Chapter 2

A Dynamic Model of Organizational Programming

How Do the Firms Discover Emerging Technological Know-how?

Abstract: The stabilization and maturity of the firm-specific programs generate significant opportunities for generating increasing returns through their worldwide diffusion. If knowledge about the dominant programs becomes common, then the pioneering firms lose rents. Since the alternative emergent programs typically have a limited reputation, the firms seek to research techniques for extending their proprietary intellectual rights onto the vendors developing these programs. The depreciation of the emerging market currencies exerts a detrimental impact on the visible investment value. Yet the upside value of trading decreasing cost resources from the emerging market networks has been growing over time, and is thereby sustaining the multinational interest.

Introduction

There has been a significant academic interest in the analysis of programs that help firms generate super-normal growth. In a stimulating review of the East Asian miracle, Krugman (1994: 62) observed, “there is nothing miraculous about the successes of Asia's "tigers." Their rise was fueled by mobilizing resources – increasing inputs of machinery, infrastructure, and education – just like that of the now-derided Soviet economy. Indeed, Singapore's boom is the virtual economic twin of Stalin's USSR. The growth rates of the newly industrialized countries of East Asia will also slow down. The lesson for Western policymakers is that sustained growth requires efficiency gains, which come from making painful choices.” In a recent analysis of rightsizing strategies, Mroczowski and Hanaoka (1997: 62) found, “Japanese companies relentlessly postpone all types of separations, including voluntary separations, and reduce both time and pay to do so, something American companies will do only very rarely. Forty-four percent of Japanese companies rely on shorter work hours, compared to 10 percent of American companies. Ten

percent of Japanese companies use pay cuts, which are very rare among US companies. The external transfer of employees to other companies is on the rise in Japan (13.2 percent of companies surveyed), while it is not practiced in the US." In this regard, Simon (1964: 15-16) suggested, "In actual organizational practice, no one attempts to find an optimal solution for the whole problem. Instead, various particular decisions, or groups of decisions, within the whole complex are made by specialized members or units of the organization. In making these particular decisions, the specialized units do not solve the whole problem, but find a 'satisfactory' solution for one or more sub-problems, where some of the effects of the solution on other parts of the system are incorporated in the definition of 'satisfactory'."

Vroom (1964: 183) found the correlation between satisfaction and performance to be positive in only 20 of the 23 studies conducted in the US, with a median of just +0.14. Over the recent years, the US component companies are rapidly acquiring European suppliers, driven by "both the trend among their customers to go global and the fact that many of the new 'world' car projects involve smaller, European originated products. Both Ford and GM have based their global small-car development operations in Europe." "Several big North American suppliers such as TRW Inc., Dana Corp. and the automotive-parts divisions of General Motors Corp. and ITT Industries Inc. have been in Europe for years, some for decades. In most European countries, the North American suppliers make up the second-largest group of suppliers after each country's own national industry… From 1994 to 1996, North American automotive suppliers made 80 acquisitions of European companies with combined revenue of $9.5 billion… European auto makers [are] increasing efforts to out-source manufacturing activities that aren't considered part of their core competencies. Fiat, in particular, has farmed out several businesses –- including spark plugs, batteries and seats -– to U.S. suppliers." (Wall Street Journal, May 15, 1997: B 4)

"The trend towards 'modularization' has created a new breed of 'system integrator' on the supply side. Such companies no longer produce just individual parts, but build entire sub-

assemblies for their car and truck making customers… Tomkins, the UK industrial group which last year spent $1.38 billion to buy Gates Rubber of the US, has consolidated its position with the $606 million acquisition of Stant, a US rubber group best known for its Trico windshield wiper blades." (Financial Times, June 12, 1997: III) In May 1997, Diamler-Benz acquired Ford's heavy truck programs, assembly equipment, tooling, technology and 250 dealers, excluding factories as well as workers, for $300 million. Diamler's Freightliner division had 30% market share in the US, valued at $4.8 billion in 1996, compared to Ford's 10% share. Diamler, which currently had just 250 heavy truck dealers in the US, expected to augment its sales by $1 billion in three years. Mr. Jurgen Schrempp, Daimler Benz Chairman, noted that with the deal, "we will be able to broaden our leading position in the very profitable North American truck business." (Financial Times, June 12, 1997: 20) In 1989, Japanese Multinational Enterprise Study Group coordinated by Tetsuo Abo at the University of Tokyo visited the US transplant of a Japanese assembler, affiliated to a Big-3 American assembler, and found that:

> "The main elements of the production equipment, such as stamping process, body construction equipment, welding robots, paint booths and ovens, deodorizing equipment, and paint and assembly robots, were brought from Japan. We noticed an interesting idea employed on its final assembly line. The assembly line is divided up into ten segments, and arranged in such a way that if one line stops it does not affect the other lines. And they have rationalized the parts supply so that it feeds from one side to every line, one after another." (Kumon, Kamiyama, Itagaki, and Kawamura, 1994: 193)

Two forces in the super-normal growth of the multinational developmental programs might be identified: (1) globalization offers access to abundant re-programmable resources that have a significant incremental rent-generating potential, and (2) globalization insures locking into trajectories that are highly contingent on the limited network-specific resources. This chapter analyzes the first force, and recommends the second for further academic research.

