

Status Quo and Development of Taiwan's Machine Tool Industry from the Perspective of Machine Tool Export Models and Major Exporting Countries

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Abstract

The machine tool industry is comprised of high-tech production and processing equipment that combines various software and hardware functions such as machinery, motor, optoelectronics, new materials and automatic control. The demands for machine tools has been continuously developed and expanded, from the early mold and home appliance industries to today's automotive, aerospace and 3C industries. Furthermore, it has gradually extended to emerging industries such as biomedical, green energy and space, indicating that the machine tool industry plays an important role in overall national industries. Taiwan's Machine Tool Industry is world-renowned and enjoys a complete vertical division of labor. Based on the production and sales statistics in 2016 and 2017 issued by Taiwan Machine Tool & Accessory Builders' Association (2018), this study conducts comparison, analysis and exploration on the machine tool export model and major exporting countries, output conclusions and offer relevant recommendations on policy formulation and management that are proposed for the government and industry respectively.

Keywords: machine tool industry, export model, exporting countries

1. Introduction

Machine is one of the national pillar industries and it is quintessential towards any modern industries, in which metal processing machine tools, also known as working machines or machine tools, which can be regarded as representatives of the machinery industry. The International Standards Organization (ISO) defines a machine tool as the machine that uses a non-human power to push a physical, chemical, or other type of work piece. The machine tool is the processing machine that is capable of manufacturing a variety of machines, ranging from a screw to a wing and a propeller used in an airplane; a machine tool is required to complete it just because the machine tool is the necessary machine for basic processing and precision machining. The machine tool industry has key impact on the overall economic system (Cheng and Chyou, 2012). In addition, the machine tool industry is comprised of high-tech production and processing equipment that combines various software and hardware functions such as machinery, motor, optoelectronics, new materials and automatic control. The demands for machine tools has been continuously developed and expanded, from the early mold and home appliance industries to today's automotive, aerospace and 3C industries. Furthermore, it has gradually extended to emerging industries such as biomedical, green energy and space, indicating that the machine tool industry plays an important role in overall national industries. According to the data issued by Taiwan Machine Tool & Accessory Builders' Association (2018), Taiwan's machine tool boasts the production value of more than US\$3 billion in 2017, making it the fifth largest exporter in the world and an important export trade product. It fully reflects the level and quality of Taiwan's machine tool products and further illustrates that the machine tool industry has played a key role in supporting the development of Taiwan's industry by supplying the production equipment needed for its own manufacturing industry (Chiu, 2016; Chen and Tien, 2017).

The Machine Tool Industry supports the Manufacturing Industry with a low profile. The products manufactured by the machine tool manufacturers generate funds for other manufacturing industries. Different from the general consumer products, machine tools have long life cycles, which requires for sustainable high performance, high

quality and high reliability. Therefore, the machine tool manufacturer must ensure that its products are reliable so that it can always maintain the maximum appropriate rate in the production line, maintain the best productivity and the highly reliable machine tools can guarantee the production capacity to generate profits for customers (Pan, 2012). In the past, manufacturing was the main force behind Taiwan's economic growth. Right now, Taiwan's manufacturing industry has matured with diverse industrial clusters, complete industrial system and industrial chain, and strong industrial R&D capabilities. In particular, the machine tool industry has an annual output value of about US\$5 billion, of which nearly 80% is exported to more than 100 countries around the world, making it one of the most representative industries of "Made in Taiwan" (Chiu, 2016). In addition to the optimized design of the machine tool and the hardware assembly of more precise components, the Machine Tool Industry can also improve the accuracy and reliability by software such as computer-aided simulation design and processing, error compensation, and monitoring machining parameters. Furthermore, it can achieve automatic production and production process visualization and convenient management objectives through the Internet of Things (IoT), Information and Communication Technology (ICT) and Robotic Arm (Chuang, 2018).

