Chapter 7

A Dynamic Model of Technological Investment

How Do the Firms add Value to the Emerging Networks?

Abstract: Investments into technology involve purchase of new machinery, adoption of world-class methods, and research and development of new approaches to using firm-specific or tradable materials. American firms emphasize continuous research and development of new material options, leveraging on the expertise of the human capital traded from the domestic market. In addition, liberal immigration policies of the US offer substantial access to the diverse expertise not yet codified scientifically by the academic community. Japanese firms, who actively sponsor their workforce for management and scientific experience in the US, are in a unique position to minimize the costs of organizational learning. The sustainability of the lower learning costs has been conditioned on the extension of discovery process into the newly emergent landscapes.

Introduction

Creative technological investments are essential to the growth of firms. Without creativity, it is difficult for firms to sustain the competitiveness of their products. Barger (1951: 2) analyzed the development of transportation industry in the US until the end of World War II. The study highlights, "Combined passenger and freight traffic of all commercial agencies (land, water, and air) grew five times during the half century between 1889 and 1939, and almost doubled once again between 1939 and 1946… For the most part the new agencies have grown rapidly, and the older ones have expanded only slowly or have actually contracted… From about 1920, claiming much business that might have moved by rail, but also developing many new customers, highway traffic by truck and busline grew rapidly, and after 1930 airline traffic. To the highways the railroads lost mainly short haul traffic, much of it highly profitable. The airlines claimed long-distance passengers. In the case of waterways… during the interwar period [there was a] progressive loss of international traffic (both passenger and freight) to foreign-flag operators."

Bendix (1956: 444-5) evaluated the factors supporting the super-normal development of the US at the turn of the 20th century, as compared to that of the European nations. The findings showed that, "During the nineteenth century, the authority and success of the Western powers as well as the failure of the native peoples were attributed to differences in race. This doctrine of race was as questionable and self-serving as the entrepreneurial ideologies that justified the exercise of authority in industry…. In responding to their own changing beliefs, as well as to the challenge of nativist movements, Americans have sought to administer aid in the spirit of help and guidance, which respects the different cultural traditions of native peoples and seeks to enlist their willing cooperation." Cochran (1957: 36-37) illustrates, "Many of the early American automotive entrepreneurs were men familiar with the large bicycle companies that flourished in the [eighteen] eighties and nineties. American rural roads were of dirt or gravel that would not support a long, heavy vehicle in bad weather. Both manufacturers and potential customers thought in terms of bicycle and carriage design… Commercial manufacture of such "horseless carriages" started in 1894, and in 1899, the first year of large production, some 4,000 cars were manufactured by fifty-seven supply and assembly shops… Rubber companies supplied tires, bicycle-makers wheel and other parts, wagon builders the bodies, and some of the numerous American machine shops began to specialize in motors… the automobile assembler needed only a large empty building, some simple tools and machines, and a few workers." Edwards (1979: 126-7) remarks, "The famous Five-Dollar Day that Ford announced in 1914 was not necessary to fill the company's vacancies; it did, however, create an enormous labor surplus. The day after the announcement was made, there were ten thousand people outside the gates clamoring for jobs;… Thus it is no coincidence that the first large-scale entry of blacks into northern industrial employment occurred in the Ford plants. By 1926 Ford employed ten thousand black workers, over 90 percent of Detroit's black industrial labor force."

Fisher, Jain, and MacDuffie (1995: 117-118) noted, “Innovations in technology have also steadily increased the versions of car available by introducing new features (automatic transmission, front-wheel drive, disk brakes, and so forth) that never completely replaced the old features (manual transmission, rear-wheel drive, drum brakes).” “In many auto companies, the unit of analysis for capital investment accounting is the new car model program. The program manager for a new model project is given a budget with which to purchase tooling such as stamping dies, welding equipment, and molds for plastic parts. The goal under this system is to maximize the market value of the new model subject to the capital budget constraint.” Additional learning of the techniques supporting the cost-effectiveness of the traditional products offers opportunities for enhancing the value-added by creative machine tools. The first industrial revolution in England at the turn of the 18th century highlights the potential value of learning from the traditional international experiences. The industrial revolution originated in the mining industry, with the merchants specializing in the international trade with the newly discovered American and Asian regions leading the technological and organizational change. As such, instead of a common pattern of change emergent under the home-base revolution, there was a great diversity in learning across different industries. Pollard (1965: 101-102) highlights “In some cases, as in textile spinning, in printing, or in steam-engine making, entrepreneurs were dealing with mechanical devices completely different in nature from the equipment they replaced; in others, as in iron puddling and in some engineering processes, there were substantial changes in techniques, which yet merely replaced the earlier, recognizably similar, though less ‘efficient’, methods; in the chemical industry and in coke smelting, there was the discovery of possible chemical reactions which had just not been known at all before; and in other industries still, as in civil engineering and mining, it was possible by new methods of calculation and measurement to register achievements on a scale which had been quite unthinkable as long as work had progressed merely by rule of thumb and by unsystematic experience.”

