

*conventional machining center,  
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## **COMPARATIVE RESEARCH INTO MARKETABILITY REINFORCEMENT IN CONVENTIONAL MACHINING CENTER OF CHINA, INDIA, JAPAN, KOREA AND TAIWAN-MAKES**

This paper describes the results of a comparative research into the marketing and product strategies for the conventional MCs of China, India, Japan, Korea and Taiwan-makes. In this work, information from conventional MC manufacturers of these countries is collected on the spot and with the help of a questionnaire to identify the relevant strategies for differentiation. The parameters considered are the target customers, date of delivery, sale price, features of operability, design attributes, after sales service, motivation to purchase, target market segment. Based on these parameters, mind maps are drawn. The differences in the strategies among Japan, Korea and Taiwan manufacturers is that although most of the manufacturers in these countries have employed in-house design and assembly systems, and strongly rely on supply chain management, still the Korean manufacturers maintain the competitiveness through cheaper sales price and shorter delivery time, the Taiwanese manufacturers focus on current customers through cheap pricings but do not pay proper attention to business-oriented-enterprise management; while the Japanese manufacturers are capable of introducing directly opposite attributes in the product design. The Chinese and Indian manufacturers produce machines that are cost effective and focus on the inland market. The delivery time is long due to obsolete manufacturing facilities and sparse competition.

### **1. INTRODUCTION**

As literally shown, the conventional MC (Machining Center) and TC (Turning Center) can facilitate the versatile machining requirements in the commercial and defense supplies, resulting in the utmost leading kinds among the machine tool<sup>1</sup>. On the strength of the wide availability and with the rapid development of the due variants, MC and TC grow their importance to a large extent and also extend their realm amazingly. In addition, both MC and TC can take over the machining work, which has been carried out by the special-purpose machine tool to a various extent. For example, MC can machine the rail crossing and mechanism housing of the rifle, which were so far machined using the rail planer and machine tool for the ordnance production. In fact, markets of both MC and TC are worldwide and expand their circumstance almost daily. In contrast, the production

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technology for both the kinds becomes very popular now, inducing the difficulty in the product differentiation. In addition, the manufacturer must produce the conventional MC and TC by the large volume production with wider versatility. In principle, the machine tool has been produced so far using the small batch and small volume manufacturing.

Having in mind such a wide availability of MC and TC, we must furthermore be aware of a very near future perspective of these kinds as follows.

Within the variants of MC, that of quinoxial-controlled type can deal with the turning operation by facilitating the rotating table. This variant is called as the “Mill-Turn”.

In the case of TC, a potential successor is of twin-spindle type together with having the function of milling, which can be regarded as a variant of the “Mill-Turn”.

There have been no obvious definitions for the conventional MC and TC. Thus, in this paper, we employ the following definition. The conventional MC is of single spindle and also of less than four-axis controlled type.

The conventional TC is of single spindle type and not having the second headstock.

In short, the conventional MC and TC including their variants become the representatives within the family of the machine tool, and duly one of the indicators when carrying out the comparative research into the international competitiveness for the productivity of the nation. More specifically, the production technology can create the wealth of a nation, the machine tool is duly a kernel of the production technology and the conventional MC is the utmost representative of the machine tool.

As can be readily seen, not only the industrial, but also industrializing nations are very keen to reinforce the market competitiveness and to enhance the utilization technology of the conventional MC, and thus a facing necessity is to grasp correctly what is under way within each nation in both the production and the utilization of the conventional MC.

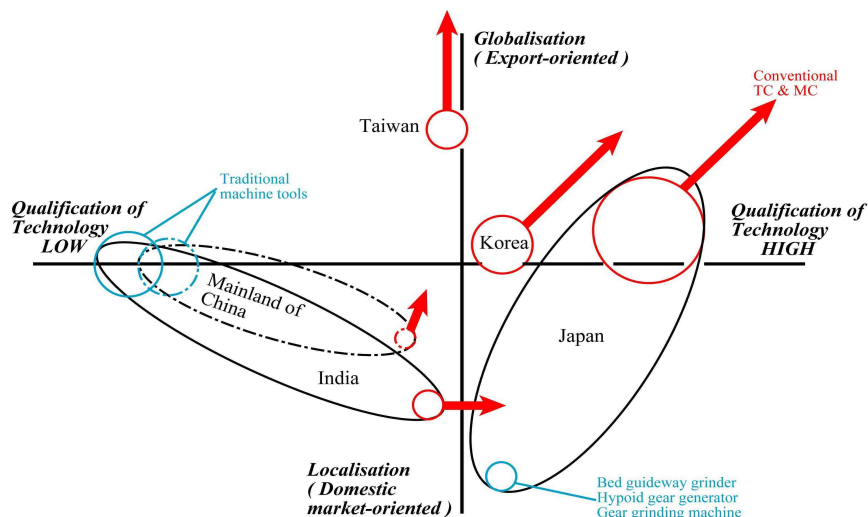


Fig. 1. First-hand view of machine tool industries in Asia (around 2004)

In consideration of such states mentioned above, this paper describes the results of a comparative research into the marketing and product strategies for the conventional

MCs of China, India, Japan, Korea and Taiwan-makes. Obviously, these nations can be classified into the two groups on the basis of the technological qualification and market being merchandized such as shown in Fig. 1. As well known, Fig. 1 is in the form of “Puttick Grid” representation. This format is very simple, but effective to understand quickly the corresponding information. In the former group consisting of Japan, Korea and Taiwan, at issue is to clarify the advantage and disadvantage features for each nation in the production of the conventional MC, so that the individual manufacturer can plan the desirable market strategy. In contrast, the latter group consisting of Mainland of China and India, at issue is how to establish the manufacturer having the strong international competitiveness.

