

# Japan's Changing Industrial Landscape\*

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## Abstract

This paper explores various strategic options available to Japanese firms faced with the increasing market pressures in the global economy. Whether Japanese firms are able to retain the competitive edge will depend on the continuing gains in their manufacturing capability, their capacity to exploit and adapt to changing market circumstances, and innovativeness at many levels. We discuss six main developments that are changing the industrial landscape in Japan and in this context, we explore the nature of the responses required of firms and examine some implications of the measures adopted for the Japanese economy as a whole.

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Internationally competitive manufacturing industries have made Japan prosperous. And even though the share of manufacturing in total GDP has fallen to 22 percent and less than a fifth of the workforce is engaged in manufacturing, the productivity and innovativeness of key industries will be critical to sustaining this prosperity as well as Japan's standing in the global economy (see Figure 1). Starting with light manufactures a half century ago, Japanese firms rapidly built up a formidable international competitive advantage, first in metallurgical and engineering industries, then in the production of transport equipment, a wide range of electronic and optical products and precision equipment, making exports one of the main drivers of growth.<sup>1</sup> Over time, as Japanese wages have risen, the competitiveness of labor intensive industries such as those producing textiles and household consumer durables has declined.<sup>2</sup> But in other areas, including for instance the production of autos, electronics, production equipment and steel, firms are striving hard to maintain their edge over their foreign competitors.

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<sup>1</sup> Although the share of exports in GDP is about 11 percent and somewhat lower than that of comparators (Harrigan and Vanjani 2003), Japan accounts for 6.5 percent of global export and rising exports still strongly influence economic performance (Sender 2003). Exports are primarily of manufactures two-thirds of which are drawn from three subsectors, machinery, electrical equipment, and transport equipment (see Table 1) (JETRO 2003). With domestic demand for steel falling by between 2-4 percent p.a. and the production of autos expected to shrink to 10 million by 2005, exports will become a more important source of demand.

<sup>2</sup> In the domestic market Japanese firms such as Rinnai, Matsushita, and Toshiba dominate the market for large domestic appliances and most smaller appliances, PCs and laptops are sourced from other East Asian suppliers to OEMs while sold under Japanese brand names.

Whether Japanese firms are able to retain the lead they have enjoyed over rivals will depend in part on the continuing gains in their manufacturing capability through a progressive improvement of production networks (national and international) painstakingly constructed over decades. Increasingly though, competitiveness will derive from the capacity to exploit and adapt to changing market circumstances and on innovativeness at many levels that also helps to reverse the slowdown in productivity growth that has persisted for well over a decade (Hayashi and Prescott 2002; Morana 2004). Japanese firms have traditionally excelled at process innovation. This now needs to be further reinforced by far reaching innovation in products, organization, business models, the use of IT and in the provision of services that complement the product offerings, thereby enhancing profitability without risking the loss of focus. Such a many faceted innovativeness is becoming vital because Japan's industrial system will be confronting challenges different from and sharper than was the case in the past from intensifying competition, slower growing markets and diminished pricing power, and lower profitability.<sup>3</sup> How firms marshal technical and research skills and rise to these challenges and how they shift resources to promising new industries will be decisive for their longer term survival and for the dynamism of the Japanese economy (Miyagawa, Ito, and Harada 2004).<sup>4</sup>

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<sup>3</sup> Major electronics producers such as Sony, Pioneer and Fujitsu have been faced with weakening profitability during 2002-2003. In the latter part of 2004, these companies and even Samsung reported declining profits.

<sup>4</sup> Miyagawa, Ito, and Harada (2004) show that although investment in IT capital amounted to a quarter of the total investment in 2000, such investment is lower in manufacturing than in services and the ratio of IT capital stock to the total stock is well below that in the U.S. One inference they draw is that higher IT

In the balance of this paper, we will discuss six developments that are changing the industrial landscape in Japan. In this context, we explore the nature of the responses required of firms and in the concluding sections, examine some implications of the measures adopted for the Japanese economy as a whole.

### **Intensifying Competition**

There can be little doubt that the dismantling of trade barriers and the falling costs of transport and communication by integrating international markets are intensifying global competition.<sup>5</sup> But fewer impediments to trade are only one of the factors that has affected the tempo of market competition. Equally important is the codification and diffusion of production technologies, as well as the adoption of uniform standards with foreign direct investment (FDI) serving as an important channel, the accumulation of labor skills in many countries, and in the case of the burgeoning electronics sector, the dominance of digital technologies. All of these have lowered the entry barriers to firms in emerging economies and allowed them to quickly acquire the skills and manufacture products of the quality needed to penetrate global markets. In several countries, these developments have been abetted by the deepening of financial systems that have provided entrepreneurs with the funds from local and foreign sources to harness the available technologies and invest in production facilities. Thus, East Asian economies for example, have been gripped by an industrial revolution that has enabled them to overtake

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investment would support faster productivity growth along with a parallel shift in labor to subsectors with potential for such growth.

<sup>5</sup> This process of globalization is described in World Bank (1999), Wolf (2004), Bhagwati (2004), O'Rourke and Williamson (1999) and Micklethwait and Wooldridge (2000).

Japanese firms in the medium and low tech industries. As a result, the production of such items as textiles, toys, leather goods, TVs, sound equipment, and microwave ovens is now entrenched in the industrializing economies of the region and firms from these countries such as Exequel (a maker of shirts), Galanz (the leading producer of microwave ovens) and TCL (the largest manufacturer of TV sets in the world) have emerged as the leading producers. The challenge is no longer limited to the technological mid range but has spread to products such as LCD monitors and TVs, mobile handsets,<sup>6</sup> telecommunication equipment, notebook computers, many different types of ICs and electronic components and subcompact cars. Companies such as Samsung and LG Philips are expanding their market shares in ICs, handsets, flat screen TVs and LCD monitors. Quanta and Acer from Taiwan (China) dominate the production of notebook computers; Asustek, another Taiwanese firm, is the world leader in the production of motherboards; and Lenovo is the third largest producer of PCs. More recently, Chinese firms such as Huawei and ZTE are expanding into the middle tech end of the market for routers, switches and other kinds of telecommunications equipment by offering aggressively priced products, a full range of equipment, and financing for the buyer. The Republic of Korea accounted for 10.4 percent of global electronic components production and Greater China for 11 percent in 2002 while Japan's share was 25 percent. Given how rapidly firms from industrializing East Asian countries have been able to establish a commanding position in these relatively high tech activities, and given also the scale of their investment in manufacturing capacity, IC design, R&D and IT, these and other firms will become increasingly formidable competitors for Japanese companies such as Sony,

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<sup>6</sup> Samsung had 13.5 % of the global handset market by September 2004.

Toshiba, NEC, and Hitachi. Samsung exceeds the market valuation of Sony, is winning awards for the design of its consumer products, and in 2004 its high-end TVs were the best selling brand in the U.S. As TV sets comprise more than half the shipped value of consumer electronics sold worldwide, the rising share of other East Asian producers is a serious threat ("Samsung Design" 2004; "Sony Struggles" 2004).

How are Japanese firms responding and what might be the nature of future strategies? First, Japanese firms derive advantages from an early start which is reflected in manufacturing capability, high productivity levels achieved through 'learning by doing', accumulated tacit knowledge and entrenched global brands.<sup>7</sup> Second, through foreign direct investment (FDI) they have located production facilities throughout South East Asia, China and other countries,<sup>8</sup> exploiting as appropriate the advantages presented by fiscal incentives, lower wages, market access, infrastructure and transport costs, and combining these with manufacturing expertise. The initial surge in FDI by Japanese firms was prompted by the appreciation of the yen in the 1980s. Since then, Japanese firms have been constructing regional supply chains in East Asia, first investing in

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<sup>7</sup> In addition, Japanese firms tend to be heavy users of industrial robots. In fact, close to 40% of operational stocks of industrial robots are in Japan as of the end of 2004. The use of robots greatly improved the productivity of these firms since the capability of these robots has been rising dramatically, while prices have fallen rapidly. Combining the quality improvement and price reduction in industrial robots, the relative price of robots to labor is now only 12 (with the index set at 100 in 1990). The automotive sector is by far the heaviest user of industrial robots around the world. In Japan (and Italy), there is one industrial robot for every 6 workers (UNECE 2004).