Rent-generating Potential of the Re-programmable Market Resources

Re-programmable resources of the market offer significant potential for sustained value-added. Despite severe scarcity of the competitively priced capital, several East Asian nations averaged

8% annual growth rate for nearly thirty years until the mid-1990s. Since mid-1960s, the firms in the East Asian nations imported large bases of machinery and intermediate processed inputs from Japan, and exported them in value-added form to the Western nations, primarily the US. By the mid-1990s, the per capita income in Singapore and Hong Kong stood above that in the UK, standards of living in Taiwan and South Korea were at par with most European nations, and the lifestyles in Malaysia, Thailand, Indonesia, and China were rapidly transforming for the better. But in 1996, growth of imports of South Korea fell from 32% in 1995 to 11%, and the growth of exports of South Korea fell from 30% to 4%. Similar drastic reduction in the trade dynamism was experienced in other Southeast Asian nations also. On the whole, the overall growth rate of the Southeast Asian region fell from 9% in 1995 to 7% in 1996, and even lower thereafter. In terms of the US$, the nations in the region lost substantial wealth and earnings power.

As an another illustration, in response to the energy crises, several of the electric utilities in the US made long-term commitments to the coal- and nuclear- fired power generation plants over the late 1970s and early 1980s. These commitments were executed as the low-risk low-cost financial debts, to be serviced out of the revenue stream over a long-term. As the petroleum prices subsided, the plants fired by the natural gas became several times more cost-effective. The coal- and nuclear- fired plants could not dispose off their older non re-programmable technology, and were burdened with the 'stranded costs' of unpaid machinery loans. The principal clients inevitably invested in their own dedicated gas-fired generators. Under these conditions, the incumbent electric utilities carried large surplus machinery capacity, as well as surplus distribution networks. Upstart dedicated electric utilities noted that if they are allowed a competitive access to the surplus distribution networks, then they could supply their lower cost electricity to the clients nationally – without the risks of stranded non-programmable costs. The incumbent stranded electric utilities were not impressed, and demanded super-normal carrying charge for the use of their distribution network to sustain their low-risk profile. On the whole, the

situation motivated the emerging entrepreneurs to seek alternative mechanisms for growth. There was thus a growing use of the software-driven electronic products throughout the market.

The flexibly programmable software services carry revolutionary rent-generating potential. Amidst escalating competition in the parental brewery business at the end of World War II, Akio Morita, the founder of Sony Corp., invested all surplus savings into personal research in 1946. In 1950, he developed Japan's first tape recorder. In 1953, Sony was offered latest transistor technology by the Western Electric. Sony's first transistor radio, launched in 1955, used only $25,000 worth of licensed technology services, paid as royalty to the Western Electric. By 1957, Sony had patented a proprietary pocked-sized transistor radio. A transistor television was introduced in 1959, and transplanted to the US in 1960. Sony generated rapid growth on the home video recorder developed in 1964, and Trinitron color television tube launched in 1968. Sony licensed its video recording technology to Matsushita Electric, whose upgraded VHS technology successfully contested potentially superior hardware of Sony's Betamax VCR in 1976. Humbled by the experience, Sony again relied on Morita's software to offer an imaginative Walkman in 1979. This mega-hit product instantly offered access to the frontier compact-disc hardware of the Dutch engineering expert Phillips. For complementary pre-programmed software resources, Sony acquired CBS Records for $2 billion in 1988 and Columbia Pictures for $4.9 billion in 1989. The new portable compact-disc player was a super-hit in Japan, but carried only limited conviction in the US. As such, by 1996, 5% of Sony's $43,326 million sales were struck in the insurance and financing services. Japan powered 30% of the sales, the US 27%, Europe 23%, and the emerging markets a strong 20%. For added programming edge, Sony sought the alliance with Microsoft for making electronic audio-video educational products, and with Intel for developing desktop home computer systems.

Though Sony has constructed a sharp image as the most entrepreneurial Japanese company, Matsushita Electric has gained critical proficiency for vertically integrated fast-track

improvements in the hardware programs traded from the market. Set up by a grade school dropout, Konosuke Matsushita, the origins of the Matsushita Electric lay in Yen 100 (US$ 50) of capital used to market lamps in wooden casing beginning 1918. Under opportune conditions, Matsushita expanded into the wood-laminate products for military use during the late 1930s and early 1940s. After the War, Matsushita Electric prospected Philips in 1952 to form a joint venture, Matsushita Electronics. The venture assembled simple televisions, refrigerators, and washing machines. Matsushita used the increasing returns to acquire Victor Company of Japan (JVC) from RCA in 1954, and thus expanded into tape recorders and stereos also. To support the VHS format developed by JVC for VCRs, Matsushita acquired the US television plants of Motorola in 1974. With the credible distribution commitment for its VHS format, Matsushita generated super-normal growth, and rapidly diversified into semiconductors, office and factory automation, automotive electronics, and air-conditioning operations during 1986 and thereafter. For an integrated platform, Matsushita also acquired 80% stake in the MCA's US multimedia operations in film, theaters, television, and publishing, for $6.1 billion in 1990. This time around, it found little interest among the MCA executives for using its proprietary formats across a wide range of new compact camcorders, high definition televisions, and compact cassettes, when better re-programmable options could be traded from the market. In 1995, Matsushita had to salvage its losses by divesting MCA to the US liquor leader Seagram. As an alternative option, Matsushita acquired 10% stake in a Japanese satellite television broadcasting firm, Direct TV, in 1996. By 1996, Matsushita owned a diverse portfolio of 183 manufacturing, sales, and research subsidiaries in 43 nations worldwide. The communication and industrial equipment operations contributed 30% to its total $64,102 million sales. With 55% of total sales focused on the core Japanese market, Matsushita Electric suffered a growing squeeze on its rent-generating power.

Hypothesis Formulation

Under conditions where the domestic skills have been intensively researched, development of the international level operations yield substantial new technological options.