## 2. COMPARISON AMONG JAPAN, KOREA AND TAIWAN

With the amazing and rapid technology improvement and development in both the Korean and Taiwanese MC manufacturers, a crucial point in the comparative research into the market strategy is to predict when Korean and Taiwanese manufacturers will be able to catch up the Japanese manufacturer. In consideration of widely prevailing production technology for the conventional MC across the whole world, we have now such a two-pronged assertion as follows.

“The Korean and Taiwanese manufacturers will be able to overcome the Japanese manufacturer in a very near future, whereas both the Korean and Taiwanese manufacturers will not be able to take over the role of the Japanese manufacturer in the world market”.

Table 1. Production, export and import volumes

		Brazil	China	India	Japan	Korea	Taiwan	Mil. US\$
Year	All the kinds of machine tools	Production volume	310	n.a.	85	4,660	1,035	1,299
		Export	58	264	9	3,866	324	1,054
		Import	184	2,075	74	406	672	628
2002	Machining center	Production volume	n.a.	n.a.	17	1,277	232	465
		Export	36	4	1	924	87	352
		Import	36	362	19	14	61	24
Year	All the kinds of machine tools	Production volume	697	4,000	226	10,073	1,940	2,640
		Export	74	657	10	7,395	865	1,984
		Import	338	4,630	520	975	1,836	1,385
2005	Machining center	Production volume	n.a.	n.a.	68	3,013	538	1,120
		Export	15	13	2	1,861	207	760
		Import	76	1,297	145	34	199	36
Year	All the kinds of machine tools	Production volume	1,289	13,960	404	15,567	4,372	4,807
		Export	103	1,456	14	8,463	*1,375	2,965
		Import	845	5,676	1,040	583	*1,037	1,429
2008	Machining center	Production volume	n.a.	n.a.	32	3,590	*1,134	*1,744
		Export	40	98	4	2,884	*333	1,174
		Import	210	2,088	320	50	*270	58

Numerical value with \*: For the year 2007

This paper aims, in part, at the verification of the validity of the latter assertion, and duly an underlying hypothesis is in it that both the Korean and Taiwanese manufacturers are possible, but not capable to overcome the Japanese manufacturer in the production volume aspect, even when the technological qualification of both the Korean and Taiwanese manufacturers will be superior to that of Japanese manufacturer in a very near future. A root cause of difficulties in both the Korean and Taiwanese machine tool industries lie in the acute shortage of the supply capability of the conventional MC to the world market.

Of note, Table 1 shows the production, export and import volumes of all the kinds of the machine tool, extremely placing the stress on MC of basic type and all the variants. As can be seen, the production and export volume of Japan are much more than those of Korea and Taiwan, and we can verify the validity of the assertion mentioned above.

Importantly, we can expect a large market in China than other countries, and in the case of MC, we can observe that China is import-oriented, whereas Taiwan is export-oriented. It is furthermore interesting that the export and import volumes are in leverage in the case of Korea. From the statistic aspect, furthermore, we can observe some interesting facts, but have certain difficulties in understanding their causalities. Within this context, thus, the two questionnaire investigations have been carried out and the results will be discussed in the following.

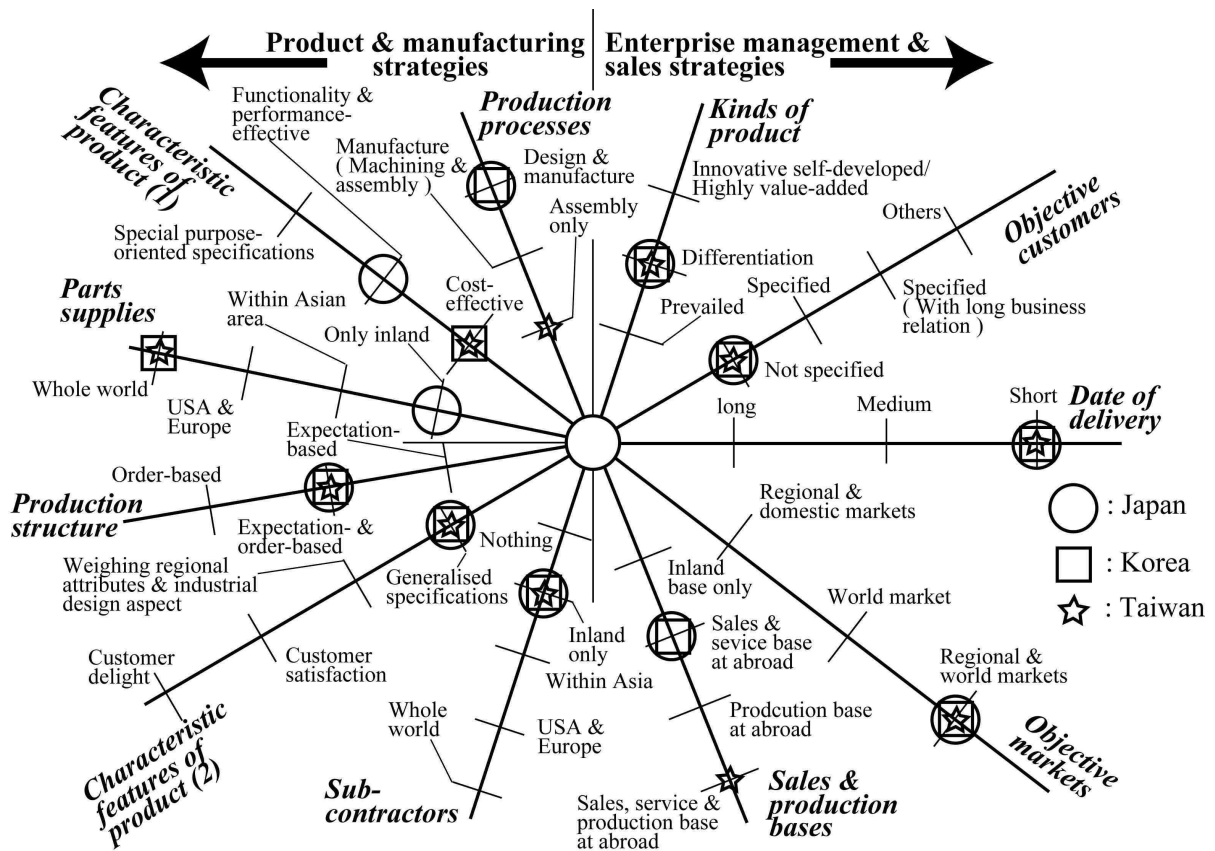


Fig. 2. Comparison for strategies among leading Japanese, Korean and Taiwanese manufacturers – in case of conventional TC and MC production