<sup>8</sup> The cumulative FDI by Japanese firms in ASEAN4 was US\$100 billion between 1985 to 2003 while the investments by firms in the US and Europe were \$49 billion and \$72 billion, respectively (JETRO 2004).

ASEAN countries, then in China starting in early 1990s.<sup>9</sup> Third, Japanese firms benefit from marketing systems developed by the giant trading companies such as Mitsui and Mitsubishi, and brand names.<sup>10</sup> Last but not least, globalization is creating huge markets enlarging the economies of scale and scope for incumbent producers. These are major advantages but for many Japanese firms they are not enough to prevent an erosion of market share, pressure on profit margins and a narrowing of growth prospects.

Sony and Fujitsu are two examples of leading Japanese manufacturers that face an uncertain future. In an effort to maintain their competitiveness in key product lines, they are continuing their quest for innovations while particularly, in the case of Sony, exiting product lines that are no longer profitable. In addition many companies are entering into alliances with competitors to share the costs of R&D and the construction of production facilities and also to fill gaps in product offerings.<sup>11</sup> Virtually all the major electronics

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<sup>9</sup> Within the electronics industry, 126 subsidiaries were established in ASEAN countries in the 1980s, 189 in the 1990s, and only 9 subsidiaries since 2000. Contrastingly, investments in China grew in the 1990s. In the 1980s, Japanese firms established only 19 subsidiaries in China. However, since then Japanese firms have established 249 subsidiaries in the 1990s and 61 since 2000 (JETRO 2004).

<sup>10</sup> In this regard, the *sogo shosha* (general trading companies) helped establish an early and commanding lead in marketing, distribution and product sourcing.

<sup>11</sup> Sony has entered into an alliance with Samsung to manufacture flat panel displays at a factory in Asan, Korea and with IBM and Toshiba to produce the new “Cell” microprocessor for its game console (“The 9-in-1 Wonder Chip” 2005; Ward 2004). Meanwhile, NEC has embarked on a joint venture to manufacture LCD panels with SVA Electron of China (Ramstad 2004) and Matsushita, Hitachi and Toshiba also entered into a joint-venture in LCD operation (“Hitachi and Matsushita” 2005). Fujitsu, meanwhile, is selling its LCD production to Sharp in order to streamline its product and shed loss-making units (“Fujitsu in Talks” 2005).

companies now are engaged in such cooperative arrangements because the “technological arms races” are proving too costly for even the largest firms.<sup>12</sup> They are also finding that vertical integration, while risky, has its advantages.<sup>13</sup>

As we will discuss below, these responses to the rising pressure of international competition are unlikely to be sufficient. The main reason is that the leading incumbent MNCs are liable to settle into a routine of incremental innovation and the refining of existing product lines. Moreover, they tend increasingly to move towards high end products leaving their competitors to take the market for cheaper models for which the profit margins are narrower.<sup>14</sup> Experience suggests that this strategy can backfire as market share shrinks and once new entrants have consolidated their grip on the lower priced mass market products and established brand reputation, it becomes easier to penetrate the more profitable, higher priced segments of the market.

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<sup>12</sup> See Baumol (2002) on the innovation imperative. The recent joint effort by Sony, IBM and Toshiba to produce the 64-bit parallel processing chip called the Cell, initially for the Sony Playstation 3, is another example of the scale of collaboration ("Joint Venture's New Chip" 2005; "Pentium's Reign" 2005).

<sup>13</sup> Digital technologies are forcing companies to rethink the outsourcing of components because the profitability of assembly operation is on the decline and the larger returns—which also differentiate one producer’s products from that of another—are to be made from manufacturing key components. Thus vertical integration, although a risky strategy, is back in favor. This could spread to the auto industry as well.

<sup>14</sup> Christensen and Raynor (2003) discuss this process and the role of lower priced disruptive innovations. A recent example of this is Samsung’s abandoning of the production of its lower priced TVs in China. Both Korean and Japanese producers are likely to face competition from Chinese companies such as Chery and Geely that have launched a range of subcompacts. Chinese manufacturers are a major force in the market for smaller motorbikes.



Italian manufacturers of clothing and textiles such as Mantero and Marzotto faced with intense competition from East Asian firms have managed to hold on to a sizable share of the expanding market for luxury brand name products but only through heavy investment in design, and continuous technological improvements in the weave, finish, variety and quality of the materials. Similarly, emphasis on design, quality and marketing has allowed Italian furniture suppliers to sustain their global dominance (although Chinese furniture makers are now drawing abreast) but in the U.S. the manufacturers of bedroom furniture have lost half of the domestic market to Chinese suppliers ("China Price" 2004). But both these industries and others are faced with loss of market share as East Asian firms are mastering the necessary skills and moving upstream. Diversifying into technical textiles for the construction, medical services, transport and other industries has provided some Korean textile firms with a new lease on life. Mass customization of clothing and footwear with the help of computerization and IT is also enabling some firms to regain their market share. Again, survival in a competitive milieu is a function of technological advances in materials with superior attributes, in techniques of combining manmade with natural fibers to produce materials that better serve existing demands or help to create new niche markets, and through innovative techniques for offering consumers a higher degree of satisfaction.<sup>15</sup>

The Japanese auto industry is proving equal to the challenge of competition. Through ceaseless product and process innovation and determined efforts at reducing

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<sup>15</sup> More than a third of men's clothing sold in the U.S. now incorporates some technical innovation that contributes to, for instance, crease and stain resistance and "breathability."

costs, exemplified by the Toyota Production System,<sup>16</sup> it is increasing market share worldwide while sustaining profitability at levels well above those of its rivals.<sup>17</sup> Producers of consumer electronics, office equipment and optical instruments are in a less comfortable situation in large part because of digital technology and modernization. Industry leaders such as Canon, Sharp, Matsushita and Sony must now exert the full extent of their innovative capability and organizational skills to stay ahead of the competition in industries where product cycles are now measured in months.<sup>18</sup> One strategy is to miniaturize components and package them ever more tightly in pagers, PDAs and cameras making full use of an acquired expertise. The advantage of tight packaging into one black box is that such components are also much harder to copy and provide a longer stream of rents.

For textile manufacturers rising costs leave fewer choices, which is why the subsector has been shrinking at an average rate of 8 percent p.a. between 1998 and 2003. Large companies such as Toray and Toyobo are diversifying into adjacent industries or focusing their activities on spinning and weaving that are more capital intensive or developing new synthetic fibers. Producers of apparel have less room for maneuver.

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<sup>16</sup> Both the assemblers and producers of parts have been equally aggressive in pursuing innovation.

Toyota's success with its hybrid technology reflects the success of their efforts.

<sup>17</sup> The profit margins of Japanese automakers, Toyota, Nissan, and Honda, are 6.7%, 6.8%, and 5.7% respectively. In contrast, the margins for GM, Ford, and DaimlerChrysler are 1.9%, 2.4%, and 0.3%. Among the other producers, Renault and Hyundai are highly profitable with profit margins of 6.7% and 6.6% ("The Car Company" 2005).

<sup>18</sup> Canon, for example, has replaced conveyor belts by production cells in which small groups make entire products. This reduced the labor needed for production and saved on factory space (Migliorato 2004).

They must either compete on the basis of design, as well as innovations in styling, stitching and the use of new materials, or face extinction. European firms provide models of how to survive and even prosper in the global economy, but there is no question that the Japanese textile industry faces a bleak future and smaller firms have a harder time finding the industry's backbone, and a harder time pursuing in-house resources with which to routinize innovation or contracting with universities or research institutes to assist them with innovation.