Sample and Data Source: Steven, Levinsohn and Pakes (1995) give estimates for the factors impacting the listed retail value, corrected for the longitudinal changes in the US consumer price index, of the auto vehicles. The estimates use the data on all the base model vehicles sold in the US by the leading American, European and Japanese firms over the period 1971-1990, constituting a total of 2217 model-year observations. The relevant factors include, globalization (year of sales), luxury service (whether air-conditioning a standard feature in the model), vehicle size, engine power (horsepower/ weight), fuel efficiency (miles/gallon), and corporate reputation (average unit price of the models marketed by the firm). Three kinds of rent-generating effects of each of these factors are computed in Table 2.1: (1) **Operating Value:** estimates using ordinary least square equation. The varying **re-programming factor** across different models in different years is evaluated as 1 – R sq. (2) **Financial Value:** estimates using the general method of moments, with instrumental variables for the corporate programming (average value of various explanatory factors for the product models of each firm), local programming (average value of various explanatory factors for the models of firms from a nation), national programming (average value of fuel efficiency across all models and firms for a given year, reflecting predominantly the American values for conservation), and international programming (impact of programming-free condition on the market share, valued as the simulated variation in the rate of substitution between auto and non-auto expenditures of the consumers from an income group targeted by a given model). The varying **re-programming factor** across models in different years is evaluated as 1 – R sq. (3) **Strategic Value:** estimates using a fully identified system, explicitly evaluating the **re-programming factor** as the 'life cycle volumes of each vehicle model across all the years.' Both dependent and explanatory factors are transformed using natural

logarithms. **Financial-effect** of each explanatory factor is quantified as the 'operating power estimates – financial power estimates.' **Strategic-effect** of each explanatory factor is quantified as 'financial power estimates – strategic power estimates.' Standard errors are in brackets.

Network-specific financial programs significantly limited the operating value of globalization, but had a strong positive impact on the corporate reputation on account of the re-programming initiatives. Firm-specific strategic programs promoted luxury services, thereby generating super-normal rents on smaller sized and less fuel-efficient models. Consequently, the incentives for re-programming were considerably attenuated.

Table 2.1: Forces Impacting Listed Retail Cost of the Vehicles in the US

Factor	Operating Value	Financial Value	Strategic Value	Financial-effect	Strategic-effect
Globalization	0.013 (0.002)	0.019 (0.002)	0.026 (0.004)	-0.006 (0.003)	-0.007 (0.004)
Luxury service	0.680 (0.019)	0.619 (0.038)	0.290 (0.052)	0.061 (0.042)	0.329 (0.064)
Corporate reputation	1.882 (0.119)	0.952 (0.194)	0.726 (0.285)	0.930 (0.228)	0.226 (0.345)
Vehicle size	0.125 (0.063)	-0.046 (0.081)	1.499 (0.139)	0.171 (0.103)	-1.545 (0.161)
Engine power	0.520 (0.035)	0.477 (0.056)	0.313 (0.071)	0.043 (0.066)	0.164 (0.090)
Fuel efficiency	-0.471 (0.049)	-0.415 (0.055)	0.293 (0.091)	-0.056 (0.074)	-0.708 (0.106)
Reprogramming Factor	0.344	0.220	-0.387 (0.029)	0.124	-0.607

Note: Standard errors in brackets

Authentication: Re-programming Value of Larger Vehicles

The balance between corporate reputation and re-programming factor is:

0.952 reputation unit = -0.22 re-programming unit

0.726 + 0.930 reputation unit = -0.387 + 0.322 re-programming unit

=> 1 re-programming unit = 3.2843 units

The balance between vehicle size and re-programming factor is:

-0.046 size unit = -0.22 re-programming unit

1.499 + 0.171 size unit = -0.387 + 0.322 re-programming unit

=> 1 re-programming unit = -2.7182 units

➔ *A focus on larger vehicle size neutralizes the impediments to re-programming deriving from strong corporate reputation.*

Incremental Re-programming Value of Fuel Efficiency

The balance between the fuel efficiency and engine power is:

-0.415 efficiency unit = 0.477 engine unit

0.293 + (- 0.056) efficiency unit = 0.313 + 0.043 engine unit

=> 1 engine unit = -0.0527 units

And balance between vehicle size and engine power is:

-0.046 size unit = 0.477 engine unit

1.499 + 0.171 size unit = 0.313 + 0.043 engine unit

=> 1 engine unit = 0.6530 units

➔ *A focus on fuel efficiency yields stronger engine power than a focus on vehicle size.*

Incremental Re-programming Value of Engine Power

The ex-ante balance between the engine power and luxury service is:

0.477 engine units = 0.619 luxury units

The ex-post balance between the utilization of engine power and luxury service is:

0.313 + 0.043 engine units = 0.290 + 0.061 luxury units

=> 1 luxury unit = 4.4243 units

Similarly balance between the corporate reputation and luxury service is:

0.952 reputation units = 0.619 luxury units

0.726 + 0.930 reputation units = 0.290 + 0.061 luxury units

=> 1 luxury unit = 8.0195 units

➔ *A focus on engine power yields a higher luxury servicing capability than a focus on corporate reputation.*

On the whole, corporate reputation for large sized vehicles yielded decreasing returns over time. In contrast, increasing returns from the fuel-efficient inputs promoted stronger engine power and luxury service capability, in even the small sized vehicles. Therefore it is proposed that:

Hypothesis: Organizational Learning and Manufacturing Reactions

The less a firm owns the visible assets, the greater the technological investment

Operational Measures

The Big-5 Japanese semiconductor firms account for 95% of the Japanese and 40% of the global semiconductor production. These firms are NEC with Yen 1170 billion of sales in 1995, Toshiba with Yen 970 billion of sales, Hitachi with Yen 950 billion of sales, Fujitsu with Yen 590 billion of sales, and Mitsubishi with Yen 550 billion of sales, in semiconductors market. In 1995, 45% of Fujitsu's, 55% of Hitachi's, 65% of NEC's, 75% of Toshiba's, and nearly 100% of Mitsubishi Electric's accounting profits derived from the semiconductor operations, which in all the five cases generated less than 25% of the total corporate sales.