Demands for the export market are growing, such as China's increasing demand for precision processing equipment, US manufacturing flowing back, the strengthened investment in construction for Japan's 2020 Tokyo Olympics and the increased investment by the Italian government in "Industry 4.0". Driven by the international market, coupled with the Taiwan government's push for smart equipment as a development focus, Taiwan's machine tool industry enjoys optimistic and prosperous growth. Therefore, in order to understand the changes in the export of Taiwan's machine tools in recent years, this study makes use of the production and sales statistics issued by the Taiwan Machine Tool & Accessory Builders' Association (2018) and conducts comparison, analysis and exploration on the machine tool export model and major exporting countries. Finally, this study outputs conclusion and offers relevant recommendations on policy formulation and management are proposed for the government and industry respectively.

2. Literature Review

Since the 1950s, Taiwan's Machine Tool Industry has had small-scale production of machine tools. However, being limited in technologies, the products are mainly lathes, punching machines, drilling machines and etc. and lack of high quality and precision. After the 1970s, domestic manufacturers have been able to produce traditional models with high precision, including: high-speed precision lathes, vertical horizontal milling machines, surface grinders and radial drilling machines. Since 1971, Taiwan began to cooperate with Japan to develop a lathe and opened the era of numerical control (NC) machine tools. After 1976, Taiwan's machine tools gradually opened up to the US market and gradually became an export-oriented industry. At the beginning of 1990, the output value of Taiwan's machine tool industry has increased to 25 billion yuan, accounting for 6.8% of the Asia-Pacific region and 2.1% of the global. In 1998, the output value exceeded 60 billion yuan. With the machinery industry as the pillar of national industry, it is an important industry in the manufacturing field of Taiwan. Among them, the machine tool is called the "mother of machinery", so the machine tool is also known as the "mother machine", which is an essential machine for various basic processing and precision machining. Taiwan's machinery industry is well-known for its close integration and high-level division of labor. Taiwan's machine tool industry is mainly exported to Mainland China, the United States, Europe and Southeast Asia. The proportion of export sales is approximately 80%.

The most famous industrial cluster in Taiwan's machine tool industry comes to its network-based production system (the so-called outsourcing cooperation system), which adopts the Taichung area precision machinery technology innovation park as the main production settlement. The upstream and the downstream value chain have been formed, generating a large amount of economies of scale and local employment opportunities. Taiwan's Machine Tool Industry is mainly concentrated in the central part of Taiwan. Because the SME-based machine tool and its co-operators have formed a division of labor to produce a network, Taiwan's machine tool manufacturers and the overall industry are more likely to be resilient and more impactful. The social relationship between the manufacturers embedded in this industry cluster allows the cooperation between manufacturers to adapt to the changes in the market, quickly and flexibly adapt to various forms of cooperation, and use all available resources in the system to engage in research and development, design, trial production, production, assembly, sales and other aspects, in order to enhance the added value and competitiveness of the product in this process (Liu, 1999; Chang, 2010; Chen and Tien, 2017; Chuang, 2017).

The division of labor system in Taiwan's Machine Tool Industry has always been a source of competitiveness recognized by foreign countries. Overall speaking, Taiwan's machine tool industry supply chain is solid and complete from R&D and design, component manufacturing to machine assembly, testing, sales, except for the end sales service and upstream key components. The manufacturers do not need to invest a large amount of

equipment in the plant and the operational risk can be greatly reduced. Faced with unpredictable changes in the economy, they can adapt to production strategies by adjusting internal and external production ratios or selecting different cooperative factories. Some machine tool manufacturers within the cluster are capable to conduct strategic alliances to expand the market through complementary production or co-marketing. In industrial settlements, information and intelligence are rapidly exchanged, technology and creativity are highly turbulent, and talents, technology, and support systems are clustered to create a more competitive professional battlefield. Furthermore, because the institutional environment of industrial clusters encourages the establishment of new ventures, it injects endless creativity and motivation into the industry. Vendors within the cluster are also able to try different production organization patterns in response to changes in competitive conditions with the support of clusters. Consequently, these factors have contributed to the vitality of Taiwan's Machine Tool Industry (Chang, 2010; Chen, 2014; Chen and Lin, 2014; Chen and Tien, 2017).