The significance of international interactions is well illustrated by the case of basic material in the auto industry. The auto industry began the use of steel as outside panels in 1903. In 1912, The Budd Co. patented the first all-steel car body. Following the aerospace makers, the auto assemblers adopted the lightweight plastics during the 1920s to make auto interiors comfortable. After the World War II, Japanese firms sought to exploit the well-developed auto-grade steel by importing steel scrap from the US. The resulting products expanded the size of the American auto market by putting the vehicles within the purchasing power of the lower income groups. By 1970s, several Japanese steel-makers had forged strategic alliances with the American firms, and commercialized specialized processing of the imported as well as domestic scrap in mini-steel plants. The output of these plants suffered from a high material variability, abnormal wastage in auto applications, high costs of tooling, and difficulties in executing standardized quality tests. During the 1980s, upstart American firms discovered creative ways of improving the quality of steel manufactured under mini-steel model. Japanese steel makers expanded their direct investment networks in the US, and exploited new generation zinc-alloy galvanized steel. The new steel offered an ability to apply paint efficiently, precise and uniform coating thickness, consistent stamping and spot welding, and stable corrosion resistance. In the late 1980s, Japanese automakers positioned new vehicles as luxurious, gaining substantial quality premium over traditional subcompacts. American firms sustained profitability using products that were more spacious and recreational. During the early 1990s, Japanese steel plants in the US adopted the frontier annealing technology, along with the advanced vacuum-degassing facilities, to make ultra-low carbon interstitial-free steels. These offered substantial improvements in shape, surface appearance, and sheet consistency, of auto vehicles. By mid 1990s, Japanese auto firms had moved into a wide range of recreational vehicles, including sedans, coupes, and vans.

In the meantime, American defense jet industry, motivated by the native papermaking techniques, designed relevant innovations in the high-performing thermoplastic composites, made from synthetic chemical resins. When reinforced with stiffer carbon fiber, and enhanced toughness and service temperatures of the resins, these composites became sufficiently durable for the auto-vehicles. As of 1985, the cost of auto-grade carbon fiber was about $16-20/ pound, compared to $5/pound needed for commercialization. A joint academic-industry research consortium, sponsored by the US government in late 1980s, targeted to design a commercially viable, 80 miles/gallon, mid-size Super-car by 2004. However, Ford Motors, using alliances with vendors such as Cambridge Industries, was able to demonstrate the first prototype of composite-skinned all white Super-car as early as at the 1995 North American International Auto Show. The Super-car weighed 50% less than, and saved 20% costs over, the conventional vehicles.

The proficiency of technological investment is thus a function of: (1) discovery of the new global learning options for upgrading evolutionary resources, and (2) strategically motivating the market to develop tradable innovations for revolutionary assembly. This chapter investigates the first force, and recommends the second for further academic research.

Discovery of the New Global Learning Options

The revolutionary Post-war development of Japanese firms highlights the value of research-obviating learning discoveries. Japanese firms had strong links with the local vendors, who enjoyed expertise in original as well as repaired mechanical parts, such as generators, starters, engines, and rear axles. The low-tier suppliers, with limited capital base, were particularly adept in efficient repairing and fixation of complex parts. During the 1980s, in a bid to upgrade their reputation, the lead Japanese assemblers motivated their first-tier suppliers to organize teams of low-tier supplier engineers. These teams were encouraged to visit each supplier by rotation, identify key technical strengths of the visited supplier, and explore transfer of own experiences for further improvement. This articulated information was absorbed through the first-tier suppliers into the assembler work-system, via interactions with cross-functional teams. Once the absorption process was completed, the recession loomed large by the late 1980s.

In the meantime, German firms sought a premium luxury image, using a variety of plastic alternatives, with a view to differentiate them from the heavy steel-intensive vehicles. A 1990 analysis of the German firms revealed that, "Efficiently processing the approximately 250 pounds of over 20 types of plastic typically found in current automobiles is the main challenge in recycling." (Mechanical Engineering, 1990: 66) The recycling of plastics used in the cars was quite costly, because of the considerable safety precautions and technical effort needed to separate chemicals from the plastics. The commercial market for this plastic recycling was virtually lacking. To preserve their reputation, German firms made considerable firm-specific investments into recycling plants. Typically, they teamed up their experienced personnel with the lead engineers of their best vendors to post-mortem various imported vehicles. The aim was to discover best disassembly procedures and material processing techniques.

Under these conditions, there was a significant common interest among the Japanese and German firms to make direct investments into the US. In the US, Andrews, Berger, and Smith (1993: S 5) note, "there is a Corporate Average Fuel Economy (CAFE) requirement of 27.5 miles per gallon... If this requirement is not met, the automobile manufacturer is required to pay a penalty on every vehicle sold. [This penalty is] US$5 times the number of tenths of a mile per gallon below the requirement. Therefore, the incentive for producing the most fuel-efficient vehicles possible is driven by energy conservation, environmental awareness, customer expectations, and a monetary penalty." The authors provide estimates on the adoption of proven energy-saving technologies using a sample of 2193 new auto and truck models, constituting 80% of the 1988-90 model years vehicles sold in the US. The estimates show the extent to which: (a) within firm, (b) within vehicle line, and (c) cross-firm, variances are significant. There were significant within-firm variances, averaging 0.00232 (standard deviation = 0.00733), as well as significant vehicle-line effects averaging at 0.00146 (standard deviation = 0.000055). The across-firm variances, measured as the correlation between manufacturer means over multiple simulation runs, averaged 0.271 (standard deviation = 0.368), and were not significant. Thus, proven energy-saving technologies were available in the market through the vendors. The investments into these technologies were hampered by the limited complementary resource links of the firms across all vehicle platforms. In Table 7.1, the use of energy-saving technologies is averaged for the three top corporate leaders in Japan, Germany, and the US. As is evident, American firms had inter-changeable resource links that helped adopt the energy-saving technologies. Japanese firms had made about 50% progress. German firms, in contrast, were pursuing abnormally energy-intensive technologies. Inadvertently, German firms managed a global sales of just 5 million vehicle units in 1990, as compared to 13 million vehicle units realized by the Japanese firms as a whole. The total sales of American firms also lagged at 10 million.