Fujitsu, that traditionally derived nearly all of its profits and 40% of its revenues from the mainframe computers business, made a substantial commitment for using debt capital to finance fresh research in 1989. At the time, Fujitsu held number 2 position in the world computer market, behind IBM, which had been an early influence in Fujitsu's entry into the mainframe business. In late 1992 and 1993, Fujitsu incurred the first loss in its corporate history. By 1993, Korean firms abruptly ended the seven-year long Japanese dominance of the global semiconductor market, by acquiring a matching global market share of 41.6%. In 1993, Fujitsu licensed the distributed server technology from Sun Microsystems for manufacturing and sell back of $200 million worth of original equipment components annually. Fujitsu agreed to act as a Japanese distributor for $175 million of Sun's products, constituting a fourth of Sun's total sales in Japan.

Sun was at the frontier of developing Java Programming for revolutionizing multimedia Internet and telecommunications. In 1994, Fujisu formed a 50% joint venture with Advanced Micro Devices (AMD) for constructing a wafer fabrication facility in Japan. Fujitsu's worldwide sales of semiconductors surged by a record-breaking 44% to $147 billion in 1995. During the fiscal 1995-96, total new semiconductor chip investments in Japan reached a high of $11 billion (Yen 1167 billion). The market was shocked in 1996, when Fujitsu cut the unit prices of its memory chips by 75%. Until 1995, Fujitsu's personal computers were sold overseas as part of an integrated package, including larger more popular systems assembled by the Taiwan's Acer Group. In March 1996, Fujitsu sought to exploit its newly constructed portfolio of component technologies in display manufacturing, memory and storage, by investing $50 million into the Fujitsu PC Corp., for assembling premium Pentium notebooks to be sold directly in the US. It also allocated nearly half of $3.6 billion R&D (Research and Development) budget into the Internet and multimedia telecommunications, and set a target of raising its total corporate sales by at least 30% in two years. It set plans for investing $1 billion into a manufacturing facility in the US, supported with $100 million tax incentives from the Oregon State government.

Mitsubishi Electric, which traditionally focused on semiconductors as core operation, found itself most interested in the Fujitsu's creative programs. During the middle half of 1996, Mitsubishi Electric's net profits fell by 75%. Its production of 16-Dram semiconductor memory chips fell from Yen 550 billion ($4.86 billion) in 1995-96 to Yen 500 billion ($4.42 billion) in 1996-97. Mitsubishi Electric's early development was influenced by the technology licensed from the Westinghouse Electric. At the end of World War II, Mitsubishi Electric's operations were dominated by the military applications. It found the going difficult in the de-militarized Japanese landscape. In 1958, Japanese government agreed to finance its R&D into superconductivity technology, including wires, magnets, electronic devices, and helium refrigerators. Mitsubishi Electric soon emerged as the largest Japanese supplier of defense

electronics for the Japan's Defense Agency. The newly emergent Japan's Space Agency also sought its dedicated services for developing satellites and ground stations. Over the 1980s, Mitsubishi Electric gained a leading 40% share of the $1 billion global television projection market. In 1992, it decided to shift its focus from the mainframe orientation of its government-dominated business to the commercial client-server network systems. In 1993, new divisions were created for network development and systems integration services. Eight domestic R&D labs were consolidated into two new corporate research centers for information technology and for the advanced technologies. In 1993, it also launched the world's first super-conductor magnet for magnetic resonance imaging (MRI) that obviated the need for refilling liquid helium. It also celebrated its sixty years of elevator manufacturing expertise by introducing the world's fastest passenger elevator, carrying a speed of 750 meters per minute. It bagged lucrative power, steam turbines, and generator contracts from several Asian electric utilities. In October 1993, the UK customers were offered $150 off on a joint purchase of TV-VCR package. Mitsubishi Electric won prestigious rights for manufacturing new Alpha microprocessor of Digital Equipment Corp. in late 1994. Thus, as of Fiscal 1994-95, Mitsubishi Electric derived 40% of its overseas sales revenues in Yen, generating super-normal gains on the rising yen fundamentals.

The above experiences suggest a need to correct for the **diffusion-effect** of overseas investments in the falling fundamentals of local currency, and thence in the investment power.

Test of the Hypothesis

Over the recent years, Mitsubishi Electric has been seeking to generate competence in the auto electronics sector, backed by the special demand from the group-affiliated Mitsubishi Motors, which in turn is affiliated to the US Big-3 Chrysler – now part of the Number 1 German assembler, Daimler-Benz. In 1988, Mitsubishi Electric commissioned a wholly owned auto parts transplant in Cincinnati, and sought dedicated contracts from the Big-3 US auto assemblers for its creative services. Soon after gaining strategic awareness of the commercial challenges involved

in the frontier design specifications of the large luxury vehicles, it rapidly upgraded its indigenous auto electric equipment operations of the Himeji Works in Hyogo Prefecture. Himeji, which had been in place since 1943 and whose operations were deeply contingent on the forty affiliated domestic suppliers, enjoyed a record sales of Yen 190 billion during fiscal 1994-95. Himeji was especially commended for the creative offerings of three key auto electrical devices: alternators, distributors, and starter motors. In addition, its electronic engine and driver control parts also carried innovative value. The value of Himeji's option was first recognized in the Philippines. Mitsubishi Electric had a joint venture with a Philippines firm. The new parts imported from Himeji works, and then assembled along with additional sub-systems purchased locally, gained special patronage of the Mitsubishi Motor's transplant in the Philippines. Soon, the local Filipino auto affiliates of Toyota and Honda also ordered the imports of Himeji-crafted components. For enhanced delivery speed and upgraded product quality, Himeji Works initiated new plans for shifting the production of all non-standardized high variety parts to the Filipino joint venture.