In a globalizing environment, the profitability and growth of firms now stems from innovativeness especially in countries where the labor costs are high. As will become apparent below, the innovative capability of Japan's industry will depend on not just the investment in R&D but a range of other changes. These will include the mergers of firms into more optimal sized entities, the exit of loss making firms, the entry of entrepreneurial and innovative firms, the opening of overseas subsidiaries, the adoption of new business models, greater attention to technological possibilities in other areas such as the life sciences, nanotechnology, energy, more efficient use of the workforce,<sup>19</sup> and the emergence of networked clusters of firms that promote as well as leverage basic scientific research in major universities.<sup>20</sup>

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<sup>19</sup> In recent years, firms have begun adopting flexible work rules and hiring more temporary workers, a shift that has been accelerated by legislation introduced in 1999 and in 2004 (Pilling 2004).

<sup>20</sup> Recent research on the likely outcomes of industrial restructuring in Japan suggest that output could rise by 1.6 percent over a three year period and 15 percent over 20 years (Kim 2003). On the possibilities for closer linkages with universities and research institutes, see Lehrer and Asakawa (2004).

## **Slow Growing Domestic Markets and Aging Consumers**

A second development that will affect the vast majority of Japanese firms producing largely or exclusively for the domestic market derives from the likely future trend in demand and in the composition of this demand. There are at least five factors that will influence the prospects of the manufacturing sectors. First is the impending decline in the size of the Japanese population and the increasing ratio of older people. As of 2005, the size of the labor force (and of the male population) has already started to fall. Close to a fifth of the population is over the age of 65 and the average age is now 41. By 2050 the ratio of the elderly will exceed one-third and the average age will climb to 53 ("The Incredible Shrinking" 2004).<sup>21</sup>

Demographic developments, which curtail household formation, will depress the demand for a wide range of consumer goods ranging from clothing and footwear to consumer durables and autos. The composition of demand is likely to move more in the direction of services, which could become sources of economic strength but are currently neither innovative nor highly productive ("Dead Firms" 2004). Moreover, a population with such demographic characteristics may be less demanding of innovation which in turn would affect the fortunes of Japanese firms operating in international markets. In other words, it can be argued that the domestic market environment could become less conducive to the pace of innovation needed for Japanese firms to sustain their leadership in the global economy. This would also slow economic growth. However, the aging of the population also presents Japanese firms to take the lead in products tailored for the

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<sup>21</sup> This demographic transition by increasing the resources assigned to the less productive segments of society, will have a dampening effect on growth (Bloom, Canning, and Sevilla 2001).

“seniors” market. For example, the perfecting of reliable and cost effective humanoid robots and smart houses by firms such as Sony, Honda, and Toshiba could open up a vast new market for home helper, security, and entertainment devices.

Second, a rising preponderance of the older age groups in the population could lessen the degree to which the domestic market can serve as a barometer of international trends for young people. Currently, for electronic equipment, clothing and a variety of cultural products, the highly discriminating “antennae” markets of Tokyo (as in Shibuya) and Osaka enable Japanese firms to test their newest products and to refine them prior to launching them overseas. Japanese pop culture (such as anime) is widely influential and Japanese designs of toys and cell phones command global markets ("Japanese Style" 2004). However, as the number of target consumers in these markets declines, so will their utility to companies. The changing demographic composition of the domestic market will call for a change in the strategic orientation of Japanese MNCs and smaller firms to use the domestic market as a springboard to enter international markets. The trend setters might become the older age groups in Japan, while firms might need to take their cues from younger age groups in other Asian countries.

Third, with Japanese household savings already having dipped to levels not much higher than those of U.S. households in the mid-1990s,<sup>22</sup> a further decline in the savings rate is unlikely to contribute significantly to domestic demand, the stagnation of which has depressed economic growth and is partly responsible for the weakening of the economy during 2004-2005. In fact, younger households may have to raise their savings

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<sup>22</sup> In 2002, Japanese household savings were in the 3-4 percent range down from 8.5 percent in 1991 (Campbell 2004).

to counterbalance any shortfall in pension benefits from the social security system. Thus the growth of domestic demand is likely to be paced by the expansion of GDP which will be driven almost exclusively by increases in factor productivity.

Fourth, as Europe is discovering, once economies start to stagnate, there is a strong incentive for young and talented knowledge workers to emigrate. Some 400,000 Europeans with advanced degrees have settled in the U.S. and three out of four Europeans receiving tertiary level education in the U.S. do not return to their own countries. More than half of Japanese recipients of doctorates in science and engineering fields from US institutions do not intend to go back home and the stay rate in the U.S. has been raising (National Science Board 2004).<sup>23</sup> The number of Japanese who are long-term residents and permanent residents abroad has been steadily increasing to reach more than 900,000 people in 2003. By 2006, this number will be more than one million (Japan Ministry of Foreign Affairs 2004). Most of these are individuals with high levels of education and skills. Demographic and economic changes in Japan could reduce the relatively small number of foreign knowledge workers that come to Japan and could further contribute to a larger net outflow of highly skilled Japanese workers to East Asia and the U.S. in search of better opportunities.<sup>24</sup> One can argue that these trends are caused by the stagnation of industry in Japan. A reforming Japan that is able to revive

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<sup>23</sup> In 1990-93, 43% of doctorate recipients in science and engineering field intended to stay in the US. This rate has increased to 44% and 55% in 1994-97 and 1998-2001 respectively. Although the number of Japanese doctorate recipients in S&E fields are small with only 655 in 1998-2001 (National Science Board 2004).

<sup>24</sup> Currently, the number of foreign workers in Japan is just 0.15 percent of the workforce as against 3 percent in Taiwan, 9 percent in Germany, and 11 percent in the U.S. (Lorange and Turpin 2004).

growth would offer job opportunities that would attract many of the Japanese émigrés, possibly reverse the net outflow and even induce more talented foreigners to seek work in Japan. Political developments in 2005, increased the likelihood of this scenario, but Japan's ability to rebound still needs to be tested.

Fifth and finally, the demographic trends might also favor a few urban agglomerations such as Tokyo and Nagoya over other urban centers. Both these areas have almost continually gained population through in-migration since the early 1950s. Osaka, however, has experienced net out-migration since 1974.<sup>25</sup> Firms located in metropolitan areas where the population and economic activity are declining would find themselves at a disadvantage and it is conceivable that a substantial geographical redistribution of industrial activity within and beyond Japan could occur. In the process there are likely to be many exits of firms and some industrial clusters might lose critical mass and not survive.

Japan's demographics will force firms to modify their strategies if they want to survive. For some, the best course will be to follow markets and knowledge workers overseas, largely or completely switching their focus to foreign markets. Others might find that a change in product mix will be desirable. In some cases a greater reliance on services and products catering to the needs of an older population might be a far better bet. Health care is certain to be a growth industry and in this industry there is a plenty of scope for innovation, IT use and regulatory changes that would spur productivity. Entertainment, biotechnology, and robotics are other possibilities. Dynamic companies

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<sup>25</sup> Statistics Bureau (2003). Tomiura (2003) also notes the decline in the fortunes of the Osaka region relative to the other two.

might also find that agglomeration economies compel them to move from declining centers to the few growing ones with a higher proportion of younger consumers. Under this scenario, Tokyo and metropolitan areas closer to East Asian markets might become more attractive. In any event, the far reaching changes in the demographic pyramid will make it impossible to continue with business as usual. There will be a need for product innovation oriented towards the growing segment of consumers in upper age groups. And many firms might find that profitability will depend on bundling a lot more services with products.