Figure 2 is a reproduction of the questionnaire investigation around 2004, in which the strategies of the Japanese, Korean and Taiwanese manufacturers were compared emphasizing the enterprise management, sales, product design and manufacture aspects. Fig. 2 is called as the “Mind Map (Radar Chart)” representation, and as same as the “Puttick Grid” representation, very effective to understand quickly the corresponding information. In short, we cannot observe the obvious differences in the strategies among these three countries from Fig. 2. More specifically, nearly all manufacturers in these three countries have produced the conventional MC by employing the in-house design and assembly systems and also by weighing the outsourcing of part machining. In addition, they rely on the SCM (Supply Chain Management) of world class in purchasing the necessary part and unit in a large extent. Importantly, to accumulate the technological resources, the conventional MC manufacturer intends recently to conduct the in-house machining of the core part.

Intuitively, the Mind Map appears as to be relatively simple, and we often face some necessities to detail the due information. Table 2 shows such detailed information to facilitate the understanding of the advantageous feature for the Japanese manufacturer. From Table 2, some interesting trends can be observed as follows.

Table 2. Advantageous and disadvantageous features in conventional MC and TC of Japanese-make as compared with those of Korean and Taiwanese-makes (around 2004)

Determinants	Related Information	
	Advantageous	Disadvantageous
Abilities for Product Innovation & New Product Design	Very poor in Korean and taiwanese manufacturers	Amazing ability improvement by joining Japanese engineer within Korean and Taiwanese manufacturers
Design Ability for Variants	Supply of technical data, drawing, design data and concerns for model machine with larger amount of rewards	When having the model machine, excellent design ability for its variants By positively using the “Cost-driven Superiority” , strong market competitiveness in Asia, BRICS and Third World
NC Controller	Familiarity, usability and brand worship of users for Fanuc-make	Powerful sales activities of Siemens in China and India Sharp inroads of Heidenhain
Leading-edge & Core Parts ( Ball screw, Linear guide, Servo motor, NC controller, Rolling bearing and so on )	Both the Korean and Taiwanese manufacturers rely on the industrial nations even now, and do not use those of domestic-make to the export one  Although endeavouring to replace the imported parts to those of domestic-make, in principle, there remains the “ Follow-up Structure ” ,	Even in Japan, linear guide with higher accuracy, nut for rolling bearing and small chuck available for higher-rotational speed are imported from Europe  In Korea, those of domestic-make are prevailing by carrying out technological co-operation with foreign enterprises  Employment of ball screw of Taiwan-make by Japanese and Korean manufacturers
Marketability in Mainland of China	Strong purchase motivation of user to the machine of Japan-make, because of its high quality  Cost-effectiveness of the machine of Japan-make when considering its higher functionality and performance	Because of over-performance specifications, the machine of Korea-make can easily overcome that of Japan-make, provided that the Korean manufacturer can produce cheaper machine with simplified specifications

The Korean manufacturer has relied largely on the Japanese part manufacturer. For instance, the Daewoo Co. imported the core parts for NC turning machine and MC from Japan, and in 2004 the imported parts rate around 40 % and 25 % to the necessary number of all the parts for NC turning machine and MC, respectively.

The Taiwanese manufacturer can characterize by the following features. There are several MC manufacturers together with a huge number of subcontractors. These MC manufacturers are, even in competitive state, purchase the same unit and part from the same subcontractor. For instance, the Fair Friend has 60 subcontractors for machining, 20 unit suppliers and 80 suppliers for the standard part.

The MIRL (Mechanical Industry Research Laboratory), one of the semi-national body organizations, designs the conventional MC by the request of the manufacturer or assists the product design in the manufacturer.

The manufacturer always considers the technology as one of the tools for the trade activity, i.e., tools for getting the money.

Summarizing, a crucial problem in both the Korean and Taiwanese manufacturers were in the poor design ability for the new product, and this shortcoming remains even now.

Following the investigation mentioned above, another questionnaire investigation has been carried out in 2008. Fig. 3 shows the utmost representative result. In this questionnaire, the format differs to some extent from the previous one by emphasizing the aspect of product differentiation. The causality of differing format lies in the changing perspective of each manufacturer, i.e., from manufacturing innovation to product innovation to enhance the marketability.

