Potentialities of Japanese Robot Industry

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Accelerating Growth of the Japanese Robot Industry

Though still far below the multi-billion-dollar auto industry and rapidly growing semiconductors business, Japanese industrial robots have come to be viewed as one of the front-running technological industries in the years ahead, along with aircraft, atomic energy and data processing industries, according to the Ministry of International Trade and Industry (MITI).

Production of Japanese industrial robots has shown a double-digit annual growth in value in recent years, and the 1980 production is estimated to have risen 50% from a year ago, topping ¥60 billion (U.S. $261 million).

Table 1 shows average annual growth rates of the so-called research-and-development-intensive industries classified in the knowledge-intensive industries.

As seen from the table, atomic energy, semiconductor and robot industries showed extremely high growth rates. Above all, the growth rates of semiconductors and robots have accelerated in the years after 1975.

Also on the uptrend are numerically controlled (NC) machine tools, data processing software and electrostatic copiers.

In the United States and Europe, the robot industry is about to assume greater prominence.

Business Week, a U.S. economic weekly magazine, featured industrial robots in its June 1980 issue, and predicted a potentially rosy future for the robot industry. It envisaged at least a 12.5-fold growth in value for the robot industry in 1990 compared with 1980, and a 100-fold growth if giant computer makers such as International Business Machines and Texas Instruments branch out into the robot industry.

In Europe, automakers, including Renault of France, Italy's Fiat, Sweden's Volvo and Daimler-Benz of West Germany, have begun to install robots en masse on their assembly lines.

In Japan, automakers have bent strenuous efforts to streamline production lines through using robots since the early 1970s, which has enabled them to take the lead among the world's major automakers in employing robots on assembly lines.

Now in the midst of the so-called "auto war" between the United States and Japan, U.S. makers have started putting many robots on their production lines, having finally realized that the high productivity of their Japanese competitors stemmed from the large degree of automation by robots and efficiency in automation techniques.

The auto war has spread to Europe. Automakers there, traditionally not

Industrial robots play a major role in car assembly.

enthusiastic about automation, have finally begun to understand the important role robots play in productivity and quality improvement, thus showing signs of keen interest in robotics.

Meanwhile, it is estimated about 100 business missions came to Japan in 1980 for industrial survey purposes from the United States and Europe. They are believed to have returned home, deeply impressed by robots at work in various factories and excellent automation techniques that sustain Japan's high productivity.

Japanese Robots: No. 1 in the World in Numbers

It is widely acknowledged that Japan is now the world's leader in the number of robots. More than 20,000 robots are estimated at work today in Japanese factories.

While the definition of a robot differs between Japan and the United States and Europe, this figure is said to be more than the total of robots in all other countries.

The number of Japanese robot makers is also large. The Japan Industrial Robot Association says there are 140 robot makers in Japan as against 40 in the United States and Europe, respectively.

Robot research laboratories in Japan exceeded 85 in number in 1980 (see table 2), presumably well over those in the United States and Europe.

"Intelligent robots" being developed at Japanese research laboratories are highly evaluated internationally.

The International Industrial Robot Symposium is held annually. The 11th symposium was held in Japan in October 1981—the third to be held in this country.

At the 11th symposium, 750 researchers represented the United States and Europe, and about 100 research papers were presented, including those submitted by South Korea, China and Spain for the first time.

Secret of Growth of Japanese Robot Industry

There are several reasons for such remarkable growth of the Japanese robot industry. Basically, the industry has trod the same path as the automobile, steel and semiconductor industries in their development. It began with introduction of ideas and techniques that originated and developed in advanced industrial countries, notably the United States.

Later, the robot industry strove to catch up with the level of U.S. and European industries by attaining high production efficiency and quality control through excellent production techniques.

However, we have to note also other factors different from the ones mentioned above. That is, unlike automobiles and semiconductors, a quantitative demand for industrial robots sprang up in Japan much earlier than in other advanced countries.

"Cheap and bad" was the label foreigners affixed to Japanese manufactured goods in the prewar and early postwar eras. In an effort to escape from this image, Japanese manufacturers pursued thoroughgoing quality control, pressing ahead with automation, as well as maintaining competitive prices by raising productivity.

This way of manufacturing goods makes it possible to provide in abundance products ranging from lower first class to upper second class at a relatively low price.

In the sector of private industrial production, Japan has followed this method and approach to the markets of advanced industrial countries. Labor-saving automation as in the case of industrial robots has best suited to Japan for sharpening its international competitive edge price-wise.

In labor-management relations, too, there existed conditions peculiar to Japan to easily allow introduction of robots to production facilities: high quality labor and a traditional permanent employment system.