### **Innovation**

Both global competitive pressures and the changing characteristics of the domestic market call for greater innovativeness. However, there is no simple formula that all firms can apply. Nor are there clear guidelines for the government to adopt with respect to policies or institutions. Japanese multinational firms invest heavily in R&D and the productivity of their research is reflected in numerous patents. As Table 2 shows, Japan is second only to the U.S. in the number of patents registered with the USPTO in 2002-3. Furthermore, 8 of the top 15 patenting organizations in 2003 were Japanese (see Table 3). They are also a class apart with respect to manufacturing capability and in their attention to process innovations. Toyota is the world leader in automobile production and the standard against which other companies measure their own performance. Honda is at the cutting edge of automotive engine technology and the largest producer of internal combustion engines. Both these companies lead the pack in hybrid auto technology. Japanese MNCs have invested in R&D centers in the U.S., Europe and now China to tap



the research potential in these countries and to stay abreast of new technological developments abroad. Starting with domestic research consortia to exploit local synergies and spread research overheads, Japanese MNCs have moved into research alliances with non-Japanese firms to accelerate technological advance. Medium sized Japanese firms in the auto parts, electronics, engineering and other industries many of which have followed the bigger MNCs overseas, have also begun investing more in R&D and engaging in research partnerships. In other words, the threshold of innovation capability in Japan is high which makes the challenge of raising this threshold that much more acute.

Among the avenues to greater innovativeness, five offer the most promise. These are: closer linkages between firms, universities and research institutes; increased contacts between Japanese and foreign researchers that promote the circulation of knowledge workers;<sup>26</sup> the entry of new firms; a diversification of research effort to tap deeper into fields such as the life sciences; and efforts to create a milieu that encourages cross disciplinary research with the potential of yielding a richer harvest of commercializable innovations.

Through the 1990s, Japanese firms were benefiting from scientific research conducted by universities although a substantial share of this was being done in U.S. universities. This experience has encouraged both firms and the government to raise the

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<sup>26</sup> Japanese researchers published co-authored papers in science and engineering fields with researchers from 114 different countries in 2001 while the researchers in the U.S. collaborated with those from 166 different countries. Even though the breadth of international coauthorship is rather wide for Japanese researchers, the share of coauthored articles are only 20% of all the articles in science and engineering field. Close to half of the collaborators are those from the United States (National Science Board 2004).

contribution of Japanese universities to commercially relevant research through closer business university linkages (see Branstetter and Kwon (2004)). While Japanese firms have long maintained informal ties with university researchers and relied upon them for consulting services,<sup>27</sup> these linkages have only begun tightening during the past decade as institutional changes have induced academic researchers to seek closer contacts with the business sector with larger firms taking the lead. The number of cooperative research projects between universities and businesses has increased to 6,767 cases, a three fold increase since 1998 (Japan Patent Office 2004). Similarly the number of patent applications from universities has increased from only 145 in 1997 to 948 in 2003 (Japan Patent Office 2004).

Now that the national universities are being given additional incentives to raise a part of their funding from private sources, university business linkages can multiply further.<sup>28</sup> Since the introduction of Act on the establishment of technology licensing office in 1998, the number of licensing agreements with both for domestic and foreign firms has increased dramatically to reach 1,679 and 654 cases in 2003, respectively and now the royalty income has risen to more than 500 million yen (Japan Patent Office 2004). The advantage of a closer linkage with universities stems from the need to increase the ratio of significant to incremental innovations. Breakthrough innovations

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<sup>27</sup> Corporate researchers co-author papers with peers in universities, sponsor contract research, and spend time working in university labs.

<sup>28</sup> Branstetter and Kwon (2004) found that Japanese manager of larger companies felt that scientific spillovers from universities were no less important than did the U.S. managers. The needs to cut down expenditures so as to pare the public debt is reflected in the proposal to cut government spending on R&D especially the life sciences, starting in 2006 ("Budget Plans" 2005).

especially in the life sciences, frequently rest on scientific advances calling for basic research that is the strength of university departments and not necessarily of corporate research labs. This is reflected in the frequency with which pharmaceutical patents cite scientific research. The challenge for both parties will be to arrive at a workable division of labor that is appropriate for Japan's future technological needs and harnesses the strengths of both the university as well as the corporate research establishment. In terms of R&D spending in basic research, both business enterprises and tertiary level institutions spend a comparable amount equal to about 0.15% of GDP in 2002. In contrast, R&D expenditures on basic research by US firms amount to only 0.08% of GDP in 2003 while that by universities is 0.31% (OECD 2004). Currently, the contributions academic research centers can make lie mainly in the area of basic research while corporate research labs have a well established capacity to commercialize innovations. While this may change, over the medium term, the greatest gains for the industrial community may be in working with university departments at two levels: one is to provide material support and feedback that will improve the quality of the training provided by universities; the other would be to possibly redirect some of the basic research conducted in universities towards areas with longer term commercial promise. Firms could in turn adjust the focus of their applied research and adopt a more 'open' approach to innovation so that it complements and more fully capitalizes on the findings of academic scientists.<sup>29</sup> This way, the universities would continue to emphasize

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<sup>29</sup> Laursen and Salter (2004) find that when firms adopt more open R&D strategies they are more likely to tap the research in universities. Chesbrough (2003) also emphasizes the advantages of openness as the avenue to greater innovativeness.

teaching and research that better equips their students with needed skills and extends the frontiers of knowledge, which is their core competence. Corporate research centers meanwhile, can channel more of their resources into producing useful innovations rather than embarking on riskier basic research.

The increasing circulation of knowledge workers and closer links among them via the internet, are contributing to the productivity of research in the U.S., in Europe, and in East Asia ("Quickening" 2000). Such circulation not only stimulates the diffusion of ideas and the exchange of tacit knowledge, it also promotes heterogeneity in research communities that can help to spark innovations. It can lead to more co-authored papers, and the intermingling of academic and corporate science personnel induces the kind of interdisciplinary research that is fruitful with respect to innovation with commercial potential. Circulation of knowledge workers between Silicon Valley and Taiwan (China), for example, is believed to have helped in the development of high tech clusters in the Taipei-Hsinchu Park area and to have created a close knit scientific and business communities on both sides of the Pacific (Saxenian and Hsu 2001). Not only has the movement of knowledge workers resulted in a bi-directional flow of technology, it has also brought about venture capital and international business contacts and greater flow of business intelligence in its wake. The net result of this is an upsurge of innovative activity spearheaded by new firms that are frequently a more reliable source of cutting edge technology than large, long established corporations.<sup>30</sup>

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<sup>30</sup> Anderson (2004 p. 59) claims that "corporate R&D spends 80 percent of its time and talent on product improvements and 20 percent on really new stuff".

The circulation of knowledge workers and contacts among them has certainly benefited from advances in IT, a decline in travel costs, and in impediments to travel. Governments and universities have also played major roles in encouraging such interchange though this has slowed following 9/11. This they have done through special programs, grants, and scholarships so as to create transnational scientific communities and enable critical masses of researchers to emerge in key scientific fields. One such attempt is currently underway in Singapore where the government in conjunction with the leading universities and research institutes, is seeking to build a world class biotechnology cluster. It is pulling in researchers from all over the world and offering them a highly attractive research environment. Other initiatives underway in Europe, for example, the Erasmus and Socrates programs, provide models for the Japanese academic community to consider.<sup>31</sup>

The distribution of S&E articles in Japan is fairly skewed, with more articles written in chemistry, physics, and engineering/technology fields compared to the distributions around the world, OECD, or the US (see Table 4). As mentioned above, given the rising importance of the interdisciplinary linkages and innovations stemming from such cross-fertilization, increasing the breadth of research and encouraging cross-disciplinary exchanges may be a worthwhile strategy.

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<sup>31</sup> 150,000 Japanese were outside of the country as students, researchers, and faculties in 2003. More than half of them were in North America. There were more than 360,000 Japanese living abroad (but without permanent residency nor citizenship) for business purposes. Among these people, close to 140,000 are in North America and a similar number in Asia (Japan Ministry of Foreign Affairs 2004). The share of foreign students in Japanese universities was only 1% for the total number of undergraduates and less than 10% of graduates in 2001 (National Science Board 2004).