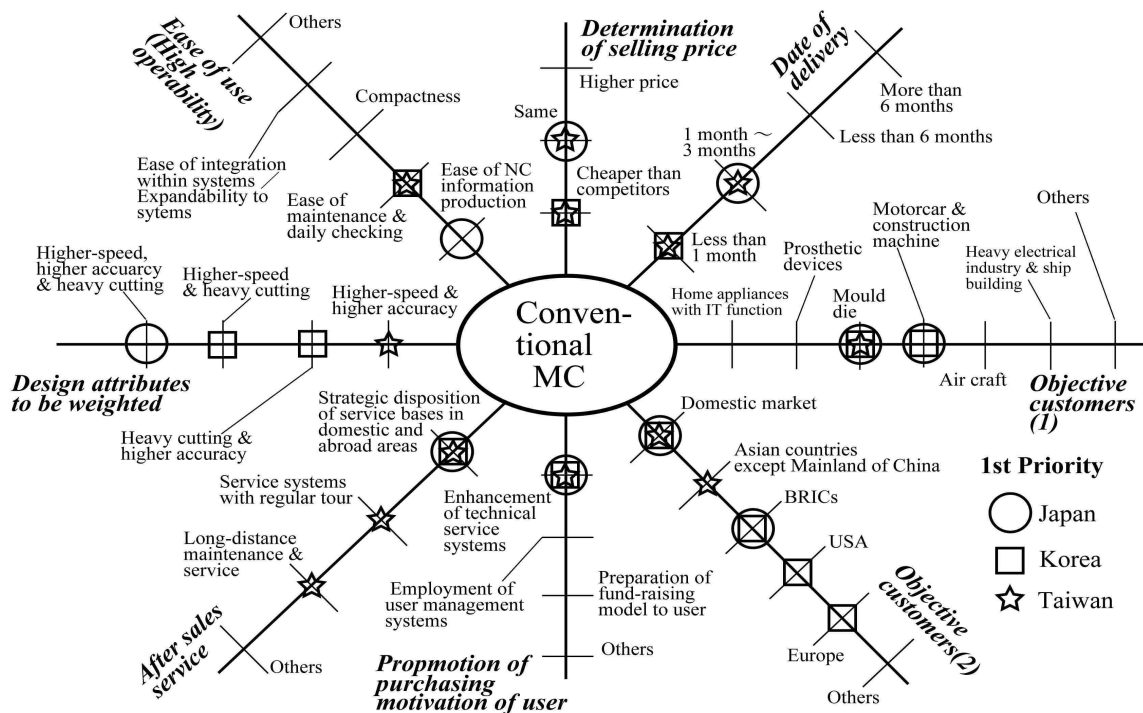


Fig. 3. Mind map representation for product differentiation strategy

Supposedly, we may obtain very scattered and plural answers to the same question, i.e., that related to each axis in the Mind Map, which render the questionnaire investigation useless. This is, in principle, because of the wider availability of the conventional MC. Thus, we affix the priority order to the answer and have in fact produced Fig. 3 by taking the answer of first priority.

As can be seen from Fig. 3, there are no obvious differing features among the product attributes of Japan-, Korea- and Taiwan-makes. For example, each manufacturer is very keen to raise the inland market share together with deploying to abroad. Admitting it, we can furthermore point out some characteristic features as follows.

The Japanese manufacturer is in advanced and beneficial position by leveraging the directly opposed attributes in the product design, i.e., leverage among “Higher-machining accuracy”, “Higher-cutting speed” and “Heavy cutting ability”. In accordance with the design principle of the machine tool, one of these attributes should be satisfied to be the desirable machine in reality so far.

The Korean manufacturer can maintain the competitiveness by realizing the cheaper sales price and shorter delivery time.

The Korean and Taiwanese manufacturers show, moreover, some interesting trends as follows.

In Korean manufacturers:

- The conventional MC targets the automobile and construction machine industries.
- There is a noteworthy improvement in the core part and unit supplies from abroad, although still relying on the Fanuc- and Siemens-made NC controller.
- For the variant of the conventional MC and TC, i.e., quinaxial-controlled MC and TC with twin-spindle, the due technologies are in immature.

In Taiwanese manufacturers:

- The conventional MC targets all the industries together with appealing the cheaper sales price.
- User management especially looking after the present customer, but not future potential customers, i.e., business-oriented enterprise management.

In addition, we must be aware of the importance of the “Fixed Point-like Observation” to understand correctly what is and was under way in the objective nation by comparing Figs. 2 and 3. Such an observation is, as can be imagined, very helpful when conducting the technology transfer.

Reportedly, the Japanese, Korean and Taiwanese manufacturers eye the BRICs (Brazil, Russia, India and China) as the next large-sized market, and thus, Table 3 summarizes the technological strategy and also the potential variant of the conventional MC being scrutinized by these nations. As will be obvious from Table 3, each manufacturer is very keen to enhance the competitiveness by employing various remedies, and in short, both the Japanese and Korean manufacturers have conceptualized the “Junior Machine” as a strategic product for BRICs<sup>2</sup>. In addition, they intend to manufacture the junior machine as a whole at the 1<sup>st</sup> tier subsidiary or sister company so as to reduce the manufacturing cost.

Table 3. Remedies for BRICs markets from technological aspects in representative Japanese, Korean and Taiwanese manufacturers at 2008

Nations & Region	Strategies in General			Various Strategies for Machine Kinds Available for BRICs
	Design technology	Manufacturing technology	Others	
Japan	Weighing attributes: Long durability of higher-speed spindle Compactness of machine	In-house manufacture of core parts so far supplied by other companies Reinforcement of product inspection		Merchandisation of junior machine Fulfillment of support systems for utilisation technology
Korea	Merchandisation of a variant, design attributes of which can differentiate that of other manufacturers	Establishment of machining & assembly technologies for unskilled worker Reduction of assembly time by using qualified units Cost reduction in the machine with simplified specifications by producing it at sister company	Employment of user management systems	Cost reduction by simplification of functionalities Employment of shipping destination-oriented specifications Enhancement of operability
Taiwan	Applicability to machining of new materials Weighing design attributes for higher rotational & travelling speed	Dependence upon skilled worker Employment of JIT Installation of processing facilities for higher accuracy OBM in consideration of cultural differences		Employment of ODM (Original Design Manufacturer) Merchandisation of already well-established machines Merchandisation of machines with global market-oriented specifications

Summarizing, the Japanese manufacturer is still in the superior position as compared with those of Korean and Taiwanese manufacturers, although they have improved their technological qualifications and are able to plan approvable market strategies.