Global production models have always dominated the development trend of Taiwan's manufacturing industry. Product strategies need to be planned globally, targeting to reduce costs and improve the efficiency of vertical integration. In addition, several Taiwan machine tool leaders organized M-Team in 2006. Through the team-based teamwork between the machine tool factory and the cooperative factories, the Toyota Production System (TPS) is proactively promoted to improve the production efficiency of the company and the collaborative network system. The promotion of TPS, in addition to implementing technology upgrades and accelerating industrial development, has also enabled Taiwan's machine tool factories, cooperative factories and their collaborative production networks as well to significantly improve their abilities to respond to sudden changes in external supply and demand. Furthermore, another more institutionalized benefit-sharing mechanism among the constituencies emerged in the cluster (Chang, 2010; Chiu, 2016; Chen and Tien, 2017).

However, in terms of overseas markets, Mainland China is the main market for the exports of Taiwan's machine tool, accounting for about 35% (Taiwan Machine Tool & Accessory Builders' Association; 2018). With the rapid development of Mainland China's economy and the establishment of Taiwan's factories in China, the demand for machine tools in Taiwan has increased greatly. In addition, China has proposed strategies such as "One Belt, One Road", "Made in China" and "Internet Plus" in the recent years. Consequently, machine tool manufacturers have actively developed the Chinese market, starting with setting up marketing bases and further establishing production bases in China (Chen, 2015). In 2015, China passed the "Made in China 2025" promotion program and it is regarded as the Chinese version of the "Industry 4.0" plan, revealing the goal of China's transition from a manufacturing power to a strong country in the future and also illustrating the growth path of China's manufacturing industry. "Made in China 2025" also became China's first long-term plan that covers two five-year plans, including the 13th Five-Year Plan (2016-2020) and the Fourteenth Five-Year Plan (2021-2025) (STPI, 2015). The internationalization layout of the key industries of "Made in China 2025" will be better integrated into the global industrial division of labor system. China will focus on the countries along the "Belt and Road" to deepen international cooperation in manufacturing, encourage and guide Chinese enterprises to invest in the industry, conduct extensive exchanges with various circles at home and abroad, expand bilateral, multilateral and regional cooperation and support the establishment of local Industrial System (STPI, 2015).

In the future, in order to pursue innovation and competitiveness, the market demands of Chinese industries shift to medium and high-end specialized machine tools. In addition, China has actively promoted domestic railway and road construction in recent years, which is bound to generate demands for upstream machinery and equipment. As China's machinery industries are in urgent needs to develop equipment with high added value and technology to meet the needs of industrial structure optimization, there are increasing demands for mid-range and mid-to-high-end model products and automated manufacturing units that are conducive for the exports of machinery tools in Taiwan. From the perspective of Chinese industrial policies in recent years, it is clear that China has promoted the industrial transformation and upgrading plan (2011-2015), the 12th Five-Year Industrial Technology Innovation Plan, the 12th Five-Year Development Plan of the High-end Equipment Manufacturing Industry, the 12th Five-Year Development Plan of the Machine Tool Industry, China Manufacturing 2025 and Internet+ plan, which all promotes the sustainable expansion and growth for the demand market of those machinery equipment. The rapid expansion of production capacity of these equipment- manufacturing industries has driven the rapid growth of machine tool consumption in Mainland China. At the same time, China's industrial structure has been optimized and machinery imported models will be mainly locked in high value-added, high-tech, emerging industries and equipment manufacturing (such as boring and milling machining centers, flexible machining units (FMC), turning centers, CNC grinding machines, etc.). The export of machine tool will definitely generate more opportunities. In addition, China has actively invested in the semiconductor and panel industries in recent years and will build a large number of fabs and panel plants to

enhance the demand for semiconductors and panel equipment. At the same time, China promotes smart manufacturing and the development of high value-added technological equipment in response to the demands for industrial upgrading and structural optimization. As a result, there is an increasing demand for mid-range and mid- to high-end models and automated manufacturing units (Wei, 2016; Chuang, 2017; Chiu, 2018).