However, the strength of current research fields in Japan needs to be preserved and where possible strengthened. As it is, the quality of the articles published by Japanese institutions is only moderately high when measured by the number of international citations to these articles (see Table 5). Even in the fields where Japan publishes relatively more articles, they are not necessarily cited more widely. In fact, most Japanese articles are seldom cited internationally at all. Overall, articles from Switzerland are cited most frequently with the relative citation index exceeding 1.00 for many fields. Japan needs to establish herself as the place for innovative activities to attract globally mobile knowledge workers. The quality of university research is likely to be one of the main attractors for such people. However, without articles originating in Japan being widely cited around the world, and thereby establishing the reputation of Japanese research, Japan will have a harder time enlarging its role as a research hub.

We have already referred to the significance of new entrants in promoting innovation, however, this is a point that deserves some elaboration. There is little doubt from an analysis of patent counts, whether in Japan, the U.S., Korea, or Germany, that large companies are the most prolific sources of such output. Undoubtedly also, larger firms are better able to produce, develop and market innovations because they have the financial heft and experience needed to fine-tune and test an innovation, to invest in often expensive production facilities, and to engage in international marketing. The Playstation, the new PSP from Sony and the plasma display panels developed by Pioneer are three examples of complex products incorporating numerous innovations which only companies with substantial experience, research capacity, production skills, marketing

depth, and reputation, could produce.<sup>32</sup> But a wealth of empirical findings on the electronics, telecommunication, software, and biotech industries suggest that new entrants and small companies are much more cost effective producers of innovations, and that they are especially successful in introducing “disruptive” technologies that can give rise to new markets. Over the past 20 years, Japanese high-tech industries have gained only a tiny number of new startups.

Thus a market environment that encourages new entry would significantly influence the quality and state of innovation in Japan. In part, ease of entry is a function of barriers arising from registration and licensing requirements and associated with the transaction costs of starting a new business. These are not especially high in Japan. Partly it depends on access to risk capital, which also has become more abundant in Japan with the rise of domestic venture capitalists and the increased presence of foreign ones.<sup>33</sup> Entry is also governed by factors influencing the exit of loss making businesses, the incentives for leading engineers to set up new firms, the market practices of incumbent firms, and the degree to which predatory or exclusionary behavior is checked by competition policies. Lastly, entry by firms that are introducing new technologies is affected by the perception of the risks associated with failure.

In Japan, incumbent firms can influence market competition in ways that can create a chronic overhang of excess production capacity that depresses profits and

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<sup>32</sup> Similarly, pathbreaking research on surface-conduction electron-emitter display flat panels has been done by Canon. Toshiba through a joint venture while Seiko Epson has produced a rival organic light emitting diodes ("Canon and Toshiba" 2004).

<sup>33</sup> Japanese insurance companies and banks are among the main sources of VC, the former favor late stage financing while the latter more often support entry level firms (Mayer, Schoors, and Yafeh 2003).

thereby discourages entry. One is the tendency to quickly imitate a successful product or strategy. The other is the barrier to exit created by the availability of bank financing, labor market institutions supporting life time employment,<sup>34</sup> and costly bankruptcy procedures. Both of these combined exert a downward pressure on profits (Porter and Sakakibara 2004). Concerns regarding the profitability of new ventures add to the risk of failure which is a major disincentive for young entrepreneurs.<sup>35</sup> The costs of failure of a new business, in terms of reputation, loss of 'face', and the sharply diminished scope for raising funds to start afresh, remain steep enough to make the more creative elements in society excessively risk averse. Both exit barriers and the 'fear of failure' may be of diminishing significance but they continue to dampen market dynamism and as such deserve to be addressed at many different levels by the government, business and financial communities. Some evidence that successful startups have begun to multiply over the past decade is provided by Maeda (2004).

The salience of cross disciplinary research in generating some of the most successful innovations is no longer open to question. A little reflection suggests that for most products, it is necessary to bring together many different kinds of expertise. For

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<sup>34</sup> Although the labor market in Japan has been changing since 1990s, the proportion of the regular workers has fallen from 74.4% to 64.5% while the proportion of non-regular workers increased from 18.8% to 28.1%. This change has given the firms flexibility they needed to restructure their businesses ("Japan: OECD Highlights" 2005).

<sup>35</sup> Many budding entrepreneurs are aware of the relentless effort needed to launch and sustain a new business venture -- a lessons that the owner founders of Japan's many SMEs have communicated to their progeny (Whittaker 1997).



example, cars now come laden with complex electronics<sup>36</sup> require the input of thousands of IT specialists, and the food processing industry is heavily reliant on the research on plant genetics and on biochemical and packaging technologies to name just a few. Some of the latest advances in medicines depend on implants (of pacemakers, defibrillators, drug pumps, deep brain stimulators, monitors and valves)<sup>37</sup> that combine the wizardry of electronics, materials sciences and engineering to produce items that can survive and function in the human body for years if not decades. Similarly, the development of new energy sources that are environmentally friendlier involves a marriage of many different technologies.<sup>38</sup>

An even more complex mix of the physical and social sciences is required to come up with technologies that will serve to enhance security and to do this as unobtrusively as possible.

There are plenty of studies to show that fruitful cross disciplinary research calls for institutional arrangements conducive to informal communication among researchers from different fields (and cultures). The effectiveness of such mingling can be rendered more purposeful and the thinking of researchers sensitized by analytic preparedness and a

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<sup>36</sup> Car navigation equipment is among the most profitable competitive products offered by Japanese companies.

<sup>37</sup> See Citron and Herem (2004).

<sup>38</sup> In the area of materials development a company called Material Connexion has helped Nike, Estee Lauder, Target, and others find new and innovative materials to improve their products (Finn 2004).

keen awareness of the opportunities inherent in arriving at combinations of technologies that lead to innovative practical applications.<sup>39</sup>

Often world class universities or the very large research labs, still maintained by companies such as IBM and Lucent, can provide such a milieu. Very probably universities have a better chance of creating the atmosphere where free exchange and novel technological combinations can emerge. But such universities are few and they need to bring together high standards of academic excellence, an openness to ideas, and an international faculty as well as body of students. Moreover, they need to orient themselves more towards the business community. It is a difficult balancing act. Nonetheless, the rewards for the individual, institutions, and for society as a whole are substantial making it an objective some of Japan's universities might want to forcefully pursue.

### **Avenues for Diversification**

For manufacturing firms whose profit margins are being squeezed by competitive pressures, diversification offers opportunities but can also pose severe problems. The major Japanese manufacturing corporations are already quite diversified, having moved into products adjacent to their core businesses. But companies have many unrelated activities as well. Toyota, for example, controls a construction company and Toray is engaged in medical, IT and other lines of business. The process of diversification is by

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<sup>39</sup> Lester and Piore (2004), p.5, "The real well springs of creativity in the U.S. economy in the capacity to integrate across organizational, intellectual and cultural boundaries, the capacity to experiment, and the habits of thought that allow us to make sense of radically ambiguous situations and more forward is the face of uncertainty".

no means a science. Many attempts at diversification either through own investment in a new activity or the takeover of an existing business end in failure. This is more likely if these are nonadjacent activities, and the diversifying firm lacks any special expertise in the area it is entering and cannot easily leverage its other assets such as marketing and brand name. But there are successful instances as well. In the U.S. for example, IBM has been highly effective in developing a consulting arm that now generates more than half of the corporate earnings. Likewise GE Capital is a major source of profit for GE Corporation. The point of these examples is to note that for some manufacturing firms the way forward might well be to develop in-house skills in related service based activities or to acquire firms that are providers of such services. Sony is one high profile example of a firm that has diversified into entertainment services encountering substantial difficulties along the way.<sup>40</sup> The attraction of services stems from higher value added, and the lower risk of commodification to which manufactures are more susceptible.<sup>41</sup> Some companies will prefer to maintain their focus on manufacturing and rely on innovation as well as a variety of other means to hold on to their competitiveness. But for others, the way forward will be to acquire a dual capability in services, to apply lean production techniques, and introduce new innovations so as to smoothen out fluctuations in earnings apart from boosting profits.<sup>42</sup> This will test management skills,

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<sup>40</sup> During 2003-4, Sony's income from its movie unit rose substantially and encouraged it to buy MGM studios. The movie business hit a lean patch in 2005 with declining cinema ticket sales.