The “Junior Machine” is based on one of the design philosophies, in which the machine tool as a variant maintains the original dimensional specifications as that of basic type, but has the simplified functionality and performance specifications. Thus, we can expect to realize the cheaper machine together with having the function of the “ease of use”. The concept of “Junior Machine” is credited to John Lang & Sons located near Glasgow in the 1930s. After then, Ikegai Iron Works revived the concept to merchandise the cost-effective engine lathe in the 1960s.

### 3. PRESENT PERSPECTIVES IN CHINA AND INDIA

As shown in Fig. 1, the machine tool technologies in Mainland of China and India are considerably behind as compared with those in Japan, Korea and Taiwan. In due course, the Japanese, Korean and Taiwanese manufacturers are very keen to advance in the Chinese and Indian markets. In fact, a representative Korean manufacturer exemplified by the Daewoo



Co. has already developed the conventional MC compatible with the Chinese market. In contrast, in the case of the Japanese manufacturer, the conventional MC available for the world market was simultaneously placed on the Chinese market, although the Chinese user could not afford to purchase it because of its higher price. Belatedly, the Japanese manufacturer has launched out the product lineup available for the Chinese market since 2008 as exemplified by the “Junior Machine”.

Accordingly, in consideration of the potentiality for growing up to the large-sized market in a very near future, at issue is to understand correctly the present perspective of the machine tool in China and India from both the production and the utilization technologies. Thus, Fig. 4 shows first the first-hand view for the installation state and purchasing power in the national capital enterprise. For example, the BHEL has installed the machine tools ranging from the traditional type and NC turning machine of retrofit type, through home-produced CNC turning machine, to the utmost advanced NC turning machine of German-make. In short, the Chinese and Indian enterprises are in chaotic condition, showing varieties in the manufacturing facilities, and at least we can recognize the urgent and crucial demands for the renewal of the machine tool being installed. As a result, we must discuss the following two issues at present.

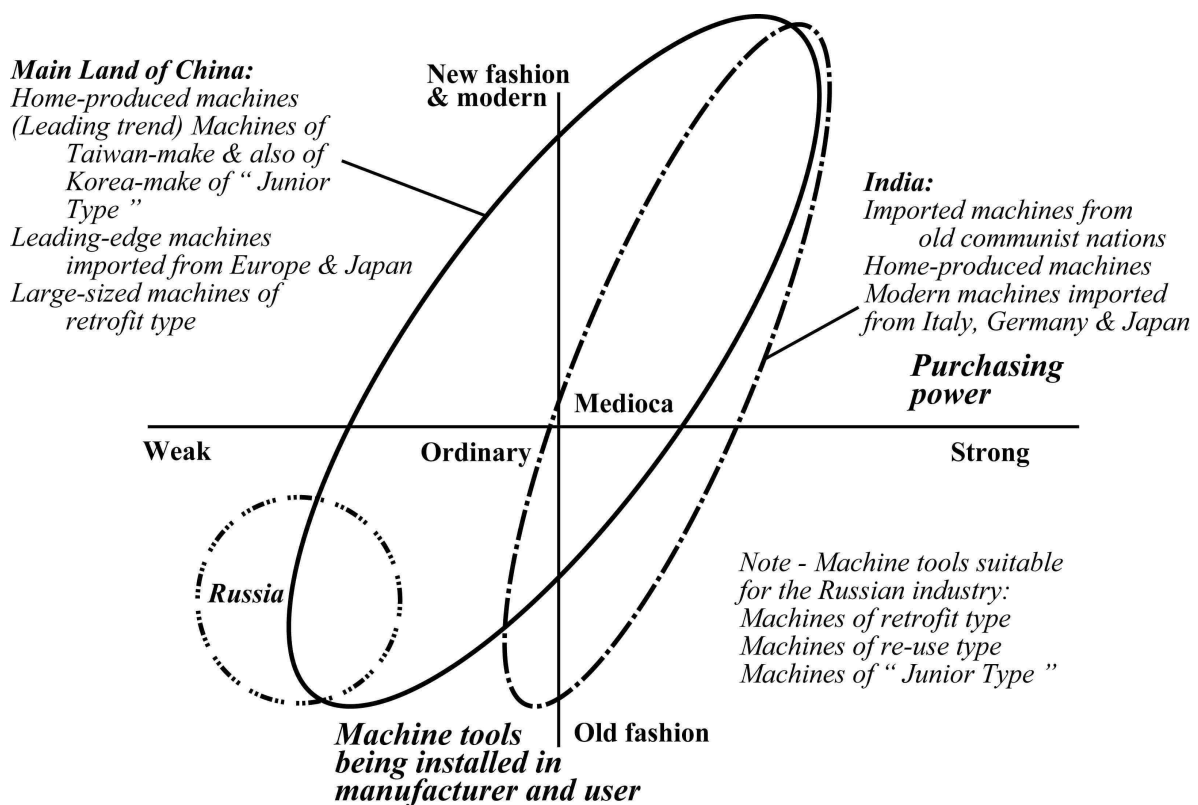


Fig. 4. Installation states of machine tools in China, India and Russia

What are the machining requirements using the conventional MC, and how many numbers of MC must be installed.

Capability of the local manufacturer to provide the necessary numbers of MCs. Thus, the questionnaire and on-the-spot investigations have been carried out, and the interesting observations will be stated below.

In carrying out the investigation, we must be aware of the following. In fact, the foreign transplant factory has more sophisticated facilities, and there is a considerable difference between the national and foreign capital enterprises. Thus, the basic necessity is to choose correctly the sample enterprise in carrying out the comparative investigation. For example, in Sumi Motherson Innovative Engineering in India, where the plastic molding die has been manufactured, nearly all machine tools being installed have been imported from the Japanese-origin machine tool manufacturers located in Singapore and Thailand.