At present, advanced countries around the world have repositioned the development direction, strategy and global layout of the manufacturing industry in response to changes in trade trends. Currently, the machine tool manufacturers in various countries are trending towards intelligent production. On behalf of the future, the machine tool factory must have a considerable number of technical standards and play the role as a competent partner in the production plants where customers are located all over the world. In response to the trend of Industry 4.0 and smart factories, advanced countries are now revitalizing manufacturing as an important economic and industrial policy, boosting Information and Communication Technology (ICT) and advanced manufacturing technologies into existing manufacturing systems and promoting the applications of smart manufacturing applications to enhance national manufacturing competitiveness. Therefore, the global machine tool factory in the future will be coordinating with the customer's global layout; that is to say, the machine tool manufacturers need to be equipped with high technical abilities in the places where the customers' factories are. In consideration of customers' smart production systematic environment and cost efficiency, the machinery tool factories are capable to offer appropriate products or service to satisfy the goals of preset production efficiency, quality, product resilience and become the power behind to push the enhancement of order receiving capabilities and the manufacturing capabilities of small scale diversified products. Promoting the germination and development of smart production systems depends on continuous creation and improvement of production equipment. The core projects are comprised of the improvement of the concepts of machines, control technology, software, tools and processes. At the same time, customers' demands for production equipment are also a major driving force to promote the innovation for machinery tool.

Empowered by smart manufacturing, the main directions of the international machine tool are equipment monitoring, analysis of the motion, automatic scheduling optimization, process visualization, processing, manufacturing precision improvement and etc. In recent years, international exhibitions on machine tools and cutting applications have all focused on smart manufacturing. Coupled with the full integration with equipment vendors, system vendors, terminal applications, telecoms, and sensing systems, the goal is to build a complete smart manufacturing environment. Nowadays, establishing independent core technologies in facing global competition is the only way we can have excellence in differentiation and value creation. We look forward to the development of basic technology from the automation of machinery to smart manufacturing and expect to shape another peak for Taiwan's industries featured with rational learning, technical capabilities and versatility. Therefore, if Taiwan's machine tool manufacturers can make good use of technologies and equipment, such as communication technology, big data analysis logistics network, cloud computing and industrial robots, they will be able to exhibit smart precision machinery and production lines that can improve efficiency, reduce costs and strengthen competitive advantages. Furthermore, the application of smart technologies will take the environmental functions, such as water-saving, power-saving, and resource-conservation into consideration to enable the customers to meet the international manufacturing environmental protection norms and requirements, and generate the added value of the machine tools (Chiu, 2016; Hsiao and Li, 2017; Wang, 2017; Yeh, 2018).

3. Methodology

Based on the production and sales statistics issued by Taiwan Machine Tool & Accessory Builders' Association (2018), this study adopts the data of Taiwan machine tool export models and major export countries for 2016 and 2017 data and conducts analysis and exploration respectively. According to the classification of Taiwan Machine Tool & Accessory Builders' Association, the machine tool export models are divided into 10 products such as EDM, Laser machines cutting M/C and etc., which has been listed in Table 1. After calculating the average and standard deviation of the export sales of 10 products in 2016 and 2017, an independent sample T test (as shown in Table 1) was performed. The comparison data of the major exporting countries of Taiwan's machine tools in 2016 and 2017 are shown in Table 2.

Table 1. T-test for Taiwan Machine Tools Exports by Product 2016 and 2017 (Value in thousand of U.S.D.)

Products	2016	2016	2017	2017	t	p
	Average	Standard	Average	Standard		
	Value	Deviation	Value	Deviation		
EDM, Laser machines cutting M/C, etc.	12886.92	5335.19	14912.75	3266.44	-1.122	.274
Machining centers	89507.67	12679.82	107232.00	12724.30	-3.418	.002*
Lathes	42899.17	5139.84	55488.33	4196.68	-6.572	.000*
Drilling, Boring, Milling M/C	20530.17	3696.69	31761.08	4069.80	-7.076	.000*
Grinding machines	20431.33	7547.95	20977.50	2090.30	-.242	.811
Shaping, Sawing, Gearing M/C	12937.00	1644.33	15165.67	1738.36	-3.226	.004*
Metal cutting machine tools	199192.50	26372.47	245537.42	21896.60	-4.688	.000*
Presses & Shearing machines	33867.58	6198.13	38289.08	3412.16	-2.165	.042*
Other Metal Forming machine tools	8624.25	2562.05	9415.42	1501.83	-.923	.366
Metal forming machine tools	42491.83	7241.24	47704.17	4487.57	-2.119	.046*
Global Grand Total	2896967		3347325			

