centers Functional Capabilities by Applications

Product	Model	Aero-space	Agri-culture	Auto-mobile	Diamond & Jewellery	Die-Mould	General Engineering	Infra-structure	Medical	Oil & Gas	Power	Pumps & Valves	Railways	Tele-comm
High Speed Drill Tap Centers	Tachyon 4/5/7			•	•				•					•
C-Frame Mill Tap Centers	Mill Tap 10/20/30/40			•					•					
C-Frame Vertical Machining Centers	PX 10/20/30/40		•						•					•
C-Frame High Speed VMC	RX 10/20/30 RAX		•	•			•							•

C-Frame Vertical Machining Centers	RDX 10/20/30						•								
High Performance Vertical Machining Centers	VMC 430/650/850/1050/1260/1370 NVU Series		•		•		•	•			•	•	•		
T-Base Large Vertical Machining Centers	VMC 1570/1580/1870/1880						•		•						
Bridge Type VMC	K Mill NVU Series	•					•								
Vertical Shaft Turning	KX/K2X Series			•	•			•	•						
Moving Column VMC	EX-F	•		•			•							•	
Double Column VMC	NX 2215/3215/3222/4222						•	•	•					•	

Source: Frost & Sullivan Analysis

Table 6.3: Jyoti: CNC Horizontal Machining Centers Functional Capabilities by Applications

Product	Model	Aero-space	Agri-culture	Auto-mobile	Diamond & Jewellery	Die-Mould	General Engineering	Infra-structure	Medical	Oil & Gas	Power	Pumps & Valves	Railways	Tele-comm
High Dynamic HMC	HX 400/500/510/600/610		•	•						•		•		
High Precision HMC	HSX 540/650/ 860/1080/1210						•				•		•	

Source: Frost & Sullivan Analysis

Table 6.4: Jyoti: CNC 5 Axis Machining Centers Functional Capabilities by Applications

Product	Model	Aero-space	Defense	Auto-mobile	Diamond & Jewellery	Die-Mould	General Engineering	Infra-structure	Medical	Oil & Gas	Power	Pumps & Valves	Railways	Tele-comm
5 Axis Machining Centers	MUTech 6						•				•			
5 Axis Machining Centers	U Mill 5/6					•					•			
5 Axis Bridge Type Machining Centers	KX FIVE NVU SERIES K3X8FIVE	•				•			•		•			•
5 Axis High Performance	MX 4	•	•							•	•			

Machining Centers														
5 Axis Moving Column Machining Centers	EX Series	•				•		•			•		•	
5 Axis Double Column Machining Centers	KX Large Series	•				•								
5 Axis Gantry Type Machining Centers	KXG Series	•											•	

Source: Frost & Sullivan Analysis

Jyoti has acquired a 160 years old French Machine Tool giant in 2007 – Huron Graffenstaden SAS, Huron is having two manufacturing plant at Strasbourg and a strong sales and service network all over Europe. The acquired company is a pioneer across world for its 5 axis machining centers, having a renowned clientele like Volkswagen, Ferrari, Roles Royce’s, Siemens, Boeing, Airbus, Fiat, BMW, Mercedes, GE etc.

Table 6.5: Jyoti: CNC Multi Tasking Machine Functional Capabilities by Applications

Product	Model	Aero-space	Agri-culture	Auto-mobile	Diamond & Jewellery	Die-Mould	General Engineering	Infra-structure	Medical	Oil & Gas	Power	Pumps & Valves	Railways	Tele-comm
Multi Tasking Machines	MTX 300	•												
Mill Turn Centers	MX Series	•					•	•		•	•			
Multi Tasking Machines	TMX 200									•				