<sup>41</sup> However, the commodification of services is on the rise.

<sup>42</sup> Canon USA, for example, has focused on software development and other services earning \$449 million in 2003 ("Canon Targets" 2004). Swank (2004) shows how financial services providers can be 'lean' and innovative.

require fresh thinking about business models, and in learning the techniques of innovating in the area of services. One thing that Japanese firms will not have to learn when diversifying into services is the importance of intangible assets, in particular human skills, experience and customer relationships.

## **Disintegration**

Starting in the 1980s, Japanese firms have been investing in production facilities abroad to take advantage of lower production and personnel costs and to surmount trade barriers.<sup>43</sup> However, over the past decade the effort to rationalize production and to pare down costs has moved to a new plane because of changes in business models, in the cost of logistics, and through the far greater integration of IT into the working of businesses and interconnections among them. IT has made many previously non-tradeable activities into tradable ones and thereby accelerated the disintegration of firms through outsourcing and offshoring.

For Japanese, as for firms in other industrialized countries, difficult choices must be made over how much to deverticalize and give up intrafirm production economies, how to outsource, how much production to move offshore, and how to optimize production geographically. One extreme approach is to focus quite narrowly on a core competitiveness and outsource all other functions to first tier suppliers. Boeing, for instance, now views itself as a company specialized in design and systems integration and is willing to let others do most of the actual production. Companies such as GE have

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<sup>43</sup> An earlier focus on SE Asia is now giving way to an emphasis on investment in China, particularly the area around Shanghai (Fung, Iizaka, and Siu 2004).

moved offshore much of their back office functions and are now ready to partially outsource these to other firms. Microsoft, Motorola, and other IT companies find it advantageous to let contract manufacturers such as Flextronics, Solectron, and Celestica manufacture the X-Box and their handsets and a company such as Nike only deals with design, marketing, quality assurance, and supply chain management.<sup>44</sup> Nike's shoes are produced by suppliers scattered across the world. Even when a clustering of component suppliers is highly advantageous for the purposes of IT production, lean warehousing and short supply chains, some major firms in the industrialized countries are finding that it might pay to let others produce for them rather than keep many diverse activities under one organizational roof. This is in spite of the risks from loss of intellectual property and of eventual displacement by OEM suppliers and others who learn to research, produce, design and market a product and no longer need to rely on a large multinational assembler. Automobile companies that are outsourcing entire modules can increasingly be at the mercy of their suppliers.

To a substantial degree, the large Japanese firms have outsourced business, computer and information services. In fact, Japan is the third largest outsourcer of services after the U.S. and Germany (see Table 6).<sup>45</sup> At the same time, the major firms, Toyota being a leading example, have kept the production of many key components in-

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<sup>44</sup> Sony found that deverticalization created problems for the development and integration of the technology for the PS2 and this was compounded by production problems. Hence it has moved towards a degree of vertical integration.

<sup>45</sup> Outsourcing is estimated to have contributed 3.3 percent of value added to the EU economy between 1993-97. Also, this outsourcing is likely to have increased the demand for skilled labor in the EU (Amiti and Wei 2004).

home and also maintained long standing alliances with component manufacturers. When they have moved overseas, assemblers have induced their suppliers to move with them, thereby geographically transplanting entire production systems.

This process is evolving. Companies such as Sony, after an initial round of outsourcing, have moved to re-integrate production of key components as with the Cell microprocessor. Others such as NEC and Toshiba have outsourced production to contract manufacturers and more could follow. But attaining the right balance so as to retain an enduring competitive edge in a fundamental industrial area will be a major challenge over the medium term. Achieving this balance and effectively managing a range of outsourced or offshored functions will also need to be paired with diversification into service activities and a readiness to move into adjacent areas of manufacturing through takeovers or own investment if opportunities present themselves. In other words, globalization and technological change has rendered the situation much more fluid. Companies will need to adopt a more flexible approach, modifying their business models as circumstances change but retaining at all costs their organizational integrity, a strategic direction, and their competitiveness based on the capability to innovate.

### **Multinational Operations**

The anticipated trends in the growth and composition of demand in the Japanese market will be strong inducements for firms to transfer more of their attention to foreign markets. Japanese firms are no strangers to multinational operations and have shown that they can adapt to foreign institutions and to labor markets while retaining management, personnel and production practices that are specific to Japanese companies and set them

apart from others. However, most of the leading corporations, with the possible exception of Honda, have still kept their headquarters and the bulk of their operations in Japan. Their management is largely if not exclusively Japanese as is the business culture. Although this is now changing, key overseas managerial positions are held by Japanese nationals and plants frequently rely on supervisors and skilled personnel from their home based operations to train staff and oversee critical production activities. This often strains the human resources of companies because such personnel are scarce and most do not have foreign language skills. Similarly, companies have setup major production bases abroad but prototyping, the launch of new products, and the initial stage of manufacturing is typically done in Japan, so that any teething problems can be ironed out and production techniques perfected. The domestic focus of production for the newer and innovative products is also motivated by the concentration of the principal research activities in Japan, the desire to test products first on domestic consumers, and to safeguard technologies and protect intellectual capital.<sup>46</sup>

Were the domestic market for various products to stagnate or to shrink as is likely, Japan's more dynamic companies will need to progressively shift their orientation towards the growing markets abroad. Production, research and headquarter functions would have to follow or companies could adopt a decentralized mode of operation that gives a large measure of autonomy to regional subsidiaries.

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<sup>46</sup> The recent announcement by Fuji Photo Film on its new investment in Japan to produce wide-view film for LCD panels underscores this point ("Japan: Fuji" 2005).

In any event, a major structural transformation of the business sector is in the offing with a building up of operations in countries such as China and India<sup>47</sup> as well as further expansion in the U.S. and Europe.<sup>48</sup> The big hurdles for firms, and particularly the medium and smaller sized ones, will arise from the need to acquire styles of management and organization that are more attuned to local cultures or keyed to emerging 'global' models of management that rely on a truly multinational workforce and to find specialized engineering and management skills locally. It will also become necessary to ensure that the high standards of productivity, efficiency, and incremental innovativeness achieved in Japan (that depend on a network of high end suppliers) are not only maintained but also steadily improved. Techniques will need to be devised to transfer tacit knowledge to overseas plants and to codify and embed often quite unique characteristics of the Japanese production system in overseas operations.<sup>49</sup>

As this process of transition and geographical dispersion unfolds, the nature of business organizations, their culture and their sense of rootedness in Japan could be quite radically altered. In order to remain competitive firms will have to adopt explicitly

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<sup>47</sup> An expensive electronics plant producing semiconductors in China can operate 360 days a year versus 260 days in Japan.

<sup>48</sup> For instance, Toyota had only 11 factories outside of Japan in 1980. However, with the expansion of their facilities abroad, now it has 46 plants in 26 countries in addition to design centers in the US and France and engineering centers in the US, Thailand, and Belgium ("The Car Company" 2005).

<sup>49</sup> Toyota has a group of line workers who will fly all over the world to train the local staff when new factories open or when changes are introduced to the existing facilities. However, Toyota is facing shortage of such managers and foremen who can work abroad on a temporary or a permanent basis. Faced with this difficulty, it has opened a training facility, Global Production Center in Toyota City, to train foreign workers and the Toyota Institute to train managers ("The Car Company" 2005).



global strategies for product development, the location of manufacturing facilities, and marketing. This will be a challenge for all companies but more so for the smaller ones some of which have begun transferring their operations overseas. SMEs have long depended upon acquiring the latest production technology, on mastering the capability of their machinery, cost and defect reduction, and incremental process innovations. This approach may have to be expanded to embrace more strategic planning, organizational innovations, and technology alliances with universities as well as other firms to introduce more product innovation and complement products with services (Whittaker 1997). Very likely we will see more consolidation of firms into larger sized entities through M&A, a trend that is already gaining momentum as cross-shareholdings are unwound, accounting rules made more transparent, and because of changing perceptions regarding the benefits of mergers (Feldman 2004). This would further transform the business landscape. How these changes and others arising from a closer integration with the global economy will impinge upon competition new entry of firms and innovation is difficult to predict.