Table 7.1: Nation-effects on Adoption of Energy-Conservation Options in Autos

Nation	Top Three Local Leaders	Beta estimate (s.d.)
Japan	Toyota, Nissan, Honda	0.0454 (0.0225)*
Germany	Benz, BMW, Volkswagen	-0.0163 (0.0309)
US	GM, Ford, Chrsyler	0.0823 (0.0202)**

Note: * t< 0.05; ** t< 0.01; Source: Computed from Andrews et. al. (1993).

Hypothesis Formulation

Specialized services of the international vendors augment the productivity of firm-specific initiatives. For instance, in late 1970s, Mitsubishi Motors was in a state of near bankruptcy. Its lead Japanese institutional stockholders, who had been actively monitoring the bad state clients, approached Chrysler for equity and technical support. In the ensuing period, Mitsubishi enjoyed a stellar international growth. First, it created about a dozen parts and assembly plants, and ten joint ventures in Asia. In 1988 it commissioned US-based joint venture with Chrysler for manufacturing new sports cars. The venture combined Chrysler's technical know-how and a computerized analysis of Mitsubishi's transformation from a bankrupt single-product firm into a profitable full-line manufacturer of products ranging from mini cars to heavy trucks. Chrysler also bought in advanced financial packages from the US software experts, to help strengthen Mitsubishi's business-side reengineering processes. Mitsubishi Japan was motivated to develop a five-point 21st century strategy: (a) greater localization in overseas markets, (b) increasing imports, (c) increasing procurement from overseas, (d) overseas procurement support in development process, and (e) domestic market sales support for vehicles manufactured overseas. The global-effects on Mitsubishi were stupendous. In 1995, Mitsubishi was invited to equally own a Dutch joint venture, NedCar, at Born with the Swedish assembler Volvo and the Dutch government. The venture was the world's first car plant to manufacture different models of sedans, hatchbacks, and station wagons, for two different auto firms on a same assembly line. The total plant production, planned at 210,000 units in 1997, was targeted to reach 280,000 units by 1999. In 1997, Mitsubishi bagged a contract to supply 75,000 units of 1.8-liter diesel-style direct-injection gasoline engines to Volvo at the Dutch plant. Volvo used these engines, which offered 35% fuel-efficiency over the conventional engines, in its S40 and V 40 models. Volvo also began a formal collaborative study to analyze feasibility of using Mitsubishi's technology in its own engine development program. In addition, Volvo requested a joint project to develop common chassis and other parts across different models of the two partners being assembled at the Dutch plant. Its spokesperson noted, "The two companies would commence studies for the next generation of cars beginning production at the start of the 21st century… This will utilize the strengths of the respective companies." (The Wall Street Journal, 1997: A 10)

Collaborative initiatives motivate additional learning opportunities. In 1994, the US government initiated a joint research consortium, Vehicle Recycling Development Center, of the US auto firms. The US was commercially recycling 75% of the car material by weight. The consortium sought to study the US and foreign cars of recent vintage, and develop ways for facilitating recycling of the residual 25% weight. This residual constituted primarily of the low-weight materials, and waste fluids such as engine oil. In the interim, Ford used its alliances with vendors such as GE Plastics and Monsanto Co., and Chrysler with vendors such as Dow Chemicals, to commercialize new directions for using the post-consumer plastic resin. The Recycling Center emphasized additional potential of substituting plastics with aluminum. The aluminum intensive vehicles could be crushed just like a 'soft drink can,' thereby conserving both inventory space as well as product weight. The US government, encouraged by the results, revised its target for fuel-efficiency, and set a new ambitious milestone of 35 miles per gallon average by the year 2000. By early 1990s, the US aluminum-can vendors had substantially boosted their research outlays for adapting aluminum body technologies to the lean auto lines. The world aluminum prices surged through the early 1990s.

Using the efforts of the lead vendors, General Motors developed an aluminum-intensive electric car, EV 1, which weighed 50% of the conventional vehicles, and offered an added emission-control. Volkswagen in Germany had been trying for the last 12 years to use aluminum in its regular vehicles. Closely following the EV 1, it eventually offered a top-end aluminum-intensive Audi model in 1993. However the customer reception to these top-end models was at best lukewarm. The fact was evident in an unexpectedly deep discounting of aluminum metal that followed in the global market. The unit steel prices, on the other hand, again began their upward trend. Ford soon made public the findings of its proprietary $30 million aluminum development program, which was first launched in 1992. Ford noted that aluminum generated sufficient trading economies, when used in large volumes, to offset otherwise high manufacturing and marketing costs of product development. Ford deployed 300 pounds of aluminum/car – about 50% more than a typical US car – in the new models of Ford Taurus. Chrysler, which was increasingly relying on Supplier Cost Reduction Initiative SCORE to support new innovation inputs, also introduced an aluminum-intensive Neon Lite model. The model was estimated to be at least as profitable, once the corrosion-resistance properties of aluminum were taken into account, as the popular Neon Steel model. In light of these experiences, it is proposed that:

Hypothesis: Technological Investment and Manufacturing Alliance

The more focused a firm's rent-generating behavior, the greater the technological investment.