Source: Taiwan Machine Tool & Accessory Builders' Association (2018); Note: *p< .05.

Taiwan is a major exporter of machine tools. Table 1 shows that the export value of machine tools in 2017 was US\$ 3,347,325 K, approximately 15.5% higher compared with that of 2016. Regarding the ranking of export products, Taiwan remains the same level with that of 2016. The top 5 are: Metal cutting machine tools; Machining centers; Lathes; Metal forming machine tools and Presses & Shearing machines. In addition, compare the export value of Taiwan machine tools in 2016 and 2017, there are significant difference in the following 7 categories, including Machining centers; Lathes; Drilling, Boring, Milling M/C; Shaping, Sawing, Gearing M/C; Metal cutting machine tools; Presses & Shearing machines Metal forming machine tools. Furthermore, the export value enjoys significant increase compared with that of 2016. Regarding the remaining three products, including EDM, Laser machines cutting M/C, etc.; Grinding machines; Other Metal Forming machine tools, although there are no significant differences, there are evident growths of the export value compared with that of 2016. In other words, all 10 categories enjoyed growth in the export value in 2017 year over year, in which the top five categories are Drilling, Boring, Milling M/C (+54.7%); Lathes (+29.3%); Metal Cutting machine tools (+23.3%); Machining centers (+19.8%); Shaping, Sawing, Gearing M/C (17.2%).

Table 2. Taiwan's major exporters of machine tools in 2016 and 2017 (Value in thousand of U.S.D)

Ranking in 2017	Country	Sales in 2016	Sales in 2017	V (%)
1	China (including HK)	924595	1172213	26.8
2	US	346605	371044	7.1
3	Turkey	146078	142511	-2.4
4	Germany	109789	123629	12.6
5	Thailand	107179	121428	13.3
6	India	92802	110073	18.6
7	Vietnam	98941	108105	9.3
8	South Korea	71351	99639	39.6
9	Russia	74263	95224	28.2
10	Netherlands	93336	94983	1.8
	Other Countries	832028	908476	9.2
	Toatl	2896967	3347325	15.5

Source: Taiwan Machine Tool & Accessory Builders' Association (2018).

Table 2 illustrates that in terms of rankings, there's no big difference between 2016 and 2017. The top 5 countries in the last two years were China (including Hong Kong), US, Turkey, Germany, Thailand. The largest export market is still in Mainland China (including Hong Kong), with an export value of \$11,722,13 K, accounting for about 35% of the total export value and a 26.8% growth year over year. The second largest exporter goes to US, with an export value of \$371,044 K, accounting for 11% of the total exports and a 7.1% growth year over year. Turkey, the third largest exporter, has an export value of \$142,511 K, 2.4% decrease year over year and

accounting for 4.3% of the total export. The reason why Turkey witnessed the decline is because of the slowdown in global consumption growth. The demands for machine tools are in decline. The top five countries with significant growth in 2017 are: South Korea, Russia, China (including Hong Kong), India, Thailand, most of them comes from Asia.