In the U.S. and Europe, workers tend to almost instinctively refuse introduction of robots for fear of being made redundant.

Particularly in Europe, being an engineer means belonging to an elite of selected minority. In short, there are not so many technicians who can handle and design industrial robots.

However, quite a number of new bachelors of engineering and technicians emerge every year in Japan.

There are more technicians in Japan than in the U.S. as well as in Europe who can handle robots which requires knowledge of machines, electronics and control systems.

There is little possibility of workers being fired with the introduction of robots in Japan, where permanent employment is an established system. Workers welcome robots because the latter take over monotonous and repetitive work under hard conditions.

Meanwhile, the word "mechatronics," presumed to have been coined by the Japanese, is in fashion. It may safely be said to signify a field of industrial technology coupled with machines and electronics.

Perhaps, Japan will show competitive strength in this field in the years to come

Table 1: Average Annual Growth Rates of Research and Development Intensive Industries (%)

	'78 Production (Sales) volume (¥ in 100 millions)	Quantity			Value		
		1970-1975	1975-1978	1970-1978	1970-1975	1975-1978	1970-1978
Pharmaceuticals (Fine chemicals)	27,939	—	—	—	11.8	16.0	13.4
Computers and related equipment (Computers only)	9,102 (3,779)	— (12.0)	— (7.8)	— (10.4)	11.8 (15.6)	18.9 (13.6)	14.4 (14.9)
Atomic energy-related equipment	3,581	—	—	—	43.1	22.6	35.0
Semiconductors (IC's)	2,517	19.7	54.8	31.8	17.1	33.9	23.1
Aircraft	730	−4.6	−3.9	−4.3	15.9	0.8	9.9
Industrial robots	247	—	—	—	17.8	30.6	22.4
High purity silicon (Single crystal)	—	−0.4	35.5	11.8	—	—	—

Source: MITI

Table 2: Numbers of Industrial Robot Laboratories

	1974 1st	1977 2nd	1979 3rd	1980 4th
Public universities	20	30	34	36
Private universities	12	16	17	22
Technical colleges	—	—	5	3
Non-profit organizations	11	13	23	24
Total	**43**	**59**	**79**	**85**

Source: Japan Industrial Robot Association

because it is blessed with engineers both in quality and numbers in the fields of machines and electronics. And engineers in the two fields are relatively well balanced in numbers here.

It is the writer's impression that mechanical engineering, especially production engineering, has been in the doldrums in recent years in the United States.

American people seem to believe that the United States has entered a post-industrial society. Brilliant students hope to choose such professions as doctors and lawyers who can make a lot of money. Also in vogue among them are business schools that will promise quick promotion to management. Science and engineering students tend to be lured into computer science.

In fact, you will see, nine out of ten, computer-related engineers working at many robot research laboratories in the United States. Few Americans want to work in oil-soaked dirty clothes in the factories.

The same tendency is seen in Japan, and it will be strengthened further hereafter. Yet, the phenomenon is not prevalent when compared with the United States. And the number of science and engineering students is far larger than in European countries.

Anyhow, these facts may explain why mechatronics is suited to the Japanese industry, and robotics is representative of the field.

Economization must be pointed out as another important factor for wide-spread use of industrial robots. While the labor cost is on the rise as ever, robot prices are on a slightly downward trend. In particular, the price of a sophisticated industrial robot is going down considerably compared with its high performance.

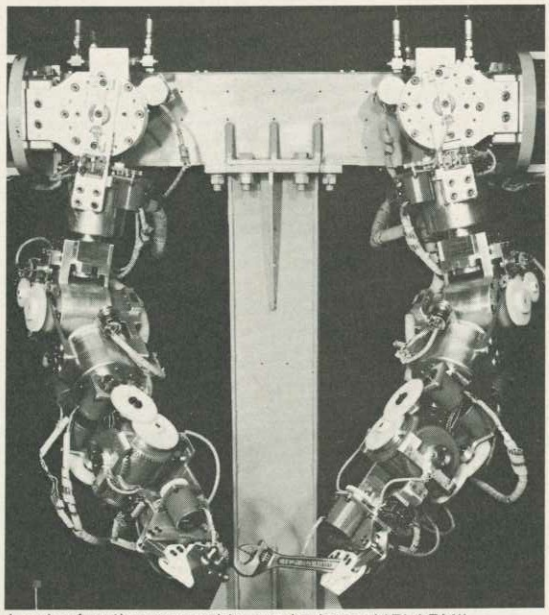
The average yearly labor cost per worker in the Japanese manufacturing sector was ¥3.5 million ($15,217) in 1980, according to a survey by Nomura Research Institute in Tokyo. The survey also showed that the manufacturing industry had tentatively set a permissible limit of investment for replacing a human worker at ¥5.8 million ($25,217) for ordinary work and at ¥7.8 million ($33,913) for hard work.