Operational Measures

In 1982, Big-3 US auto-assemblers organized an Automobile Industry Action Group, to work with the American National Standards Institute. The Action Group developed computerized forms pertaining to order, shipping, and confirmation of various items used in the auto industry. The number of forms was cut from hundreds in the past to just 18. The margin of error in auto documents was estimated to fall from 5% to 1%, yielding a savings in communication costs of $200/vehicle (Business Week, 1985: 94. 96). In early 1988, Ford surveyed 250 suppliers to evaluate the productivity of computerized data interchange. Just 5% of the respondents reported perceptible benefits of such interchange (Network World, 1988: 1, 8). Recognizing the need for integrating the data collection (shipping and receiving) with data entry, the Action Group developed an advanced system of scannable bar coding of each part, containing part number, customer stocking locations, and product descriptions. An 18-month long Manufacturing Assembly Pilot program was initiated in March 1995. The Pilot involved 16 firms, including the Big-3, a seat-vendor named Johnson Controls, and 12 second and third tier suppliers. The lead times for seat hardware supply dropped 58% (from 26 days to 11 days), and for seat cover and fabric fell 32% (from 19 days to 13 days). The order error rates fell up to 72%, and inventory turnover surged 20%. The diffusion of the Pilot system to all auto-related firms in North America was estimated to yield savings of $70/car, or $1 billion on 15 million units annually (Purchasing, 1996: 56). In the meantime, Toyota moved fast to mobilize the support of US suppliers to design modular stackable containers and pallets, for optimum cube space utilization of truck trailers during shipment and returns. The specifications developed by the Automotive Industry Action

Group were found to be relevant for 91% of the total parts and materials. With their adoption, the space efficiency surged 21%, and transport costs fell by $3.6 million annually, valued at $18/ vehicle assembled at the Kentucky, Georgetown plant. Additional diffusion-effects for reorienting Toyota's operating strategy were also evident. For instance, after the transport rationalization, Toyota doubled the production capacity of Georgetown plant to 480,000 units, using just 3.2 million square feet additional space compared to the pre-existing 3.7 million square feet for the earlier 240,000 units (Transportation & Distribution, 1992: 98, 100). The super-normal gains of Toyota suggest a need to correct for the **spillovers-effect** deriving from the assembly of derivative vendor networks, as against trading from the original resource developers.

Test of the Hypothesis

The hypothesis is tested using the case of internationally most renowned network assembler, Toyota. In January 1992, the US President George Bush, and a team of top American executives, made a high-profile trade visit to Japan. Encouraged by the terms of the partnership, Toyota voluntarily approached General Motors to reengineer the left-hand drive Chevrolet Cavalier vehicle into a right-hand drive Toyota Cavalier, to be marketed in Japan through Toyota distributorships. Chevrolet Cavalier was a front-wheel drive sedan, which used electronic-controlled automatic transmission, and obviated energy-intensive consumer dipstick test. Because of a super-high mileage and luxurious image, it had been an instant hit in the US with the women, who constituted 70% of its buyers. General Motors offered to make Toyota Cavalier at one of its most experienced stamping and assembly plant at Lordstown, Ohio. The workers responsible for making Toyota Cavalier received nearly 800,000 hours of training in the peculiarities of Japanese market. Still, the production line assembling Toyota Cavalier together with Chevrolet Cavalier and Pontiac Sunfire, managed to deliver just 50 cars/hour, compared to the target of 80. Though Toyota Cavalier had been launched with great fanfare on 8th August 1994, there was little improvement on production front until February 1995. A comprehensive analysis of the assembly line and operating procedures revealed nearly 150 design aspects where the machinery specifications differed from the Japanese product standards. Attributing the problem to the rigidity of machinery system, Toyota set up an inspection shop at the plant. Later, Business Week (1996: 39) elaborated, “one visitor from [Toyota] was dismayed to find that 80% to 90% of the cars [using current product designs] needed at least some fixing upon inspection.”

In 1995, the US government concluded a fresh agreement on measures to boost sales of foreign cars in Japan. Soon afterwards, Financial Times (1997: 4) reported, “Since its launch in Japan last June [1996], the [Chrysler’s] Neon, which was dubbed a ‘killer’ of Japanese cars because of the value for money it offers, has seen sales stagnate at 1,100 units against an initial target of 4,000 units in a year. Toyota, meanwhile, has managed to sell just over 13,000 Cavaliers in 15 months, against a target of 20,000 units.” Toyota focused its efforts on adding a self-designed Avalon sedan to its fully owned Georgetown assembly line, which had been making an intermediate lower value-adding Camry Car. The new line, based on the machinery secured from several international makers, was kept separate from the older line. This separation was a path-breaking departure from the traditional domestic approach of Toyota, under which each plant assembled all the model varieties on the same line using the same old set of machinery. In late 1994, Toyota launched a $50 million television campaign, targeted at the affluent, educated 40-something owners of mid-sized cars in the US, looking to trade up. The large leg room and trunk space in the 6-seater Avalon, the consumer reports indicated, yielded a smooth luxurious drive, equivalent to that of larger than mid-sized vehicles. The US government agreed to classify it as a large-sized vehicle, wherein Avalon had significant mileage advantage over the competing models. In its new vehicle class Avalon also had an edge “when it comes to reduced noise, vibration, and harshness. Wind noise, and almost all outside noise, were virtually nonexistent. The only complaint is with entertainment center. The so-called premium ETR/cassette with 6 speakers and diversity antenna was a great disappointment.” (Machine Design, 1995: 238) The success of the new assembly system encouraged Toyota to use modern machinery in separate assembly lines even in its new plant at Kyushu, Japan. The quantum jump in the technological base of the domestic plant network obviated any significant exports of Avalon, or other related vehicles, from the US. On the other hand, Toyota was able to once again sustain growth in the exports as well as in the home market share based on domestic production.