Except for Turkey with slight decline in top 10 countries in 2017, the remaining nine countries enjoy growth year over year. However, the export countries of Taiwan's machine tools mainly concentrate in China and the United States (the combination of these two countries reach 46% in 2017). In other words, the fluctuation of the Chinese mainland and the US economy cast the most significant impact on the production and export of Taiwan's machine tool industry. The global manufacturing sectors are moving and emerging manufacturing countries are on the rise. Regarding the emerging market in Southeast Asia (such as Turkey, Thailand, India, Vietnam, etc.). Due to the rapid development of manufacturing industries in these emerging countries and their high growth and demographic dividends have prompted the moving of the global manufacturing supply chain and machinery market. The new market demand will be expected to provide new opportunities for high-quality and affordable goods in Taiwan's Machine Tool Industry. Therefore, Taiwan's Machine Tool Industry must accelerate the development of emerging markets, continue to accumulate the experience of applications, seize the opportunities to shape the first-tier manufacturers of Taiwan's machine tools to satisfy the potential demands for emerging markets and niche-type machine tools for the sake of new growth opportunities (Chiu, 2018).

4. Results and Discussion

The players in Taiwan's Machine Tool Industry are the small and medium-sized enterprises (SME); it is difficult to achieve economies of scale and penetrate into the international market by themselves. Therefore, the government should take the initiatives to plant and provide the funds and technology of the manufacturers, strengthen their response to the needs of the manufacturers and timely play the role of coaching or coordination in the process of facilitating the cooperation among the manufacturers. By implementing relevant measures to assist domestic manufacturers to expand foreign markets, relevant public departments or research institutions should actively assist manufacturers to improve the quality and technology of their products to ensure that Taiwan's machine tool products can be successfully sold to overseas markets. In addition, when customers in developing countries desire to purchase the equipment, they hope that machine tool manufacturers could offer financing lease due to the lack of sufficient funds. However, it is hard for those SMEs to meet this special demand. Therefore, Taiwan Government issued "Smart Machinery Industry Promotion Program" in 2016, hoping that the machine tool in central area would be transformed from precision machinery to smart machinery. With the help of robotics, big data analysis and smart networking, Taiwan's Machine Tool Industry could be developed and upgraded into smart manufacturing model and smart machinery industry ecosystem with Taiwan's distinctive features. Furthermore, in the recent years, Taiwan government has actively authorized the Foreign Trade Association to lead manufacturers to participate in the world's major tool opportunities exhibition to win the orders for those manufacturers. In the future, manufacturers shall combine manufacturing technology with intelligence, promote the industrial technology upgrade, strengthen industrial competitiveness and promote the sustainable development of Taiwan's manufacturing industry through the joint cooperation model of production, learning and research (Chen and Tien, 2017; Wang, 2017).

In order to improve the competitiveness of Taiwan's Machine Tool Industry, we shall continue to strengthen the performance, quality, stability and reliability of mechanical equipment products through technology research and development. We also need to explore how to establish the differentiated advantage that can win in the international market to be able to keep abreast of market trends and find new target markets. With the integration of robotics and automation related equipment and the help of the sensors, Internet of Thing (IoT), cloud and big data analysis technology, it forms the manufacturing system with synergy effects between automatic intelligence and human-machine collaboration, which is the important trend of global machine industry.

If the machine tool manufacturers establish a good relationship with their customers and understand their preference for the product and quality information via communication, it will be conducive to enhance the flexibility of the new product and the flexibility of the product portfolio. In the face of global competition, the needs of customers are becoming more and more critical. Short delivery, small batches and high customization are the trend of the Machine Tool Industry, which is also the only opportunity for the upgrade of Taiwan's machine tool products. Faced with the need for intelligent manufacturing and intelligent production, Taiwan's tooling industry's metal forming equipment has been able to gradually acquire system integration from top to bottom end of the supply chain, from hardware to software equipment. The application of VR devices let customers know how the smart fast change system offer a comprehensive solution. At present, Taiwan's leading machine tool manufacturers have established "Industry 4.0" production lines, which can be used in a variety of

industrial fields, such as aerospace, automotive, transportation, precision molds, computer 3C and etc.