The price of a play-back type industrial robot, suitable for repetitive work, with high accuracy, is now down to ¥10 million ($43,478) on average, compared with ¥15 million ($65,217) per unit several years ago.

Thus, the price of a robot compared with the cost of a human worker has been down considerably.

Fig. 1 shows improvement in economization on the robot in the past. The trend is expected to continue hereafter and there is a strong possibility that the robot price will be below the permissible limit of labor-saving investment in 1990. (See Fig. 1 and 2)

Therefore, I think the time has come for the Japanese robot industry to take off. In the spring of 1980, robot-related share prices jumped on the Tokyo stock market.



A pair of anthropomorphic manipulator "MELARM" (developed by MEL)

A robot seeing-eye dog "MELDOG" (developed by MEL)

In late 1980 Fujitsu Fanuc, a leading manufacturer of NC machine tools and robots, completed a virtually unmanned factory where "robots make robots" in Shizuoka prefecture, west of Tokyo. At midnight, NC machine tools and robots are making components of robots ceaselessly and unmanned conveyor vehicles run around in the silence-filled Fujitsu factory.

It seems as if there would be no obstacle facing the Japanese robot industry. But is it really so?

Is the Present Robot Really a Robot?

Industrial machines now in use cannot be called robots in the strict sense of the word in the eyes of some robot researchers.

Even a sophisticated robot does not differ in essence from NC machine tools.

In fact, prominent robot makers are machine tool manufacturers like Cincinnati Milacron of the United States, the world's major machine tool maker, and Italy's Comau. So is Japan's Fujitsu.

Mr. Richard E. Hohn at Cincinnati Milacron, an Engelberger Prize winner at the 10th International Industrial Robot Symposium in 1980, once told the writer that all the essential components of the joint-type industrial robots his team has developed were the same as those in NC machine tools the company made.

It was about 20 years ago that the word "industrial robot" was first used in the United States. A number of Japanese makers picked up the idea, and several years later began to proclaim themselves robot makers.

That means a simple robot was nearly the same as loading and unloading machines, and a sophisticated robot was made just by applying the techniques used in NC machine tools.

Some people say similar apparatuses were already made by some Japanese manufacturers at the time, though not yet named "robot."

Anyway, robot makers have endeavored since then to improve reliability and kinematic functions of a sort of automatic conveyor that was begun to be called industrial robot. In the process, they have found that the automatic conveyors coupled with NC machine tools are very useful in automating production systems.

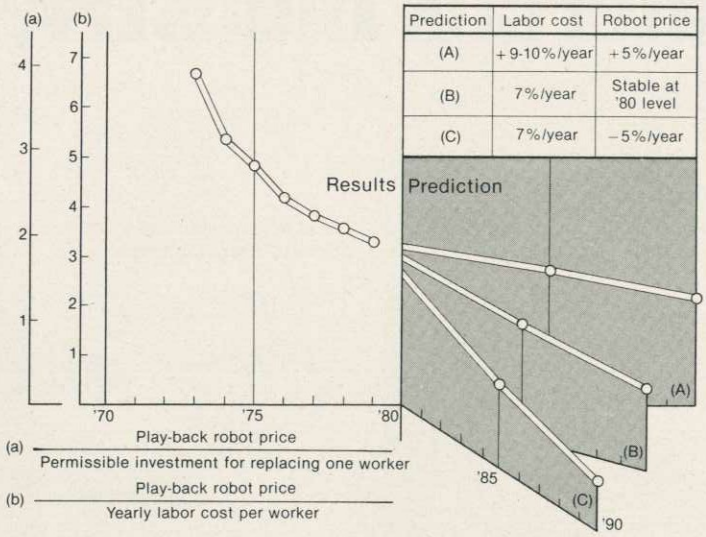
In the meantime, they have also come to know that the play-back type robot can be used by remodeling its hand for spot-welding in assembly lines of automobiles. Mass employment of such robots by automakers has proved quite efficient, thus paving the way for the present robot industry.

However, the present industrial robot still stands at a very primitive stage with its working ability limited. There are a lot of problems to solve before making an industrial robot in the real sense that can "see" and "judge" and has sensory organs and functions nearly equivalent to human arms.