### **Concluding Observations**

In this paper, we have argued that the industrial firms driving Japan's growth will need to continuously modify their strategies in order to remain competitive.

Globalization, the rising manufacturing capabilities of emerging economies in particular China, and large investments in production capacity are increasing market pressures and eating into profit margins. These pressures are being compounded by movements in exchange rates. The changing demographics of the domestic market are changing some

of the options available to business and forcing a rethinking of what firms produce and where they focus their marketing efforts.

Many companies have responded to these pressures by cutting costs, emphasizing incremental process innovations, moving production overseas, diversifying and withdrawing from certain segments of the market. These kinds of actions will remain intrinsic to future business strategies but they may not be enough. The future performance of firms could depend more on the pace and scale of innovation, on selective diversification into new products and services and on a significant restructuring of operations through deverticalization and some vertical integration, outsourcing, and geographical reorientation towards the more rapidly growing markets. We make these statements with all due caution because it is difficult to extrapolate the future course of change from recent developments. The past history of globalization is by no means linear; it is proving impossible to anticipate technological breakthroughs or to make confident predictions about the speed at which major innovations will diffuse, business models have a short half-life, and the traditional models of Toyota and Canon have performed surprisingly well, making it harder to make categorical statements about innovations in business organization, management and internal labor markets.<sup>50</sup> On the basis of past experience, it is also impossible to say whether the newly industrializing economies will be able to sustain their recent rates of economic expansion.

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<sup>50</sup> The lesson John Kay (2004) draws from Honda's remarkable achievement is that "successful business strategy is a mixture of luck and judgment, opportunism and design, and even with hindsight the relative contributions of each cannot be disentangled".

However, with these qualifications very much in mind, we have underscored those aspects of business strategy which deserve attention based on our current knowledge. Innovation capability is likely to be central. It will depend upon the strength of the national innovation system of which universities and the training of researchers are key ingredients. It will require openness and flexibility and a willingness to enter into alliances on the part of firms as well as a division of labor between them and other players.<sup>51</sup> Japanese firms, which have stressed research in the fields of electronics, IT and optics (see Table 7)<sup>52</sup>, might want to put more of their resources into the life sciences, nanotechnology and alternative energy sources in view of demographic trends and rising resource constraints. The focus of research in the U.S. (see Table 8) can be a guide.<sup>53</sup>

Charles Lieber ("How to Succeed" 2003, p.89) has rightly observed, that "Nanotechnology can overturn assumptions about how things have to be done. Instead of parts and subassemblies (in manufacturing) you start with building blocks like nanowires,

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<sup>51</sup> TOTO, for example, was able to diversify a technique for eliminating smells by using the research on photonic catalysis done at the University of Tokyo. But this was made possible by the firm's own success at developing a simulator for generating smells. Through this and other innovations, Toto now accounts for 60 percent of the Japanese market and is penetrating high end markets overseas, with products such as the Super Bowl (Tilin and Mikami (2004) and personal communication by Professor Fumio Kodama).

<sup>52</sup> The major MNCs and also firms such as the Kao Corporation, Nidec, Hoya, Bandai, and NTT DoCoMo have spearheaded Japan's innovation in these areas (Ng and Yip 2004).

<sup>53</sup> Technology Review's (2004b) annual survey of the technological strength of global companies based on the number of patents, their impact, their science linkage and their technology cycle time, identified the following leaders in each of 8 manufacturing subsectors in 2003: Aerospace, Lockheed Martin; Automotive, Delphi; Biotech and Pharmaceuticals, Pfizer; Chemicals, 3M; Computers, IBM; Electronics Hitachi; Semiconductors, Micron; Telecommunications, Lucent.

nanotubes, and nanoparticles. Put together one way, these building blocks make a computer. Put another way they make a biological sensor”.<sup>54</sup>

Innovation alone may be insufficient and in fact, the ‘optimal’ innovation strategy itself could rest on the models of business that are adopted. If trends that have surfaced in other industrial countries influence Japan, a consolidation of firms in sectors such as steelmaking, engineering, and the electronics industry is likely to reduce excess capacity and raise profit margins. The Japanese steel industry has already taken steps in that direction with the merger of Kawasaki Steel Corp. and NKK Corp. into JFE Holdings.

This may go hand in hand with deverticalization and outsourcing as firms specialize on narrower product segments (e.g. Texas Instruments is concentrating more of its resources on fewer categories of ICs such as DSP and DLP chips), and farm out non core operations to other specialists. At the same time, firms may find it expedient strategically to diversify into related and fast growing services with higher profit margins (e.g. the auto makers have profitable financing arms and the electronics giants have entered consulting, software and web related services).

Finally, the restructuring of businesses in Japan could lead many firms to adopt more explicitly global strategies. If market growth prospects are better in East and South

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<sup>54</sup> Nanotechnology quintessentially calls for close collaborative relations between universities and firms. Universities can provide the basic research in materials and the expensive laboratory facilities to generate significant innovations. Large firms have the manufacturing expertise and resources to invest in commercialization and production. Thus, we see the field populated with small firms that have come up with innovations such as Nanophase and giant MNCs such as IBM, Mitsubishi, Dow Chemicals, and GE (“Small Wonders” 2004). Recently, Rice University decisively contributed to the utility of nanotechnology by patenting a technology for untangling and separating nanotubes (Hall 2005; Technology Review 2004a).

Asia or in the Americas, businesses that need to be closer to their main markets would relocate production and eventually some of the research and headquarter functions abroad.

Economics is not an entirely reliable guide to the future, but it does provide some useful clues and our reading of these clues suggests that successful firms will need to be agile, innovative, flexible, and able to operate globally.

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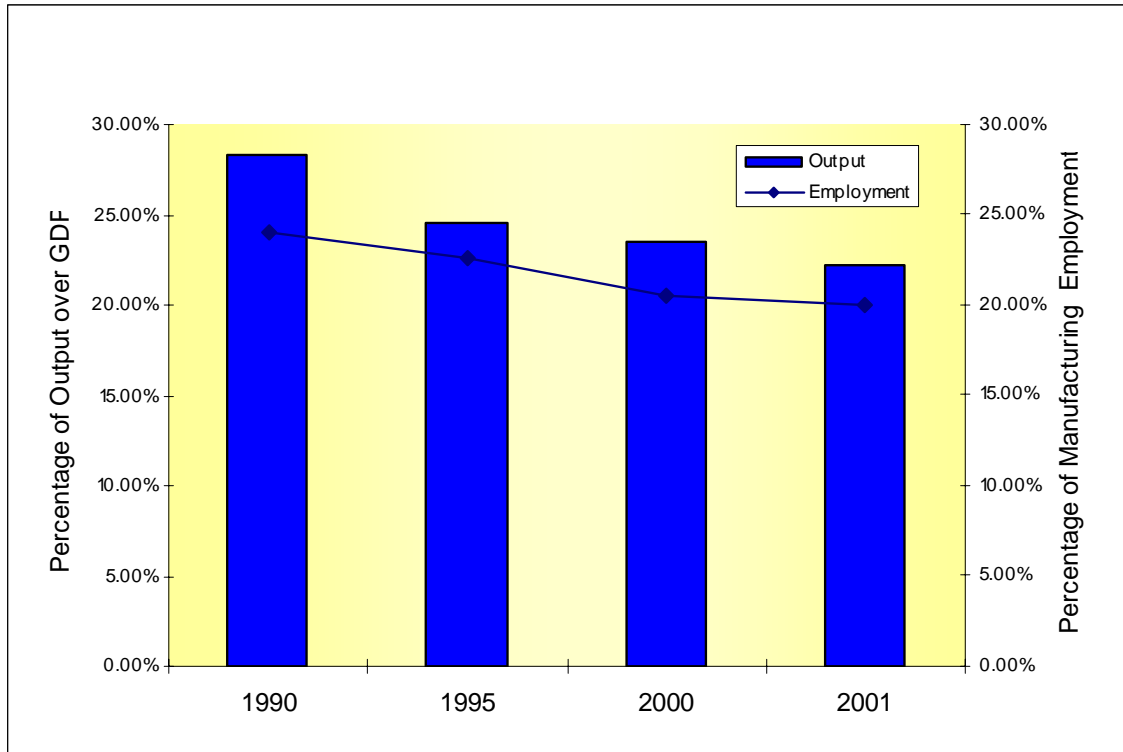
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**Figure 1: Japan's Manufacturing and Employment Ratios**



*Source:* Data for Employment from Statistical Survey Dept. Statistics Bureau, Ministry of Public Management, Home Affairs, Post and Telecommunications and data for Output is from Dept of National Accounts, Economic and Social Research Institute, Cabinet Office, Japan.