In addition, Mitsubishi Electric commissioned full engineering service bases throughout the Southeast Asian region for supporting factory automation system business, including industrial robots and inverters. Inevitably, it gained a prestigious contract for designing and furnishing exclusive 21st century car navigation systems to Volvo of Sweden in 1996. Japanese government, on its own part, invited it in 1996 to work with various renowned Japanese electronic and auto assemblers on a research consortium for designing automated 21st century national highway system. The system was targeted to be fully equipped with the radio cables and other high tech telecommunications gear, to help regulate the automated car navigation systems. The US government had been the first mover in organizing a $660 million research consortium for designing a dominant paradigm of the automated highways in 1991. The European community had estimated the potential size of the institutional global highway system market to be $1 trillion by the early 21st century, and was seeking an alternative paradigm since 1994.

The surging reputation of the second-tier Mitsubishi Electric and Fujitsu had a significant learning power for the Big-3 Japanese semiconductor firms. The market leader, NEC, put a growing priority on transplanting its memory chip component assets overseas. The Number 2, Toshiba, had originated in 1875, when a firm named Seizo-sha was founded in the Tokyo city for making telegraph equipment, following revolutionary electrification of sea-ships by Edison. Tanaka Seizo launched hydroelectric generators in 1893 and X-ray tubes in 1915. In the meantime, another firm, Hakanetsusha & Co., founded by Dr. Ichisuke Fujioka in 1890 for making lamps, developed creative position in radio receivers and cathode ray tube in 1924. In 1939, the two firms merged with an intention to better service the challenging war requirements. After the War, Toshiba launched broadcasting equipment in 1952 and digital computers in 1954, both on the heels of first American innovations. After lagging the market during the miniature revolution of 1970s, Toshiba sought to focus on the sales of peripheral equipment for regenerating its fortunes. It then rapidly moved to embody memory chips into the highly popular and profitable newly emergent laptops and personal computers. In 1987, Toshiba took everyone by surprise through first-time sales of advanced submarine sound-deadening equipment to Soviet Union. The American institutions responded by severely forcing down its US sales and stock value. In 1991, Toshiba approached General Electric for technical assistance in developing home appliance operations for the Asian market. Toshiba also bought $500 million stake in Time Warner in 1992. In 1995, it commissioned a first-class cellular phone plant in China for servicing the US market. In a revolutionary move, in 1996 Toshiba appointed a 14-year veteran, the US-based sales executive Taizo Nishimuro, as the President of its Japanese Headquarters. In 1996, Toshiba derived 77% of its $48.303 billion of sales from the Japanese market, and was targeting broad-based global advantage. Traditionally, Hitachi, with a highly vertically integrated system, had the strongest global export position of all the Big-5 semiconductor firms. But the appreciating yen had been quite detrimental to Hitachi's effectiveness.

Sample and Data Source: The data are available for the overall corporate operations, excluding all affiliates and subsidiaries. The data for nine accounting years, from April 1 1985 to March 31 1994, are used. The data were obtained from the NIKKEI NEEDS database, using the assistance of Takahiro Fujimoto at the University of Tokyo. The raw data were converted from yen to US$, for evaluating investment effectiveness at the international level. Table 2.2 presents summary data on the following: (1) **Research Cost**: measured as the R&D costs/sales, (2) **Networking Cost**, measured as the (cost of purchased inputs, including subcontractors fee)/sales, (3) **Assembly Cost:** measured as the (manufacturing labor cost + kaizen cost of capitalized inputs)/sales. Two sources of growth are evaluated: (1) **Reputation Power**, measured as exports in million US$, and (2) **Trading Power**, measured as $gross profits/employee.

Mitsubishi Electric had the least research cost, Fujitsu had the highest research cost, and the research costs were rising for all the Big-5 firms. Hitachi had a low networking cost, as did to some extent Mitsubishi Electric. There was an increased convergence in the networking cost of the other three firms, with the market leader NEC rapidly reducing its networking commitments. Fujitsu had the least, but most rapidly rising assembly cost. NEC was the only other firm with rising assembly cost. Hitachi had the highest assembly cost. There was a significant growth in the reputation-effect of all the Big-5 firms. Fujitsu continued to suffer from least reputation. Hitachi yielded its lead to Toshiba. There was a similarly strong growth in the trading power across the board. NEC was undisputed market leader, but Fujitsu also had strong second position. The other three firms tended to move essentially at par. On the whole, thus, transformation of networking options into assembly advantage dominated the NEC's leadership. However, such strategy evidently led to a diminishing reputation position of Hitachi. Toshiba was able to discover new networking options, and gain reputation lead, without starkly visible intellectual property rights. Mitsubishi, with least research costs, had the most stable competitive system.

The visibly dominant research costs yielded a strong networking domain to Fujitsu, but still for a time locked its focus out of the investment-sustaining assembly and impeded reputation.