Up to the early 1960s, Toyota made only low-end products, and still had a very poor reputation for quality. Inputs traditionally sub-contracted to the vendors had low value, low technology content, high labor content, and ease of transportation. In 1965, Toyota set up an operations management consulting division (OMCD) to evaluate avenues for enhanced role of subcontractors. Enhanced involvement of vendors, having a variety of skills, boosted the product quality. Accordingly in its American transplants, Toyota delegated a significant proportion of engineering responsibility for critical components such as instrument panels, seats, and electronics, to the vendors. Following its domestic strategy, Toyota retained the original equipment manufacturer (OEM) rights on the resulting innovative product designs. To maximize its learning power, Toyota created a tiered network of suppliers, each being responsible for only a proportion of total product innovation. As such, considerable cost savings were negotiated from the vendors as an implicit compensation for training them in world-class organizational practices. Womack (1995: 15, 16, 45) reported, "From their arrival, Japanese firms worked with their suppliers on quality issues, but in the past three years Japanese OEMs have began to take an active hand in teaching lean principles and methods to their direct suppliers and working with these suppliers to teach their subcontractors and (even) their raw material suppliers. (That is, the situation is analogous to where Toyota was with its Japanese suppliers as it launched OMCD in 1965)." It was estimated that "the amount of muda [abundant resources] to take out of the American brownfields is enormous and the task will take a decade to fully see through."

Correction Factor for the Spillovers-effect in Trading Technology

By early 1990s more than 200 Japanese auto vendors set up direct manufacturing operations in the US. These vendors included the first-, as well as second- and third-, tier players. They were from diverse industries, such as steel, rubber and electronics. Martin, Mitchell, and Swaminathan (1995) estimated that more than 40% of the customer links of their US transplants were extended to the assemblers, who were not the traditional customers of parent Japanese firms. Further, Japanese assemblers began experiencing a credible threat of import competition from the luxurious European models. In 1984, German auto leader Diamler-Benz, motivated by its principal institutional investor Deutsche Bank, acquired low-performing assets of the firms in microelectronics (Allgemeine Elektricitaets Gesellschaft), aerospace (Deutsche Aerospace), and financial appraisal (Benz Investment Services) sectors. Though Diamler-Benz reported considerable losses on newly acquired businesses, by early 1990s these businesses accounted for a fourth of its total sales turnover. In 1993, Daimler-Benz made an unprecedented decision to set up an assembly transplant in the US, closely following a similar 1992 move of its nearest competitor BMW. These decisions gained strength from the fact that Japanese auto assembly in the US as well as Europe was focused on sites away from the traditional centers of local strengths (Detroit in the US, and Germany in Europe), and still had enjoyed significant learning benefits. The new products in the US plants had unit costs of less than $30,000, in contrast to more than $70,000 common for those assembled in Germany.

Japanese firms pursued two kinds of learning links. The first were human links, such as high quality, flexible, and motivated local workforce in different regions. The second were tradable links, such as Japanese machinery and Japanese information systems. Table 7.2 gives the human-effect and trading-effect, averaged over ten resource parameters for three leading Japanese multinationals, in three major industrial segments: intermediate inputs, electronic products, and auto assembly. The data are for the transplants in three regions. Japanese

Multinational Enterprise Study Group, under the coordination of Tetsuo Abo at the University of Tokyo, collected the raw data over 1989-95 through field surveys. The data were evaluated on a scale of 1 to 5, where 1 = adaptation to local practices, and 5 = application of Japanese practices.

Table 7.2: Application of Japanese Organizational Practices Overseas

	America	Europe	Asia	Global Average
Intermediate Inputs				
* Human-effect	3.43	4.10	3.77	3.77
* Trading-effect	3.43	3.47	3.53	3.48
Electronics Products				
* Human-effect	2.27	3.12	3.40	2.93
* Trading-effect	2.23	3.20	3.13	2.86
Automobile Assembly				
* Human-effect	3.43	3.80	4.03	3.76
* Trading-effect	3.87	3.70	3.20	3.59
National Average				
* Human-effect	3.04	3.67	3.73	3.49
* Trading-effect	3.18	3.46	3.29	3.31
Average Local-effect	3.11	3.57	3.51	3.40

Japanese multinationals showed a distinct tendency to adapt to the local American practices (local-effect = 3.11). Having networked the American know-how, Japanese multinationals sought application of their practices in Europe and Asia (local-effect > 3.50). Japanese networking of American know-how was especially strong in electronics technology. The high human-effect in these regions shows how the Japanese firms delegated full responsibility for developing creative applications of American know-how to the local workforce. In Europe, Japanese firms sought to develop links for intermediate processing of technological inputs into diverse core components. The Asian transplants, on the other hand, were required to perfect high quality techniques for assembling diverse core components.