**Table 1: Share of Exports by Product Category (2003)**

<b>Item</b>	<b>Share Percent</b>
Textiles	1.8
Chemicals	8.0
Metals	6.2
Machinery other than electric	20.3
Electric Equipment	22.9
Transport Equipment	24.9
Precision Instruments	3.9
Others	10.4

*Source:* JETRO (2003)

**Table 2: Patent Output by Country**

<b>Rank in 2003</b>	<b>Number of Patents in 2003</b>	<b>Share of All Patents in 2003</b>	<b>Country*</b>	<b>(Rank in 2002)</b>	<b>(Number of patents in 2002)</b>	<b>(2002 to 2003) (Change in Number of patents)</b>
1	37,250	19.9%	Japan	(1)	(36,340)	(2.5%)
2	12,140	6.5%	Germany	(2)	(11,957)	(1.5%)
3	6,676	3.6%	Taiwan	(3)	(6,730)	(-0.8%)
4	4,132	2.2%	South Korea	(6)	(4,009)	(3.1%)
5	4,127	2.2%	France	(4)	(4,421)	(-6.7%)
6	4,031	2.2%	United Kingdom	(5)	(4,196)	(-3.9%)

Source: U.S. Patent and Trademark Office

**Table 3: Patent Output by Company**

Preliminary Rank in 2003	Preliminary number of patents in 2003	Organization	(Final Rank in 2002)	(Final number of patents in 2002)
1	3,415	International Business Machines Corporation	(1)	(3,288)
2	1,992	Canon Kabushiki Kaisha	(2)	(1,893)
3	1,893	Hitachi, Ltd	(5)	(1,601)
4	1,786	Matsushita Electric Industrial Co., Ltd (a)	(6)	(1,544)
5	1,759	Hewlett-Packard Development Company, L.P. (b)	(9)	(1,385)
6	1,707	Micron Technology, Inc.	(3)	(1,833)
7	1,592	Intel Corporation	(15)	(1,077)
8	1,353	Koninklijke Philips Electronics N.V.	(16)	(842)
9	1,313	Samsung Electronics Co., Ltd.	(11)	(1,328)
10	1,311	Sony Corporation	(7)	(1,434)
11	1,302	Fujitsu Limited	(12)	(1,211)
12	1,243	Mitsubishi Denki Kabushiki Kaisha	(10)	(1,373)
13	1,184	Toshiba Corporation	(14)	(1,130)
14	1,181	NEC Corporation	(4)	(1,821)
15	1,139	General Electric Company	(8)	(1,416)

Source: U.S. Patent and Trademark Office

**Table 4: Portfolio of S&E Articles by Field (2001)**

	Japan	US	OECD	World wide
Number of articles	57,420	200,870	551,402	649,795
Of which (%)				
clinical medicine	28.7	31.7	30.7	28.4
biomedical research	14.0	16.9	15.0	14.2
biology	6.1	6.2	6.8	6.8
chemistry	14.9	7.1	10.3	11.9
physics	19.1	8.7	11.9	13.4
earth/space sciences	3.0	5.6	5.4	5.4
engineering/technology	11.6	6.9	8.2	9.0
mathematics	1.4	1.8	2.0	2.2
psychology	0.5	4.7	3.3	3.1
social sciences	0.5	3.9	2.6	2.3
health science	0.1	2.5	1.6	1.4
professional fields	0.1	3.9	2.2	2.0

Source: Science and Engineering Indicators 2004 (National Science Board 2004)

**Table 5: Relative Quality of Publications in 2001**

	Rank	Relative Citation Index
All Fields	20	0.57
clinical medicine	22	0.54
biomedical research	17	0.58
biology	33	0.47
chemistry	22	0.63
physics	25	0.56
earth/space sciences	21	0.56
engineering/technology	27	0.54
mathematics	32	0.45
psychology	28	0.29
social sciences	31	0.34

Note: Relative Citation Index is the country's share of cited literature adjusted for its share of published literature, excluding within country citations. An index greater (less) than 1.00 indicates that the country is cited relatively more (less) than is indicated by the share of publications.

Source: Science and Engineering Indicators 2004 (National Science Board 2004)



**Table 6: Outsourcing by Country - 2002**

<b>Million of US\$</b>			
<b>Country</b>	<b>Business Services</b>	<b>Country</b>	<b>Computer and Information Services</b>
U.S.	40929	U.S.	6124
Germany	39113	Germany	2002
Japan	24714	Japan	2148
Netherlands	21038	Netherlands	1586
Italy	20370	Spain	1572

Source: Amiti and Wei (2004)

**Table 7: Share of Top 10 Patent Classes for Japan Residents**

	All	Japan	Japan Share	US	US Share	Japan Rank	US Rank
	169028	35517	21.0%	87901	52.0%		
Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)	4293	1575	36.7%	1724	40.2%	1	5
Semiconductor Device Manufacturing: Process	5096	1225	24.0%	2317	45.5%	2	2
Stock Material or Miscellaneous Articles	3177	1086	34.2%	1409	44.4%	3	7
Incremental Printing of Symbolic Information	1711	826	48.3%	616	36.0%	4	38
Synthetic Resins or Natural Rubbers (includes Classes 520-528)	3393	801	23.6%	1475	43.5%	5	6
Computer Graphics Processing, Operator Interface Processing, and Selective Visual	2325	745	32.0%	1142	49.1%	6	12
Dynamic Information Storage or Retrieval	1103	736	66.7%	157	14.2%	7	141
Optics: Systems and Elements	1903	716	37.6%	808	42.5%	8	25
Radiation Imagery Chemistry: Process, Composition, or Product Thereof	1585	688	43.4%	562	35.5%	9	44
Static Information Storage and Retrieval	1950	672	34.5%	841	43.1%	10	22
		9070					
		25.5%					

Source: USGPTO

**Table 8: Share of Top 10 Patent Classes by United States Residents**

	All	U.S.	U.S. Share	Japan	Japan Share	U.S. Rank	Japan Rank
	169028	87901	52.0%	35517	21.0%		
Drug, Bio-Affecting and Body Treating Compositions (includes Class 514)	6950	4063	58.5%	504	7.3%	1	15
Semiconductor Device Manufacturing: Process	5096	2317	45.5%	1225	24.0%	2	2
Chemistry: Molecular Biology and Microbiology	3174	2095	66.0%	223	7.0%	3	46
Surgery (includes Class 600)	2690	1731	64.3%	290	10.8%	4	33
Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)	4293	1724	40.2%	1575	36.7%	5	1
Synthetic Resins or Natural Rubbers (includes Classes 520-528)	3393	1475	43.5%	801	23.6%	6	5
Stock Material or Miscellaneous Articles	3177	1409	44.4%	1086	34.2%	7	3
Multiplex Communications	2593	1373	53.0%	444	17.1%	8	21
Surgery (instruments)	1629	1236	75.9%	68	4.2%	9	117
Organic Compounds (includes Classes 532-570)	2824	1202	42.6%	446	15.8%	10	19
		18625					
		21.2%					

Source: USGPTO