3.1. PRESENT STATES OF CHINESE MC MANUFACTURERS AND CONCERNS

Figure 5 shows a generalized view for the characteristic features in the strategies of some Chinese manufacturers including Dalian Machine Tool Mfg., who have produced the conventional MC. From Fig. 5, we can observe some characteristic features of the Chinese MC manufacturer as follows, when comparing those in the Korean and Taiwanese manufacturers.

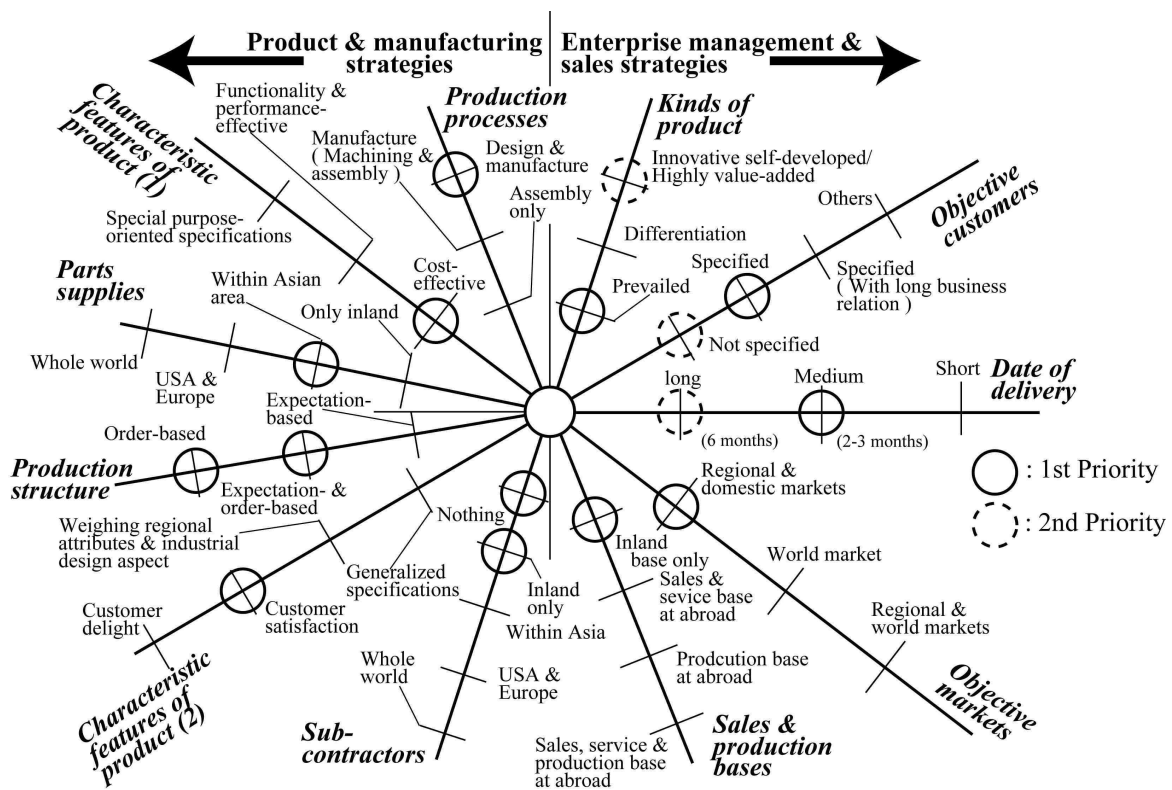


Fig. 5. Characteristic features in strategies of Chinese manufacturers – In case of conventional MC production in 2005

The leading product is the most prevailed conventional MC, i.e., MC of cost effective type, and nearly all manufacturers aim at the inland market.

The delivery time is longer, because of using the obsolete manufacturing facilities. In fact, the Chinese manufacturer has employed the traditional job shop or a group of NC machine tools of stand-alone operating systems. In addition, the longer delivery time appears as to be due to the sparse competition. In fact, each manufacturer is under the control of the Government, and ordered the kind of the machine tool to be produced.

The Chinese manufacturer has duly incorporated the subsidiaries within its manufacturing structure; however, the subsidiaries are located within the Asian region only. This appears as to be one of the reliance attitudes of the Chinese manufacturer on the overseas Chinese network.

Within the manufacturing facility context, FMC is not prevailed as yet. In addition, the Chinese manufacturer has purchased the core unit and parts, e.g., NC controller, ball screw and linear guide, from Japan as same as those in Korea and Taiwan. In Fig. 5, furthermore, we can observe an interesting fact that the Chinese manufacturer marked at the “Customer satisfaction”; however, this must be interpreted as follows.

“The Chinese manufacturer is kind of and esteems its customer to a large extent, but does not design its product as to be customer satisfaction type. In the questionnaire, the “Customer Satisfaction” is at issue as a design attribute as similar as “Customer Delight”. In the case of Taiwanese manufacturer, we can observe the same.

Within a user context, there is, in general, the differentiation in the use of NC machine tool between the Japan- and Taiwan-makes. In short, the machine tool of Taiwan-make can facilitate the rough machining and finishing of the part with ordinary accuracy, whereas that of Japan-make is for the higher-accuracy machining and also for the part with complicated shape.

To this end, it is worth suggesting that the potential kinds for the Chinese industry in the very near future are (1) the advanced TC and MC of German- and Japanese-makes, (2) junior machine based on the conventional TC and MC, (3) machines for rough machining and capable of replacing TC and MC of Taiwan-makes, (4) FTL for automobile industry, and (5) large-sized machine tools of retrofit type.