Table 2.2: Organizational learning of the Big-5 Japanese Semiconductor Firms

	Fiscal Years	Research cost	Networking cost	Assembly cost	Reputation Power	Trading Power
NEC	1985-89	6.75%	61.23%	22.92%	3568	108451
	1989-94	8.88%	56.59%	26.70%	4540	181643
Toshiba	1985-89	4.38%	53.96%	21.40%	4655	55956
	1989-94	5.36%	56.52%	18.18%	6730	85203
Hitachi	1985-89	5.45%	43.19%	34.36%	5228	52396
	1989-94	7.32%	42.31%	33.00%	6579	90261
Mitsubishi	1985-89	3.37%	51.35%	26.59%	2697	52762
	1989-94	5.06%	50.70%	26.54%	3740	89333
Fujitsu	1985-89	9.41%	53.51%	10.05%	1885	74551
	1989-94	12.87%	57.36%	17.12%	2844	114923

Correction Factor for the Diffusion-effect

Sample and Strategic Variables: The analysis focuses on the forces enabling Mitsubishi Electric to enjoy a sustainable growth advantage. Super-normal research commitments of the Big-3 firms potentially pressured Mitsubishi to imitate the dominant leadership behavior. As a complementary risk-insuring strategy, Mitsubishi Electric could seek to license the original knowledge diffused by the global vendors, such as through its core US-based collaborator Westinghouse Electric. Data are for nine accounting years, 1985-94. The sample comprises of Big-3 firms, yielding twenty-seven observations matched by year with the Mitsubishi's investment behavior. Two strategic factors in the research power (measured as R&D costs) and diffusion power (measured as royalty paid on licensed technology) of Mitsubishi Electric are evaluated: (1) **innovation-effect**, measured as the (research cost of a Big-3 firm – assembly cost of the Big-3 firm), (2) **creativity-effect**, measured as the [(R&D cost of a Big-3 firm during a year/sales of a Big-3 firm during a year) – (R&D cost of the Big-3 firm averaged over the nine sample years/sales of the Big-3 firm averaged over the nine sample years)]. Table 2.3(a) presents the regression of Mitsubishi's research power and diffusion power on the Big-3 innovation-effect and creativity-effect. The intercepts yield the **routine-effect** of Mitsubishi's strategic

developmental programs. The t-values are in brackets. As is evident, strategic routines sustained research-dominated diffusion power. Continuous path-dependent innovation of the Big-3 firms had no significant impact on the technological investments. Creative discovery of path-developing options by the Big-3 firms generated a strong research-dominated diffusion power

Table 2.3(a): Knowledge Spillovers to Mitsubishi Electric

	Research Power	Diffusion Power	Test of Difference
Routine-effect	747.56 (4.19)	119.32 (6.49)	628.24 (3.50)
Innovation-effect	159.40 (0.18)	61.62 (0.69)	97.78 (0.11)
Creativity-effect	13681.86 (4.15)	1023.07 (3.00)	12685.79 (3.82)
R sq.	0.394	0.271	

Two motivational forces in the sustained assembly of emergent networks by Mitsubishi Electric are evaluated: (1) **National-effect**, measured as the (R&D cost of a Big-3 firm/sales of the Big-3 firm) – (R&D cost of all the Big-3 firms taken together/sales of all the Big-3 firms taken together)], and (2) **International-effect**, measured as the [(R&D cost of a Big-3 firm averaged over nine sample years/sales of the Big-3 firm averaged over nine sample years) – (R&D cost of all the Big-3 firms taken together/sales of all the Big-3 firms taken together)]. Table 2.3(b) presents the regression of the research and diffusion power of Mitsubishi Electric on the Big-3 local-effect and corporate-effect. The intercepts yield the **local-effect** of Mitsubishi's corporate networks. The t-values are in brackets. As is evident, local corporate networks limited the need for visible technological investments, and reduced the dominance of research power (compare local-effect with routine-effect in Table 2.3(a)). Yet the research-intensive national-effect promoted the research power of Mitsubishi Electric. In contrast, tradable international options significantly cut the research power, and the related diffusion power.

Table 2.3(b): Sources of Knowledge Spillovers to Mitsubishi Electric

	Research Power	Diffusion Power	Test of difference
Local-effect	721.20 (14.61)	107.56 (20.47)	613.64 (12.36)
National-effect	9966.75 (2.55)	766.86 (1.84)	9199.89 (2.34)
International-effect	-15704.80 (-4.67)	-1193.33 (-3.33)	-14511.47 (-4.29)
R sq.	0.447	0.292	

How Do the Firms Discover Emerging Technological Know-how?

Sample and Financial Variables: The analysis assesses Mitsubishi's motivation for research and diffusion, in terms of: (1) **Research-effect**, measured as the [residuals of the research power equation in Table 2.3(a) – residuals of the research power equation in Table 2.3(b)]. (2) **Diffusion-effect**, measured as the [residuals of the diffusion power equation in Table 2.3(a) – residuals of the diffusion power equation in Table 2.3(b)]. Three performance variables are investigated: (1) **Networking power**, measured as the cost of purchased inputs, (2) **Reputation Power**, measured as the value of exports, and (3) **Trading power**, measured as the gross profits/employee. The data are for Mitsubishi Electric, matching year with each of the twenty-seven residual observations. Table 2.4 presents the regression of the performance variables on the research-effect and diffusion-effect. The intercepts yield the constant annual corporate-effect. The t-values are in brackets. As is evident, corporate-effect had a positive impact on networking, reputation, as well as trading power. The attempts to use research-effect as a further catalyst force did not yield sustainable returns. The use of diffusion-effect for compensatory reputation-based returns in fact tended to limit the trading power, and again was not sustainable.

Table 2.4: Gains from Knowledge Spillovers to Mitsubishi Electric

	Networking Power	Reputation Power	Trading Power
Corporate-effect	10591.50 (18.32)	5216.80 (26.28)	95592.07 (12.81)
Research-effect	24.53 (1.52)	3.99 (0.72)	15.65 (0.08)
Diffusion-effect	-161.58 (-0.82)	99.94 (1.48)	-4298.09 (-1.70)
R sq.	0.120	0.449	0.319

To productively operate the emergent networking options, the firm might seek to harness the lower cost non-reputed human capital, which has inherent skills in the relevant networked resources. The productivity gains are termed as **trading-effect**, measured as the residuals of trading power equation in Table 2.4. Two causative forces are evaluated (1) enhanced purchases, termed **networking-effect**, measured as the residuals of networking power equation in Table 2.4, and (2) enhanced exports, termed **reputation-effect**, measured as the residuals of reputation power equation in Table 2.4. The following presents the regression of trading-effect on the

networking-effect and reputation-effect. The t-values are in brackets. Networking-effect was a significant positive force in trading-effect, while the reputation-effect was a detrimental factor.

