Innovation, Technology
and the Economy

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Introduction

p. 59 According to IBM's former chief scientist, Japan's "greatest technological strength" is the "speed with which developments are translated into improved products and processes". Little systematic investigation has been undertaken to find out how much of an advantage Japan has in this regard. This paper provides new information on this score, as well as on the spillover effects of R&D investment.

II. Innovation, Time and Cost

In comparing innovation costs[1], we must recognize that the official exchange rate does not adequately reflect the relative prices of R&D and other inputs in the innovation process in the U.S.A. and Japan.

p. 60 Thus, one must construct an exchange rate reflecting purchasing power parities for resources used in the innovation process. To do so, the author obtained date regarding the relative prices of these resources in the two countries.

A random sample of 50 Japanese and 75 American firms in the chemical, electrical equipment, rubber, machinery instruments, and metals was selected. The members of this sample account for about ¼ of all R&D carried out in these industries in both countries.

Among firms from both countries, there was overwhelming agreement that the Japanese tend to develop and commercially introduce new products and processes more quickly than the Americans, although their advantage in this respect is not as great as is sometimes claimed. Averaged over all industries, the time differential was about 18%,

[1] For a description of what is meant by innovation time and cost, see p. 59 bottom

according to the Japanese data, or 6% according to the American data. The picture varies from industry to industry. In machinery, for example, the Japanese and American data indicate that there was a substantial differential.

p. 61 Japanese firms also developed and commercially introduced new products and processes more cheaply than American firms. Averaged over all industries, the resource cost differential was 23% according to Japanese data, or 10% according to American data. Here too, the situation varies from industry to industry. In machinery and instruments, based on Japanese as well as on American data, the cost differential seemed substantial; in chemicals the American data do not indicate that any substantial differential existed.

III. External vs. Internal Technology

To see whether these cost and time differentials depend on whether innovations are based on internal or external technology, we picked a random sample of 60 major Japanese and American firms in the chemical, machinery and electrical equipment and instruments industries.

p. 62 The sample is composed of 30 matched pairs, where each pair consists of an American and Japanese firm of roughly comparable size in the same industry.

The results indicate that the Japanese tend to have cost and time advantages over U.S. firms. However, these advantages seem to be confined to innovations based on external technology. Among innovations based on internal technology, there seems to be no significant difference in average cost or time between Japanese and American firms. The ratio of innovation cost or time for a new product based on external technology to that for a new product based on internal technology tends to be much lower in Japan than in the U.S. This is true in each industry as well as for all industries combined.

American firms take almost as long, and spend almost as much money to carry out an innovation based on external technology as one based on internal technology. In the development part of the innovation process an American innovation based on external technology takes less time and money than one based on internal technology, but in the commercialization part, the time and cost is at least as great as one based on internal technology.

p. 63 In Japan, on the other hand, firms take about 25% less time, and spend about 50% less money, to carry out an innovation based on external technology than one based on internal technology.

p. 64 Moreover, this is true in all industries. The contrast between Japanese and American firms in the commercialization part of the innovation process is particularly striking. The Americans have been more inclined than the Japanese to invest heavily in marketing startup costs in an effort to position such innovations optimally in the market, the emphasis being more on marketing strategies than on technical performance and production cost. This has resulted in relatively high commercialization costs for such innovations in the U.S.

IV. Time-Cost Trade-offs

To see more clearly the nature and extent of the Japanese advantage with respect to innovations based on external technology consider the time-cost tradeoff function:

$$C=f(t)$$

Here, C equals the cost and t is the time devoted to the innovation. A convenient measure of the sensitivity of cost to changes in time is $-(dC/dt)*(t/C)$, the elasticity of innovation cost with respect to innovation time[2].

There is a consistent tendency for this elasticity to be higher in Japan than in the U.S. Both for development and for commercialization, this elasticity in Japan tends to be about double what it is in the U.S.

One important implication of this result is that Japanese firms seem willing to devote a much greater amount of resources than U.S. firms to reduce the time taken to develop and introduce an innovation.

p. 65 The Japanese seem to be willing to devote about twice as many resources to accomplish such a time reduction. Apparently, this is because they believe that the discounted value of the expected profits (gross or innovation costs) from an innovation tends to decrease more rapidly due to delays in the project than do U.S. firms.