### 3.2. PRESENT STATES OF INDIAN MC MANUFACTURERS AND CONCERNS

In India, the urgent demands are to improve the social infrastructure, especially the road, railway and power supply, and thus there is a growing requirement for the machine tool, which can machine the parts for the construction machine, rail, rolling stock, electric power generator and so on. This situation has been continued during these 10 years; however, the local machine tool manufacturer cannot respond such increasing demands for the machine tool, especially for the conventional MC such as already shown in Table 1. In addition, the needs for the machine tool are not matured states as yet.

In short, the Indian machine tool manufacturer has only the weak competitiveness in the world market, whereas can be characterized by an interesting feature in the technological inheritance. More specifically, the Indian machine tool manufacturer remains

the influences from Germany and Swiss in design and manufacturing technologies, and furthermore facilitates the production and product quality controls by the Japan-origin technology. In addition, we may characterize and evaluate the Indian machine tool industry as follows.

The common trends are (a) relatively long delivery time, (b) cheaper sales price of machine, and (c) domestic market-oriented sales attitude.

A characteristic feature lies in the design in consideration of only one leading design attribute and, in part, of the leverage of two leading design attributes. This is a very interesting, and in this context, the Indian machine tool manufacturer is superior to Chinese manufacturer.

In contrast, the manufacturing facilities in the Indian machine tool manufacturer are obsolete as compared with those in the Chinese manufacturer.

Figure 6 shows some characteristic features of the Pinjore Plant of HMT Machine Tools obtained from an on-the-spot investigation. We can also observe the same mentioned above in this case. Importantly, the Pinjore plant has produced the small- and medium-sized MC, which is in fierce competition not only within domestic, but also in the world markets. More importantly, Mr. Batra of HMT reveals the increasing order for rough machining from the world to India, and thus HMT has produced MC, in which the main stress is placed on only one leading design attributes such as shown in Fig. 6.

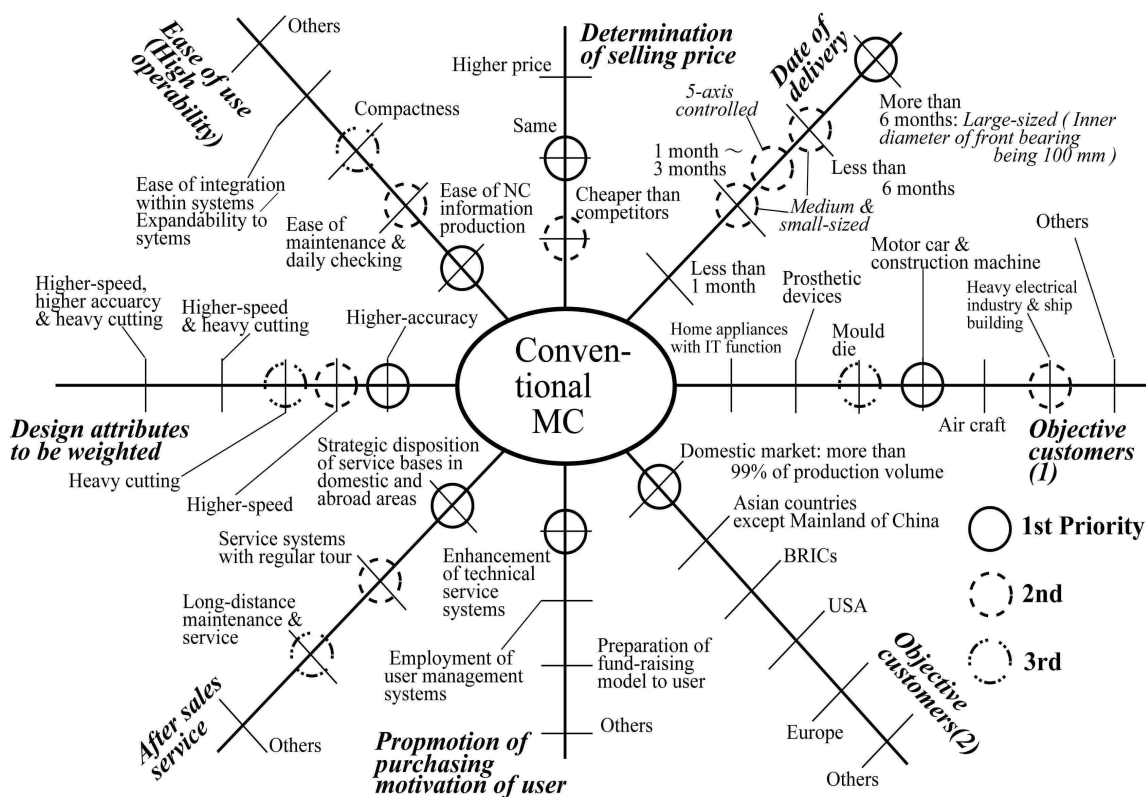


Fig. 6. Differentiation strategy of HMT machine tools in 2008 (by courtesy of Mr. Batra)

In due course, the following product deployments are being planned to enhance the marketability in HMT.

Higher-speed MC, in which the spindle speed is more than 15,000 rev/min, although the higher-speed spindle head should be imported from Weiss Co.

Quinaxial-controlled MC of tilting head type.

Large-sized die sinking machine of fixed bridge type.

MC for flexible manufacturing.

Reportedly, HMT Machine Tools is one of the leading manufacturers in India, and thus we can observe the present and a very near future perspective in the Indian MC manufacturers to some extent from those of HMT Machine Tools. In contrast, we need to have much more information to deepen our understanding. Fig. 7 shows some results of the questionnaire investigation for another two small- and medium-sized MC manufacturers, i.e., EMCO and Reliable Autotech Machine Tools. In Fig. 7, the stress is placed on the first and second priorities in the responses for the questionnaire. It can be seen that the Indian MC manufacturers advance in the various market, although the general trends are similar to those shown in Fig. 6. For example, we can observe the new horizon as follows.

The objective customers become enlarged and one of the new comers is the market for prosthetic devices.