Trading-effect = 0.00 + 17.23 Networking-effect - 21.84 Reputation-effect R sq.: 0.822
(0.00) (9.00) (-3.92)

The residual 12.1% variation in the overall trading power comprised of an annual average of $4083.53 million gained through NEC, balanced by $3873.45 million lost to Toshiba, and $210.08 million lost to Hitachi. The average annual trading gains for Mitsubishi Electric changed from negative $8.57 billion during 1984-87, to a positive $14.23 billion during 1987-91. Thereafter, Mitsubishi Electric dissipated an annual average of $10.40 billion over 1991-94.

Conclusions and the Recommendations for Further Research

The firms may further their growth through a constant appraisal of the emergent networks. In this regard, Ansoff (1965: 75, 77) observed on the opportunities for the firms of the future, "Management science, which is an outgrowth of operations research techniques developed during World War II, has developed many powerful techniques and applications for rational problem solving and decision making within the firm… [In future] Managers concerned with the internal efficiency and response of the firm (for example, operations manager, manufacturing engineer, quality control manager, accountant, and controller) will have been freed by the computer from having to make many of the programmable decisions which consume most of their attention today. Their attention will be directed toward the search for better decision rules."

Sample and Data Source: The data are from Automotive Component Manufacturers Association of India (1996), and were made available by John Paul Mac Duffie at the Wharton School. Table 2.5 presents the percentage share of Japan and the USA in the exports and imports of India's auto-components, in the years following the July 1991 global liberalization by the government. India generated a large and growing export advantage with the US. India's exports to Japan, that were quite negligible, did grow until the fiscal year 1992-93, but then began to fall back. India's

imports from Japan fell rapidly until 1993-94. Thereafter, a sharp jump in Japan's exports to India cut into the export gains discovered by the US during 1993-94.

Table 2.5: India's Automotive Components Trade with Japan and the US

	1990-91	1991-92	1992-93	1993-94	1994-95
Exports to Japan	0.14%	0.53%	0.91%	0.83%	0.49%
Imports from Japan	76.20%	76.34%	68.97%	63.22%	69.86%
Exports to the US	13.30%	13.12%	16.62%	20.30%	23.85%
Imports from the US	8.03%	7.98%	8.67%	15.63%	9.50%

During the fiscal year 1990-91, thirty major electrical, engine, drive transmission, steering, and rubber components constituted 73% of total auto parts exports, and 11.4% of total auto parts imports, of India. After liberalization, the share of these components in India's auto parts exports fell to 67.6% in 1991-92, and then stabilized at just above 40%: 41.5% in 1992-93, 43.3% in 1993-94, and 42.4% in 1994-95. Their share in imports jumped to 13.4% in 1991-92, and then stabilized at 14.4%. In the meantime, the value of total auto parts imports, comprising mainly semi-knocked down pre-assembled kits, grew steadily from $215 million in 1992-93 to $326 million in 1994-95.

Globalization and Operational Rationality: The sample comprises of 30 major parts. All data are in the millions of US$, to evaluate the international level re-programmable value of India's sustained export advantage. **Reputation power** of the international market is measured as the India's total imports of each part during a year. Two forces in the global reputation power are evaluated: (1) enhanced supply of competitive Indian inputs, termed **manufacturing-effect**, measured as (India's exports of a part during the year – India's exports of the part during the preceding five years including the current year). (2) Visibility of the India's dominant advantage, termed **engineering-effect**, measured as (India's exports of a part during the year – India's average exports per part in a sample of thirty parts during the year). Table 2.6(a) presents the regression of the reputation power for each year on the corresponding manufacturing-effect and

engineering-effect. The intercepts yield the constant **programming-effect** of the international assembly operations, on the exports of co-specialized parts to India.

After the initial volatility, involving sudden jump in the programmatic exports to India followed by decline during 1992-93, the programming-effect of the international assembly led growing exports to India. Manufacturing-effect became significant during 1992-93, and had an increasingly negative impact on the competitiveness of these exports. Engineering-effect had a significant impact on the imports from overseas during the 1991-92, but thereafter the local engineering became independent of the dominant international programs. On the whole, programmable value of India's component technology peaked in 1992-93, and fell thereafter.

Table 2.6(a): Programmable Forces in the International Auto Exports to India

	1990-91	1991-92	1992-93	1993-94	1994-95
Programming-effect	0.758 (1.945)	1.180 (4.614)	0.980 (6.351)	1.073 (5.441)	1.538 (4.935)
Manufacturing-effect	0.385 (1.200)	-0.254 (-1.257)	-0.373 (-13.338)	-0.453 (-10.632)	-0.806 (-6.270)
Engineering-effect	0.036 (0.284)	0.242 (3.555)	0.086 (1.843)	0.098 (1.704)	0.157 (1.665)
R sq.	0.644	0.796	0.899	0.860	0.745

Table 2.6(b) presents a comparable analysis using data valued in millions of Indian rupees, to evaluate the learning in international assembly for exploiting Indian option. The programming-effect has been converted into the millions of US$, for evaluating the international level power. Learning in international assembly boosted its programming-effect by 35-50% (compare with Table 2.7(a)). Learning also intensified the negative impact of India's manufacturing-effect on the reputation of international paradigm by more than 50%. India's engineering-effect constituted a significant and growing force in the international learning initiatives. On the whole, a significant reduction in the additional programmable value of India's component technology was realized during 1994-95.