Japanese successes spilled over significant learning to the competing firms. Until 1920s, Fiat performed all specialized tool-making, machinery set-up, maintenance, and plant transport functions in-house. The workers earning higher wages, who constituted 45% of Fiat's total employee base, performed these functions. In the 1930s, Fiat found that it could hire top skilled engineers from the metal vendors at about 80% of the regular wages for its own skilled employees. These engineers, classified as semi-skilled in auto industry, helped recast and forge special-purpose machinery, patterned after the American mass production system, into flexible multi-purpose ones. Fiat was consequently able to add highly popular small car models to its large vehicle portfolio, resulting in a reduction of the percentage of unskilled workers from 55% to just 6% by 1938. At the end of World War II, constrained by a severe shortage of intermediate inputs, Fiat was forced to lay off a large number of skilled workers in its Northern Italian base. During the 1950s and 1960s, Fiat, suffering from a negative reputation-effect in the Northern Italy, relied increasingly on the unskilled migrant workers from the Southern Italian region. To differentiate itself from the more reputed European assemblers, Fiat focused on niche position in small vehicle segment. Fiat's competitive position came under severe pressure when the Japanese firms began increasing their exports to Europe rapidly soon after the first oil crisis in 1974. In response, Fiat began a serious effort during the 1980s to develop links with a variety of vendors regionally and internationally, using a system of investments into modern information technology and organization of semi-autonomous workforce teams. With the technical insights developed from richer interactions, Fiat was able to cut the number of basic vehicle models from 12 in 1982 to 9 in 1986. The number of model-specific assembly components slid from 52 to 13, while that of common assembly components rose from 42 to 49. Consequently, productivity, measured as the number of vehicles assembled per worker, nearly doubled to 29 [Musso, 1995: 245-6, 261-2].

How Do the Firms add Value to the Emerging Networks?

Nelson (1992: 64-65) observes, "monitoring outside technological developments generally is an active and costly business. In most industries the means of monitoring judged most effective was either doing independent R&D (presumably while attending to clues about what one's competitors are doing) or reverse engineering… Those industries that reported reverse engineering to be effective also tended to report that they often learned a lot from conversations with scientists and engineers of the innovating firms. Some reported that they make a practice of trying to hire some away… Not just patents, but the location and organization-specific nature of the details of a firm's particular product and process technologies often make them difficult to directly imitate, even if another firm wanted to do just that. On the other hand, the general understanding behind those particular products and processes are very difficult to keep privy for very long…" The focus of the manpower on generic principles furthers the trading effectiveness.

Sample and Data Source: Japanese firms train their workforce in the non-tradable firm-specific skills. Therefore they have a motivation to trade outside know-how, as a means to balance the escalating learning costs. This is investigated using the annual data over 1976-90 for the Japanese motor vehicle sector, obtained from OECD STAN database. The annual averages for the three five-year segments are in Table 7.3(a). The labor appropriated an incremental proportion of production value during the first half, but the auto assemblers neutralized part of the escalating costs over the second half. An increasing proportion of production value was derived from the tradable material inputs. The worker productivity nearly doubled over the 1980s. Fixed investment, trade, and trade balance, nearly doubled every five years. The growth in production was slow during the first half of the period, but caught up during the second half. The tradable value of labor, and more significantly of material, rapidly deteriorated over the second half.

Table 7.3(a): Annualized Operations of Japanese Motor Vehicle Industry, 1976-90

Parameters	**1976-80**	**1981-85**	**1986-90**	**1976-90**
Labor/ Production (market rates)	13.37%	14.25%	14.09%	14.00%
Material/ Production (market rates)	69.02%	71.48%	71.81%	71.22%
Productivity ($ operating surplus/worker)	15860	16343	32929	22200
Fixed Investment (million $/ year)	4838	9032	21231	11700
Trade (million $/ year)	18248	34239	65019	39169
Balance of Trade (million $/ year)	17136	32892	56957	35662
Production (million $/ year)	75712	109360	237893	140988
Labor (purchasing power)/ Production	11.48%	14.79%	09.89%	11.44%
Material (purchasing power)/ Production	59.14%	74.13%	50.40%	58.10%

Table 7.3(b) presents comparable data for the American motor vehicle industry. There was a continuous reduction in the learning costs of labor throughout the period. The tradability of material declined marginally during the first half of the period, but rose substantially over the

second half. The growth in worker productivity, fixed investment, as well as trade slowed over the latter period. The trade balance deteriorated at a rapid pace. Yet production sustained its growth, doubling every ten years. Thus, by trading generic American know-how, Japanese firms play an important role in furthering the vehicle ownership in the US, and allow the American community to focus their productive efforts on developing additional tradable investments.