For instance, a great deal of improvement is essential in structures, control systems, sensors and many other ways before a robot can do a relatively complex job such as assemblying machines. And the technical improvement is expected to be accompanied with difficulties far greater than generally anticipated.

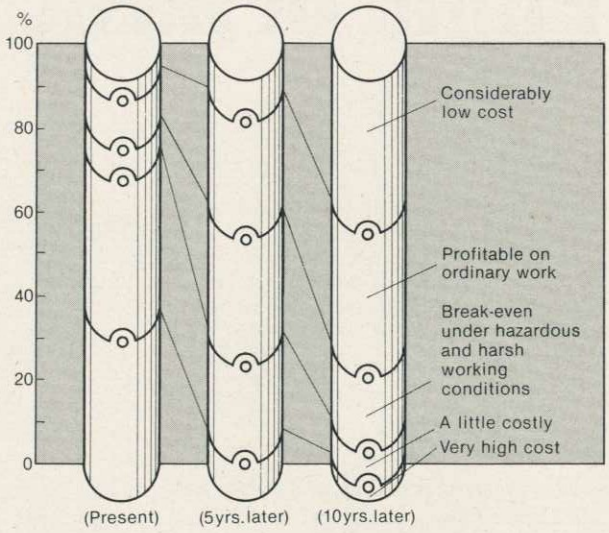
At a research room level, a "quasi-intelligent robot" has already been developed that can do a little complex job, but it is nothing but an "intellectual gadget" far from practical use.

Fig. 1. Economic Improvement of Industrial Robots (Play-back Type)



Prediction	Labor cost	Robot price
(A)	+9-10%/year	+5%/year
(B)	7%/year	Stable at '80 level
(C)	7%/year	−5%/year

Fig. 2. Users' Views of Robot's Cost Efficiency



Note: Answers in % of 726 business divisions.
Source: Nomura Research Institute

An industrial robot on display at an exhibition of industrial robots.

Growing Importance of Research into Robotics

It may be a little wide of the mark for European people to feel threatened by the present prosperity of the robot industry in Japan. As I said before, robotics at present is still at a primitive stage and in that sense all the countries in the world are at a starting line; hence the growing importance of research and development of a really excellent robot.

In many countries, research and development on the robot has been pushed ahead strenuously.

In the United States, NASA has been carrying on research with a huge budget to develop a space robot for constructing a skylab. Carnegie Mellon University, noted for its computer science, has recently set up a robot laboratory for more energetic research.

The situation is the same in European countries like West Germany, Italy and England. In Italy, Olivetti, DEA and Comau have begun to develop creative and excellent industrial robots.

France has been pushing ahead with systematic research, including the Spartacus Program, winning much applause for the high level of research and development in robotics.

Today's technological level of industrial robots, however, is still far below that of aircraft, space and atomic energy.

Japan has taken a small lead in using industrial robots, but there is a possibility that its superiority may be eroded. More important, all the countries will have to intensify efforts in research and development for cultivating the "intelligence" of industrial robots more than ever before.

More Creativity and Challenging Mind

It is no exaggeration to say generally that the industrial robots manufactured in Japan lack originality. The robot industry has marvelously exemplified the general pattern of Japanese industries that everything begins with the introduction of imported prototypes and successive modifications.

Many robots manufactured in Japan so far, are similar to Unimate, Versatran and ASEA types or Trallfa types for painting.

Should Japan respond to expectations of foreign countries in the field of technology, it will have to make efforts for developing a truly innovative and excellent robot and create wider applications.

Luckily, original research and development has begun to be seen in Japan as in the cases of "cicada" robot, an optional item for a NC machine, an arc-welding robot with a visual sensor and a robot for welfare use.

Robot researchers in the government and industry will be called on to display an enterprising and adventuresome spirit for developing a really original and excellent robot.

The demand for various robots will increase hereafter more than ever before to replace human labor in harsh working conditions. The application of robots to new fields will require a creative and audacious challenging spirit in every respect, including materials, control systems, driving mechanisms and so on.

Potentialities of the Japanese Robot Industry

The Japanese robot industry, a typical representative of the mechatronics field Japan is good at, is thriving at present, but its future is not necessarily sure-footed.

The industrial robot, in the real sense of the word, with sensory perception, intelligence and judgment has yet to be developed. There is still so much to be done in the research into man-made intelligence, the sense of sight, auditory sense, movability, materials and driving mechanism.

Therefore, the future of the Japanese robot industry will hinge on how energetically the government and private companies push ahead with research and development and on how researchers display creative and challenging minds.

International cooperation in research and exchange of information as well as engineers will become more important in the years to come so that people in the world may get the benefit of truly superb industrial robots. ●