[2] Βέβαια, τόσο το C, όσο και το t αποτελούν υποκειμενικές εκτιμήσεις (όταν αφορούν το μέλλον), άρα το εργαλείο δεν χρησιμεύει για πρόγνωση.

V. U.S.-Japanese Differences in the Allocation of Innovation Costs

p.66 The author obtained information from a sample of 100 Japanese and U.S. firms concerning the ways in which they allocate resources among the following six phases of the innovation process.

p. 67 1. *Applied Research*, which includes projects that "represent investigation directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either products or processes".

2. *Preparation of technical requirements and basic specifications*, which includes the specification of the product's characteristics, often in coordination with marketing and other non R&D personnel, as well as planning and scheduling of the project.

3. *Prototype or pilot plant*, which includes the design, construction and testing of a prototype or pilot plant.

4. *Tooling and manufacturing equipment and facilities*, which includes preparation for manufacturing and the design, construction and acquisition of manufacturing facilities for the new product, as well as tooling and equipment.

5. *Manufacturing startup*, which includes the training of production workers, the "debugging" of the production facilities and the resources expended to obtain an acceptable quality level.

6. *Marketing startup*, which includes marketing studies, advertising, sales promotion and other marketing activities before the sale of any appreciable amount of the new product.

The sample consists of 50 matched pairs, where again each pair consists of a Japanese and a U.S. firm of roughly comparable size in the same industry.

p. 68 The Japanese devote a much larger percentage of total innovation cost to tooling and manufacturing equipment and facilities than do Americans. The emphasis of Japanese firms on process engineering and efficient manufacturing facilities is well known, but never before have data been obtained to indicate how large this difference between Japanese and U.S. firms really is.

American firms, on the other hand, devote a much larger proportion of innovation cost to manufacturing startup, which may reflect grater difficulties in attaining desired quality levels. According to some Japanese firms, their manufacturing startup costs tend

to be relatively low because their engineers work more closely and directly with their workforce than do those in many U.S. firms[3].

The biggest and perhaps the most illuminating difference pertains to marketing startup. U.S. firms devote a much larger percentage (about double) of total innovation cost to marketing startup than Japanese firms. If American firms were able to reduce this percentage to the Japanese levels (while holding constant the amounts they spend on other stages of the innovation process), it appears that about 60% of the Japanese cost advantage would be eliminated[4].

VI. Summary and Conclusions

p. 69 A large part of America's problem seems to be due to its apparent inability to match Japan as a quick and effective user of external technology. As Brooks[5] has warned, "the U.S., so long accustomed to leading the world, may have lost the art of creative imitation…". This is not to deny that part of the Japanese advantage may be due to factors like (a) their propensity to overlap various stages of the innovation process, (b) their subcontractor network and (c) their fewer organizational barriers and better communication between functional departments of firms[6].

It nonetheless is striking that the cost and time required to carry out innovations based on external technology is so much higher in the U.S. than in Japan. One suspects that many firms safely could reduce the cost and time devoted to marketing startup without impairing the vital interface between R&D and marketing. More efforts might be made by both firms and government agencies to obtain information concerning foreign technology.

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[3] Of course, had the Americans devoted more money to stage 4, that is, Tooling and manufacturing equipment and facilities, expenses in stage 5 would have been lower (an indication of short-termism)

[4] Perhaps this denotes a "forced market-pull", instead of a "technology push" American approach

[5] Brooks, H., 1983

[6] Other factors are (d) the role of top management as catalyst, (e) the use of self-organizing teams, (f) the promotion of learning and (g) subtlety of control. Another factor is that, once a new product is shipped, and further improvements need to be made, the manufacturing engineering department in the Japanese plant may take these changes without going back to development.

The Japanese adeptness at utilizing external technology is well known. It is worth noticing that part of their success in this regard hinges on the thoroughness and skill with which they monitor foreign technology and determine which types of external technology to utilize.

References

Brooks, H., "*Japanese Technological Advances and possible United States Responses using Research Joint Ventures*", Testimony before House Subcommittee on Science, Research and Technology, 98th Congress, 1st. session, June 29-30, 1984