Table 7.3(b): Annualized Operations of American Motor Vehicle Industry, 1976-90

Parameters	**1976-80**	**1981-85**	**1986-90**	**1976-90**
Labor/ Production	21.05%	20.30%	18.26%	19.58%
Material/ Production	70.80%	70.45%	72.95%	71.64%
Productivity ($ operating surplus/worker)	9631	16531	19638	15153
Fixed Investment (million $/ year)	4852	6377	7838	6356
Trade (million $/ year)	36582	60799	103486	66956
Balance of Trade (million $/ year)	-7480	-24265	-50591	-27445
Production (million $/ year)	116584	151760	212760	160368

In addition, American manpower has been learning from the productivity of the Japanese workforce, and consequently pursuing vendor linkages. Such initiatives **impede** the motivation to exploit sticky firm-specific know-how, and cause the firms to limit **compensation** for the traditional path-dependent learning. Impediment-effect is measured as "(National $ purchasing power of manpower/ national $ production value) – (National $ purchasing power of manpower averaged over 1976-90/ national $ production value averaged over 1976-90)." Compensation-effect is measured as "(National $ market cost of manpower – National $ purchasing power value of manpower)/ $ value of national production." Similar effects result for the firm-specific material resources. Using the annual data for Japan and the US, in Table 7.4(a) productivity is regressed on impediment-effect and compensation-effect, separately for manpower and material. The intercepts yield the **focus-effect** of using generic know-how. The t-values are in brackets.

A focus on generic know-how helped equalize the productivity of manpower and material power. Further this productivity was essentially constant throughout the period. Impediments from the path-dependent learning had a negative impact on the productivity of manpower. The firms sought to balance these detrimental effects by seeking greater flexibility in material links.

The compensation for a focused solution of the firm-specific problems enhanced the productivity of material power, and offered super-normal gains on the manpower learning.

Table 7.4(a): Impact of Common Knowledge on Auto Assembly Power

	Manpower	Material Power	test of difference
Focus-effect	15890 (15.635)	15565 (13.150)	326 (0.209)
Impediment-effect	-198509 (-3.203)	55233 (1.040)	-253742 (-3.109)
Compensation-effect	322024 (6.283)	67085 (5.820)	254939 (4.853)
R sq.	0.674	0.568	

Japanese assemblers further their productivity by networking the agencies specialized to the American firms. The non-tradable value is termed as **Worker Social Benefit Cost Ratio (WSBCR).** WSBCR-effect is measured as [(National $ market cost of manpower)/(National $ value of production) – (International $ market cost of manpower)/(International $ value of production)]. The incentives to discover new generic opportunities internationally are evaluated as **Social Benefit Cost Ratio (SBCR).** SBCR-effect is measured as [(National $ market cost of manpower averaged over 1976-90)/ (National $ production value averaged over 1976-90) – (International $ market cost of manpower averaged over 1976-90)/(International $ production value averaged over 1976-90)]. Similar effects might be expected for the material power. Using annual data for Japan and the US, and evaluating international parameters using data for Japan, Germany and the US, Table 7.4(b) reports regression of productivity on WSBCR and SBCR. The intercepts yield **investment-effect** of US-specialized know-how. The t-values are in brackets.

The US-specialized investment had a stable positive impact on the productivity of manpower as well as material power. Still, the productivity of manpower lagged that of the material power. The non-tradable WSBCR significantly limited the productivity of both manpower as well as material power. The discovery-motivating SBCR augmented the productivity of manpower, but had a detrimental impact on the productivity of material power.

Table 7.4(b): Impact of US-Specialized Knowledge on Auto Assembly Power

	Manpower	Material Power	Test of difference
Investment-effect	18056 (11.290)	25481 (12.616)	-7425 (-2.882)

WSBCR-effect	-253244 (-2.670)	-326421 (-2.923)	73176 (0.499)
SBCR-effect	207731 (2.006)	-342881 (-3.841)	550612 (4.027)
R sq.	0.225	0.417	

As a corrective approach, Japanese assemblers seek to persist with their traditional path-dependent networks. Such a strategy limits the escalating costs of manpower learning, and thereby augments the productivity of generic material resources. Though the innovative trading hampers the nation's comparative advantage in motor assembly, still the proficiency of fixed investments could be enhanced. To investigate this proposition, **Manpower-effect** is measured as the 'residuals of manpower equation in Table 7.4(a) – residuals of manpower equation in Table 7.4(b).' **Material-effect** is measured as the 'residuals of material power equation in Table 7.4(a) – residuals of material power equation in Table 7.4(b).' The data on trade, balance of trade, and fixed investment are in millions of US$. Using the annual data for the Japan and the US, Table 7.4(c) presents the results for the regression of each of the three parameters on manpower-effect and material-effect. The intercepts yield financial-effect of innovative trade, monopolistic trade balance, and competitive fixed investment. The t-values are in brackets.

The innovative network assembly added to the financial effectiveness of trade and fixed investment. The escalating costs of manpower learning had a significant negative impact on the fixed investment. The compensating use of developed material resources boosted the trade, without necessitating additional fixed investment risks.