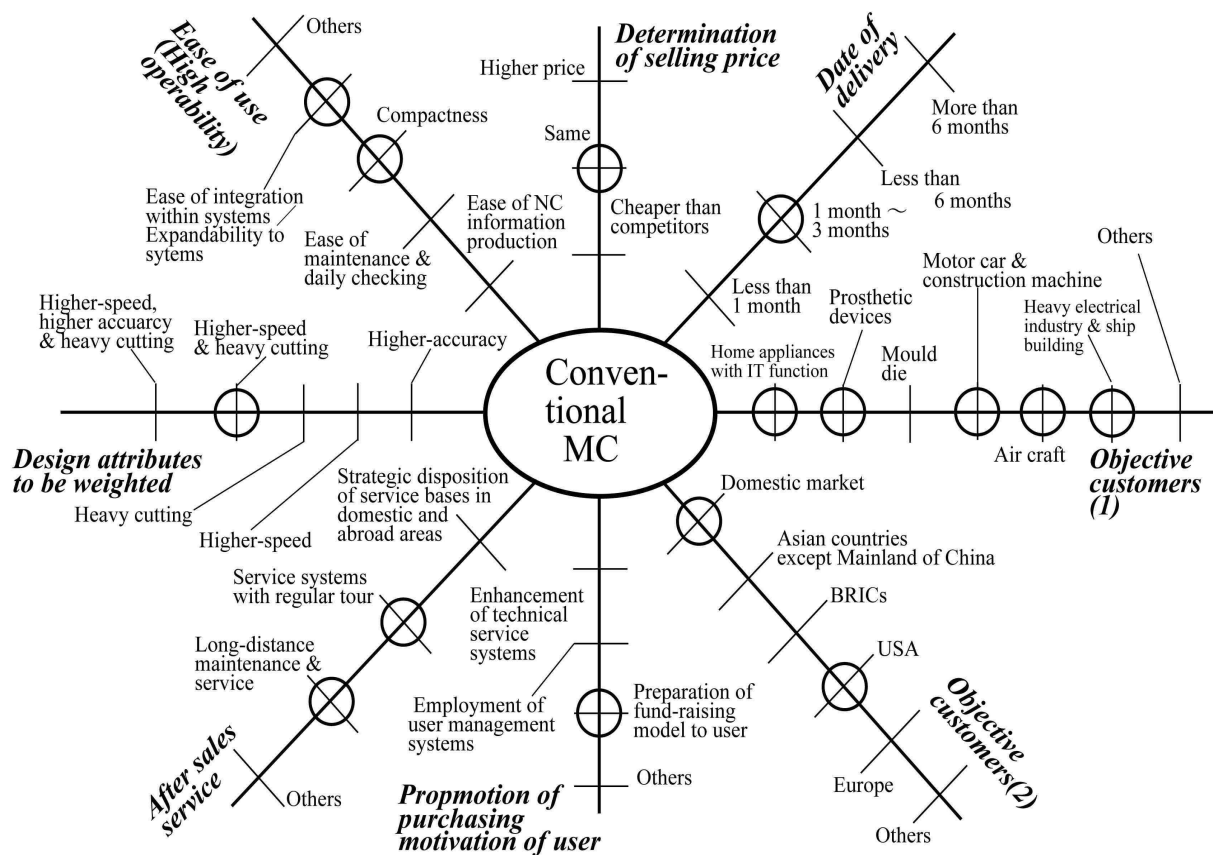


Fig. 7. Differentiation strategies of Indian MC manufacturers I 2011

The marketing strategy appears as to be changing from the domestic-oriented to export-oriented bases.

As can be readily seen from the requirements for ease of use, it implies that the Indian industry would be very keen to modernize the production facilities by employing flexible cell manufacturing.

Furthermore, it is very interesting to unveil the time series-like development of the Indian MC manufacturers by comparing the information shown in Figs. 6 and 7.

Admitting such the states of the Indian machine tool manufacturer, we must discuss the potential kinds for the Indian industry in a very near future. In this context, it is worth suggesting that the Indian machine tool users need various kinds of the machine tool and have relatively enough funds to purchase the advanced machine tool of the higher sales price. Such markets render, in contrast to those in Russia and China, the junior machine useless.

#### 4. CONCLUDING REMARKS

It can be said that the underlying hypothesis mentioned in “Introduction” is acceptable on the basis of the investigation carried out here. Obviously, the Japanese conventional MC manufacturer can maintain the superiority in the world market for the time being. Following the conventional MC, the next comer is the quinaxial-controlled MC and its variants, e.g., quinaxial-controlled MC having the function of continuously rotating table, and within this type, the Japanese manufacturer has only a strong competitor in Germany, i.e., DMG (Deckel-Maho-Gildemeister).

As can be readily seen, we need the quinaxial-controlled MC with rotating table to machine the monolithic part with complicated shape in the automobile and aircraft industries. In the automobile industry, a facing necessity is to increase the fuel efficiency, and the due remedies are to employ the monolithic part to reduce the weight and also the higher accuracy part to reduce the frictional loss. Consequently, in the aircraft industry, the more lightweight structure must be realized by employing the monolithic part together with carrying out the much more heavy machining, i.e., machining for larger swarf removal rate per unit time, for the part made of Ti alloy than ever before.

Supposedly, there could be two-pronged application area for the conventional MC and its variant, i.e., growing markets for the conventional MC with simplified specifications and for the quinaxial-controlled MC. In due course, there are a considerable numbers of research subjects in relation to this new trend. In short, a growing importance is to conduct the comparative research into the marketability strategy for the conventional MC in full consideration of its worldwide market, and if possible, including the important role of the industrial design to reinforce the marketability.

#### REFERENCES

All the information contained within this paper were obtained from “On-the-spot” and “Questionnaire” investigations conducted by authors, and thus there are no references.