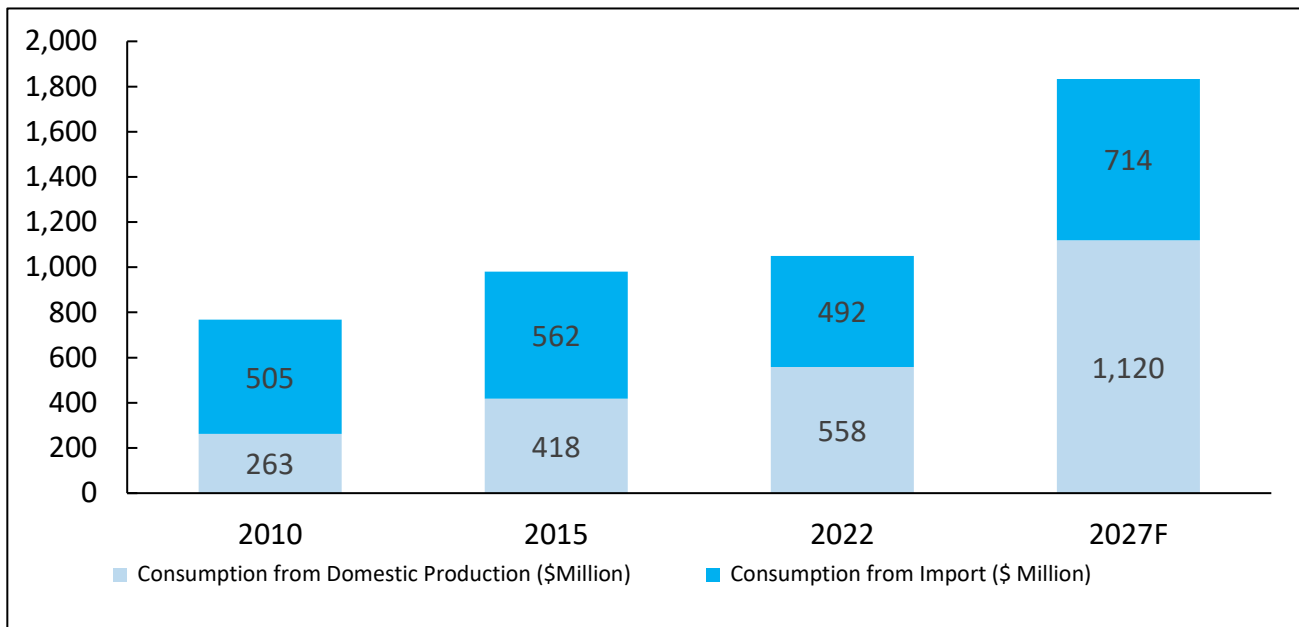
Source: Frost & Sullivan Analysis

Jyoti CNC focuses on technology and ability to deliver innovative solutions and over the years the R&D team at Huron have developed expertise in ultra-precision, multitasking, high speed 5 axes Vertical Machining Centers catering to niche applications in the Aeronautical and Dies and Moulds sector.

Jyoti CNC has emerged as a one-stop solution provider for the metal cutting requirements of manufacturing operations across industries. Jyoti CNC believe in constant innovation through continuous interaction with our customers and have a track record in providing a quick turnaround time for new product development for our customers. They are awarded “Best Metal Cutting Brand in India” for the last 4 years (2018,2019,2020,2021).

6.13. Opportunity for import substitution

Figure 6.7: CNC Machines Mismatch Between Imports and Domestic Production - 2010, 2015, 2022, 2027F



Note: E refers to estimate

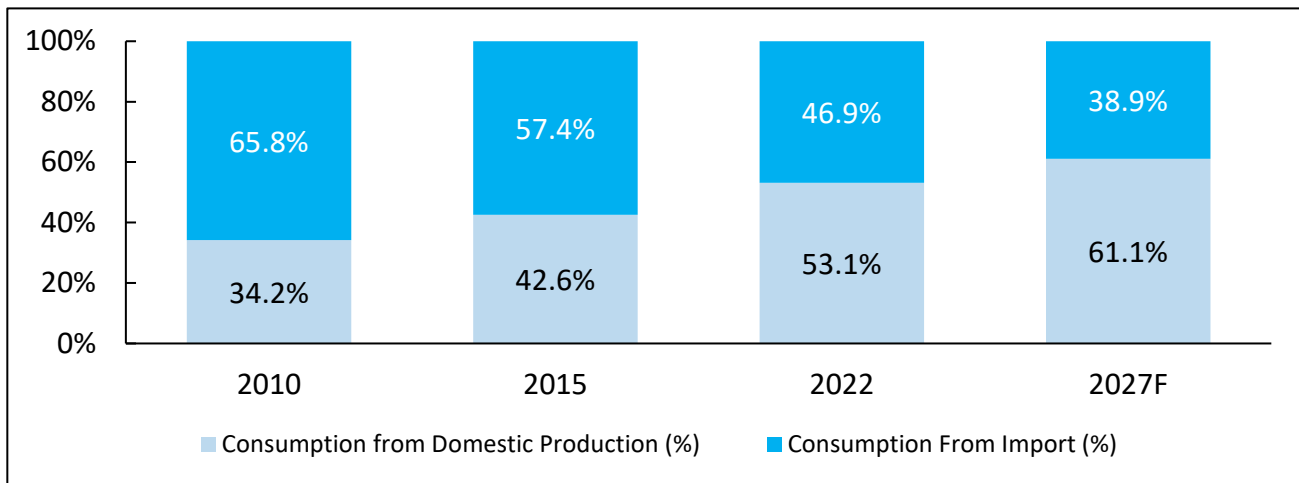
Source: Company Website, Annual Report, Filings, Primary Research, Frost & Sullivan Analysis

With the cost competitiveness, favorable investment circumstances, better engineering, and design capabilities, and effective communication skills, India is considered a favored location for global manufacturing businesses for building up production facilities and outsource. However, this industry has significantly relied on the imports of CNC machines and tools.

Since 2010, India's CNC machine consumption from import has reduced. In the Indian CNC Machine manufacturing space, the scenario has changed drastically in the last few years. With the presence of many global brands in India, the expectation level from customers has increased in terms of adopting high-end solutions having speed and accuracy. To cater such demand, Indian players are focusing on manufacturing 5+axis CNC machines equipped with industry 4.0 features in the domestic market; In addition to this government campaigns such as 'Make in India', 'Atma-nirbhar Bharat' and PLI schemes on various industries are generating good business for domestic manufacturers. This trend is expected to continue and the Domestic Production will increase in a big way in the next 3-5 years.

6.14. The trend of Imports vs domestic share

Figure 6.8: CNC Machines Consumption Share Imports Vs Domestic, 2010-2027F (%)



Note: E refers to estimate

Source: Indian Machine Tool Manufacturers' Association, Primary Research, Frost & Sullivan Analysis

In 2022, CNC machine imports in India have declined compared to 2010 and it is further likely to decline owing to the improvement in the domestic product needs as per the demand from the end user industry. Further, domestic manufacturing is receiving huge support from the Indian Machine Tool Manufacturer's Association (IMTMA) and the Government of India. The PLI (performance-linked incentive) and infrastructure investments, as well as the Aatmanirbhar Bharat and Make in India campaigns' incentives, have generated a strong business environment. Furthermore, the Indian machine tool industry and the IMTMA are collaborating closely on import localization.