Table 2.6(b): Learning Forces in the International Exports to India

	1990-91	1991-92	1992-93	1993-94	1994-95

Programming-effect	0.574 (0.946)	1.815 (3.295)	1.371 (8.764)	1.558 (7.638)	2.060 (6.056)
Manufacturing-effect	0.450 (0.979)	-0.539 (-1.647)	-0.564 (-13.112)	-0.719 (-10.367)	-1.124 (-5.705)
Engineering-effect	-0.013 (-0.066)	0.419 (2.639)	0.241 (5.514)	0.267 (4.999)	0.344 (3.984)
R sq.	0.638	0.804	0.896	0.854	0.716

Localization and Quality Control: The local nature of Indian manufacturing techniques potentially added to the value of trading Indian components, even in domains where the international assembly already had well-developed engineering programs. Such trading could help improve the quality of integrative sub-system assemblies, and generate super-normal demand for the proprietary international components in the spare replacement parts market. The data are in the millions of US$ for each of the 30 parts. Table 2.7(a) presents the year-wise regression of India's trade balance on two options for international learning: (1) **Competitive-effect** of India's manufacturing, measured as the (total production of a part during a year – imports of the part during the year), and (2) Investment-effect, measured as Current Year Production - Current Year Imports, (2) **Complementary-effect** of substituting a core component, measured as the (total production of a part during a year – average production per part during a year). The intercepts yield the **supplementary-effect** of new assembly operations directly networking more cost-effective Indian services. The t-values are in brackets.

Supplementary international assembly had an increasingly negative impact on India's trade balance, suggesting that the older operations where the substantial localized Indian manufacturing know-how had been discovered were transplanted directly to India. Competitive-effect of Indian production still had an increasingly positive impact on the trade balance. Complementary-effect of networking India's dominant production resources had an increasing, near competitive, positive impact on the international reputation power. The international networking of India's services virtually vanished by 1992-93, but grew gradually thereafter.

Table 2.7(a): Programmable Forces in India's Auto Competitiveness

	1990-91	1991-92	1992-93	1993-94	1994-95
Supplementary-effect	-15.992 (-0.895)	-11.264 (-0.348)	-32.513 (-1.425)	-42.661 (-1.965)	-57.080 (-2.843)
Competitive-effect	0.444 (1.011)	0.367 (0.432)	0.832 (1.480)	1.030 (2.039)	1.057 (2.915)
Complementary-effect	-0.347 (-0.807)	-0.230 (-0.278)	-0.813 (-1.490)	-1.002 (-2.044)	-1.029 (-2.915)
R sq.	0.842	0.859	0.091	0.137	0.239

Table 2.7(b) presents a comparable year-wise analysis for the value of India's total trade in each part. Supplementary-effect of direct multinational assembly in India was significantly positive. After declining through 1993-94, it grew substantially over 1994-95. Competitive-effect of India's production had a significantly negative, though falling, impact on the value of trade. Complementary-effect of dominant Indian production had a significantly positive, albeit falling, impact on the trade value. On the whole, after falling sharply until 1992-93, there was a growing international appreciation of the learning gains from the Indian networking option.

Table 2.7(b): Learning Forces in India's Auto Competitiveness

	1990-91	1991-92	1992-93	1993-94	1994-95
Supplementary-effect	67.561 (3.783)	66.938 (2.067)	50.996 (2.234)	45.657 (2.103)	56.718 (2.825)
Competitive-effect	-1.556 (-3.545)	-1.633 (-1.924)	-1.168 (-2.076)	-0.970 (-1.920)	-0.943 (-2.599)
Complementary-effect	1.653 (3.848)	1.770 (2.142)	1.187 (2.175)	0.998 (2.035)	0.971 (2.752)
R sq.	0.924	0.925	0.658	0.708	0.808

Accounting Power and Control: A fundamental re-programming of the international assembly could augment its flexibility to supply the semi-assembled kits, without the detrimental need for constantly replacing the individual spare parts. A group of 30 nations accounted for a stable 99% share of India's overall auto parts imports over 1990-95. The share of this group in India's auto parts exports steady grew from 62.34% in 1990-91, to 75.92% in 1994-95. The analysis is conducted for data of these 30 nations, both for those valued in the US$, and those valued in the Indian rupees. Table 2.8 presents the regression of India's exports to each nation during 1994-95, on two international reengineering techniques: (1) **Accounting-effect**, measured as the (imports

from a nation during 1994-95 – imports from the nation averaged over the five year period 1990-95). (2) **Control-effect**, measured as the (imports from the nation during 1994-95 – average imports per nation during 1994-95). The intercepts yield the **cost-effectiveness** of trading Indian services, and has been converted into the millions of US$. As is evident, global accounting system limited the international level cost-effectiveness of Indian services to near zero. Control over the Indian production system generated significant trading. This trading constituted only a tiny proportion of the Indian trading potential.

Table 2.8: Indian Auto Component Exports to Core Nations in 1994-95 in millions

	Exports (Rupee)	Exports (Dollar)
Cost-effectiveness	33.390 (2.695)	5.937 (0.790)
Accounting-effect	-8.617 (-2.285)	-0.298 (-0.081)
Control-effect	2.589 (2.299)	0.0684 (0.108)
R sq.	0.166	0.006

The investment programs assuming that the reputed firms enjoy the principal know-how could limit the networking of emerging services. Senge (1990: 58) highlights that, "In the 1960s there were massive programs to build low-income housing and improve job skills in decrepit inner cities in the United States. Many of these cities were even worse off in the 1970s despite the largesse of government aid. Why? One reason was that low-income people migrated from other cities and from rural areas to those cities with best aid programs. Eventually, the new housing units became overcrowded and the job training programs were swamped with applicants. All the while, the city's tax base continued to erode, leaving more people trapped in economically depressed areas." Therefore there is a critical need to develop the organizational learning of the emergent know-how.

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