Table 7.4(c): Financial Implications of Innovative Network Assembly

	Trade	Balance of Trade	Fixed Investment
Financial-effect	53062 (10.433)	4108 (0.671)	9028 (11.048)
Manpower-effect	-2.3181 (-1.894)	-2.1652 (-1.470)	-1.0201 (-5.187)
Material-effect	2.5669 (2.064)	-1.5173 (-1.014)	0.3798 (1.901)
R sq.	0.153	0.231	0.523

The gains from the networking of generic resources motivate Japanese firms to seek new tradable options **discovered** by the American firms. The **diffusion** of historical fixed investments to the US help utilize the generic services of the American manpower, and thereby alleviate the path-dependency on sticky American resources (for instance, patents). Such a rent-generating focus promotes **growth** in the innovative trading. Discovery-effect is measured as 'the residuals of balance of trade equation in Table 7.4(c).' Diffusion-effect is measured as 'the residuals of fixed investment equation in Table 7.4(c).' Growth-effect is measured as 'the residuals of trade equation in Table 7.4(c).' The following is the regression of growth-effect on discovery-effect and diffusion-effect. The t-values are in brackets. A lead in the discovery process had a significant negative impact on the growth effectiveness, while a creative diffusion of path-dependent fixed investment know-how had a dominant positive impact.

Growth-effect = 0.000 - 0.8949 Discovery-effect + 4.9139 Diffusion-effect   R sq.: 0.840
(0.000)   (-11.634)   (8.529)

Out of the 13.55% [(1-0.84)*(1-0.153)] overall trade residual, Japanese motor vehicle sector enjoyed an average of $12,240 million annual trade benefits compared to the US.

Conclusions and the Recommendations for Further Research

Chandler (1977: 473) notes, "After World War I the most important developments in the history of modern business enterprise in the United States did not come from enterprises involved in carrying out a single basic activity such as transportation, communication, marketing, or finance. Nor did they come from firms that only manufactured. They appeared rather in large industrials that integrated production with distribution… integrated enterprises moved into industries where they had played a smaller role before World War I. These industries, however, were nearly all in those larger industrial groups where the integrated enterprises had clustered from the start. As the firms became integrated, the industries in which they operated became more concentrated… The Du Pont Company, one of the very first to diversify in this manner, did so in order to employ the managerial staff and facilities, which had been so greatly expanded by the demands of World War I. Others soon followed." With the rapid growth in the electronics communication systems, there is an appreciation of the potential for focussed reengineering in traditional business trajectories.

In practice, there are historical as well as cultural barriers to changing organizational behavior. Goldstein (1939: 112) highlighted the relatively great constancy in the performances of the organism, with fluctuations around a constant mean, and noted, "The possibility of asserting itself in the world, while preserving its character, hinges upon a specific kind of 'coming to terms' of the organism with its environment. This has to take place in such a fashion that each change of the organism, caused by environmental stimuli, is equalized after a definite time, so that the organism regains that 'average' state which corresponds to its nature, which is 'adequate' to it. Only when this is the case is it possible that the same environmental events can produce the same changes, can lead to the same effects and to the same experiences. Only under this condition can the organism maintain its constancy and identity." Miller and Dollard (1941: 5-6) elaborated that it is difficult, "to predict the behavior of a human being without knowing the conditions of his 'maze,' i.e. the structure of his social environment. Culture, as conceived by social scientists, is a statement of the design of the human maze, of the type of reward involved, and of what responses are to be rewarded. It is in this sense a recipe for learning. This contention is easily accepted, when widely variant societies are compared. But even within the same society, the mazes that are run by two individuals may seem the same but actually be quite different... No personality analysis of two… people can be accurate which does not take into account these cultural differences, that is, differences in the types of response which have been rewarded."

Under cultural conditions that promote sustained focus on the specialized firm-specific learning, there are pressures to seek generic know-how through foreign direct investment networks. Mirza, Buckley and Sparkles (1989: 235) from the University of Bradford surveyed European firms operating in Japan. The study found that "customers are more willing to purchase goods from European firms in Japan because such firms are regarded as being near-Japanese; better qualified personnel are more willing to work for foreign firms with a track record of commitment to the Japanese economy; and a local presence is a considerable boon for establishing links with Japanese firms; relationships are long-term and between friends… Some firms designed better products simply because of the adaptations to production methods dictated by the exacting requirements (especially in quality) of Japanese customers. Others said that they had learned from Japanese production methods per se, often in factories run with Japanese joint venture partners, and the skills/techniques most frequently cited as acquired were better quality and inventory control." With the diffusion of their specialized know-how, the host firms may enjoy significant motivation to discover more generic know-how from the outside vendors. In this regard, Dore (1987: 82) noted "Schonberger, in his excellent book on Japanese manufacturing techniques, records his puzzlement at finding the testing and quality-control operations in Japanese factories always set up for easy display to visitors – if necessary with glassed walls when, say, destruction testing required a sealed-off environment. The reason was that factories were constantly being inspected by engineers from purchaser firms concerned to exercise 'voice' to improve or maintain the quality of products they bought... It is common in the engineering industries for large firms to 'second' engineers or technicians or skilled workers 'on posting' to their suppliers for this purpose."

The constant assembly of the generic vendor know-how could substantially augment the continuous innovation capability of the leading firms. For enhanced trading gains, the vendors might seek to diffuse their investment networks overseas for dedicated customer servicing. A greater marketing orientation can potentially dilute the vendor focus on the trading of further generic know-how from the international channels. As such, the leading firms may seek direct acquisition linkages with the locally operating emerging vendors. While such acquisition could augment the firm-specific competitive advantage, the acquired vendors may no longer have the flexibility of furthering their productivity through a broad-based servicing of the international community. Therefore there is a need to investigate the overall effects of the firm-specific investments into the intrinsically generic know-how, and mechanisms for generating additional rents on the already acquired know-how.

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