The Machine Tool Industry is constantly advancing in the direction of automation, intelligence and increasing processing efficiency. Therefore, manufacturers should make use of intelligent technology to enhance the performance and efficiencies of machine tools and to improve the efficiency of the machine space use. The integration of manufacturing, handling and testing equipment in the formation of automated production lines and the usage of robotic arms strengthen machine communication to increase the percent of unmanned production, strengthen the R&D and production capabilities of Taiwan products and apply the usage of e-technology. E-commerce is used as a vehicle to enable machine tools to offer service solutions and enhance the service level via technologies. In order to maintain the stable development and growth of Taiwan's manufacturing industry, it is necessary to carry out and develop high value-added manufacturing to enable enterprises to be equipped with higher profitability, expand the scale of the industry and enable a sustainable industrial growth.

Machine tool manufacturers seek for the solutions to enhance their manufacturing flexibility from the perspective of previous strategies. They can also promote their "elastic" competitiveness through the implementation of quality management activities. While strengthening their manufacturing flexibilities, they should plan the supporting approaches to reduce its impact on internal quality performance besides the improvement of its external quality performance. Along with the implementation of Taiwan's information and communication technology (ICT), mobile phone and tablets can enhance the features and competitiveness of intelligent functions such as remote management and monitoring. This study conducted a survey and a post analysis for the commercial model and manufacturing needs for different machine tool markets in different countries and offer the service plans for the packed solutions that meet the market needs, transforming from manufacturing output into service output and creating the values of Taiwan's machine tools. Therefore, if Taiwan's Machine Tool Industry can integrate Taiwan's technological advantages and move toward "visualization" of cloud service applications, "connectable" system integration and "smart", it will be able to shape the differentiated advantages of Taiwan's machine tool (Lin, 2009; Chang, 2010; Chiu, 2016; Chuang, 2017; Chuang, 2018; Chiu, 2018; Yeh, 2018).

At present, featured with low-growth rate, low interest rate and low consumer price, the global economy also called as the new "moderate economic model", suffers from high debt level and unemployment rate. The recovery of the US manufacturing industry did not meet the original expectations. There are doubts about the manufacturing recession and the recovery of the manufacturing industry in China and the Eurozone. Other emerging markets in Asia such as Vietnam, Malaysia, Thailand and Indonesia are still affected by the exit of US QE, showing a recession. The machine tool industry, which is mainly exported, is deeply affected by fluctuations in the international scene. Therefore, Taiwan's machine tool manufacturers should further adopt a market decentralization strategy in the future. They should deepen the development of those large markets, including China, Europe and US. For example, the policies of "Made in China 2025" and "Made in the USA" encourage the stable expectation of future export. In the light of economically stable recovery, the investment activities of countries and enterprises are more active for the new era of manufacturing industry- Industry 4.0 (Smart Manufacturing).

In 2011, Germany initiated the strategic policy of Industry 4.0. The United States launched the Advanced Manufacturing Partner Program to shape a competitive advantage in the manufacturing field with new generations of smart manufacturing technology. In 2015, China put forward the strategy of "Made in China 2025" and Japan a white paper related to the manufacturing upgrade revolution, indicating that the major manufacturing industries are actively promoting smart manufacturing, and also driving the trend of enterprise equipment construction and capital investment. In response to the rise of China's national supply chain, the market competitiveness of Chinese machinery and equipment enterprises has gradually been enhanced. Overall, Taiwan's machine tool export share similar situations with Japan, making Japan one of the major competitors of Taiwan's machine tool exports (especially high-end products). Taiwan's machine tool industry should develop emerging technologies as early as possible to meet future industrial needs. In the past, Taiwan manufacturers have acquired excellent achievements in promoting automation and enjoy good production quality. The long-term goal in the future should advance toward the trend of Industry 4.0, which will be the biggest opportunity.

The growth of emerging markets and the promotion of new technologies has contributed to the growth of the global machinery industry. Many players have chosen to explore other emerging markets that are less familiar; actively exploring business opportunities or partners by participating in machine tool exhibitions held in various countries. In addition, the players of machine tool manufacturers should learn from the previous experience; make self-adjustment accordingly and carry out substantial improvement actions of individual and industrial

enterprises through cross-vendor interaction and re-walk new product strategies to cope with the impact from current and future possibilities and increase added value to cope with the changing market. (Chiu, 2016; Chen and Tien, 2017; Chuang, 2017; Chiu, 2018).

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