IKMAS WORKING PAPERS
Number 11, July 1997

ELECTRONICS IN MALAYSIA

The Challenge of a Stalled Industrial Transition

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C O N T E N T S

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1. Introduction: A Critical Impasse

Malaysia has been enjoying double digit manufacturing value-added growth rates for 3 decades (Industrial Development Global Report 1995, UNIDO). Industrial investment and growth have interacted in a cumulative dynamic process which, in turn, has generated a rapid increase in the standard of living. With a per capita income of over US$3000, Malaysia is the leading East Asian candidate to follow the industrialization trajectory pioneered by Japan, with a per capita income of US$27,000 and successfully negotiated by South Korea, Taiwan, Hong Kong, and Singapore, with per capita incomes in the US$6000 to US$14,000 range.

The electronics industry has played a central role in propelling industrial growth in all of the East Asian success stories. In Malaysia, electric/electronics sector output grew at 14 percent per year over the 1968-1990 period and increased as a share of manufacturing output from 1.5 to 25 percent; the average annual growth of electronics employment was nearly 25 percent from 1968 to 1990 as the electronics share of manufacturing employment increased from 2 to 30 percent (Rasiah, 1995, p.113).[1] Foreign direct investment, particularly by American and Japanese semiconductor companies, has led the way. The foreign share of fixed asset ownership in electronics was 89 percent in 1990 (Rasiah, p.111).

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[1] Rasiah summarizes: "At the four digit industry-level disaggregation, the electric/electronics industry, which is heavily dominated by foreign-ownership, has risen from virtual insignificance in 1968 to be the leading generator of employment, fixed assets, output and exports in the manufacturing sector in 1990" (p.198).

However, obstacles are emerging to continued industrial growth along the same trajectory. To date, Malaysia has enjoyed high rates of growth without suffering major balance of payments problems. But this may be changing. A warning sign is the high current account deficit and the crucial role of foreign corporate investment inflows in financing it.

Even though Malaysia is an open economy with trade amounting to 150 percent of GDP, the trade balance has stayed positive throughout the 1990s, averaging about 3 percent of GDP. The deficit on the services account, however, has averaged over 9 percent of GDP between 1990 and 1996. Consequently, the balance on current account has averaged slightly under 6 percent for the same years with spikes of 8-9 percent in the fast growth years of 1991 and 1995.

The current account deficit has been financed by private capital inflows from abroad throughout the 1990s. In fact, on average, long term corporate investment inflow was roughly equal to the current account deficit.

Can Malaysia count on corporate investment inflow to continue to finance the current account deficit? A positive answer depends, in part, on the relation between corporate investment inflows and investment income outflows. The problem is that while the annual level of repatriation of profits and dividends has more than doubled over the 1990s, corporate investment, while still high, has slackened since 1992. The heavy reliance on foreign investment is like having a tiger by the tail: repatriation of profits is expanding directly with the ever larger fixed capital base in Malaysia but the corporate investment inflow, while not falling, is an ever smaller proportion of the outflow. Consequently, ever greater levels of corporate investment inflow are required to sustain the growth in GDP.

The looming balance of payments dilemma, however, is a manifestation of deeper, structural problems confronting Malaysian industrial development. Malaysian industry is lodged in low-skill labor and raw material intensive production activities depicted by the bottom and right hand quadrants in *Figure 1* which (quite close to the Japanese position in its early development stage). Foreign direct investment (FDI) in electronics has introduced limited complex production process activities (left hand quadrant in *Figure 1*). The foreign owned electronics companies have not widely diffused or, as yet, triggered the diffusion of, complex production process activities within Malaysia. In fact, only limited complex production activities are carried out by the multinational electronics companies in Malaysia. Chip fabrication and wafer development, for example, are done elsewhere. Instead, they have located in Malaysia bottom quadrant activities such as the assembly and testing of chips or the stuffing of printed circuit boards. Thus even what seems to be quadrant two activities is a blend of quadrant two and four, but mainly the latter.

Electronics industry success for Malaysia, in the first decade or two, was based on attracting foreign direct investment with low wages of workers and staff into quadrant four activities. Fortunately, as described below, a range of foreign-owned Malaysian production sites, especially in Penang and the Klang Valley, are making the transition from simple assembly to more complex production which requires a labor force with technical, problem-solving, and managerial skills. The problem is threefold: first, such examples of production upgrading within FDI plants are as yet the exception; second, are the higher skills associated with tending automated machinery or those associated with kaizen and multi-task skills;[2] and third, the new production methods have not been diffused into indigenous

[2] Seagate, for example, is reportedly flying workers earning $10 per day to the United States to learn how to operate robots. Penang Seagate Industries Managing Director Timothy Harris informed Business Week: "We are growing as fast as the labor market will allow, but that isn't enough" (December 2, 1996, p. 61).

Malaysian industry. Malaysian owned business enterprises have not converted the stimulus of foreign direct investment into domestic production capabilities in the form of a vibrant vendor base supplying intermediate, component, and capital goods.

This is not surprising. FDI has provided access to international markets and to labor intensive activities but, with some exceptions, it has not introduced integrated production systems into Malaysia or even the high value-added or advanced manufacturing links in the industrial food chain. This introduction does not occur without the intentional creation of an interactive (versus an interpassive) relationship between the host economic development agencies and foreign business enterprises which together advance the production capabilities and skill base of the nation. Consequently, FDI, on its own, is not and never has been sufficient for diffusing new production and business practices and thereby developing indigenous business and production capabilities in Malaysia or elsewhere in the absence of concerted complimentary local initiatives.

Malaysian industrial development is at a critical impasse. On the one side, Malaysia can not continue indefinitely along the path that has generated rapid growth over the last three decades because success has undermined the initial conditions. As a consequence of rapid growth wages have grown to 3 to 4 times that of nearby countries (Ohmae, 1995, p.121). Indonesia, for example, supplies over 90 percent of the construction workers in Malaysia. Between 20 and 30 percent of the 7 million labor force of Malaysia are estimated to hold foreign passports. Like in Japan, followed by the East Asian newly industrialized economies (NIEs) of Korea, Taiwan, Hong Kong, and Singapore, the process of rapid industrial growth reduced the competitive advantage of low-skill labor

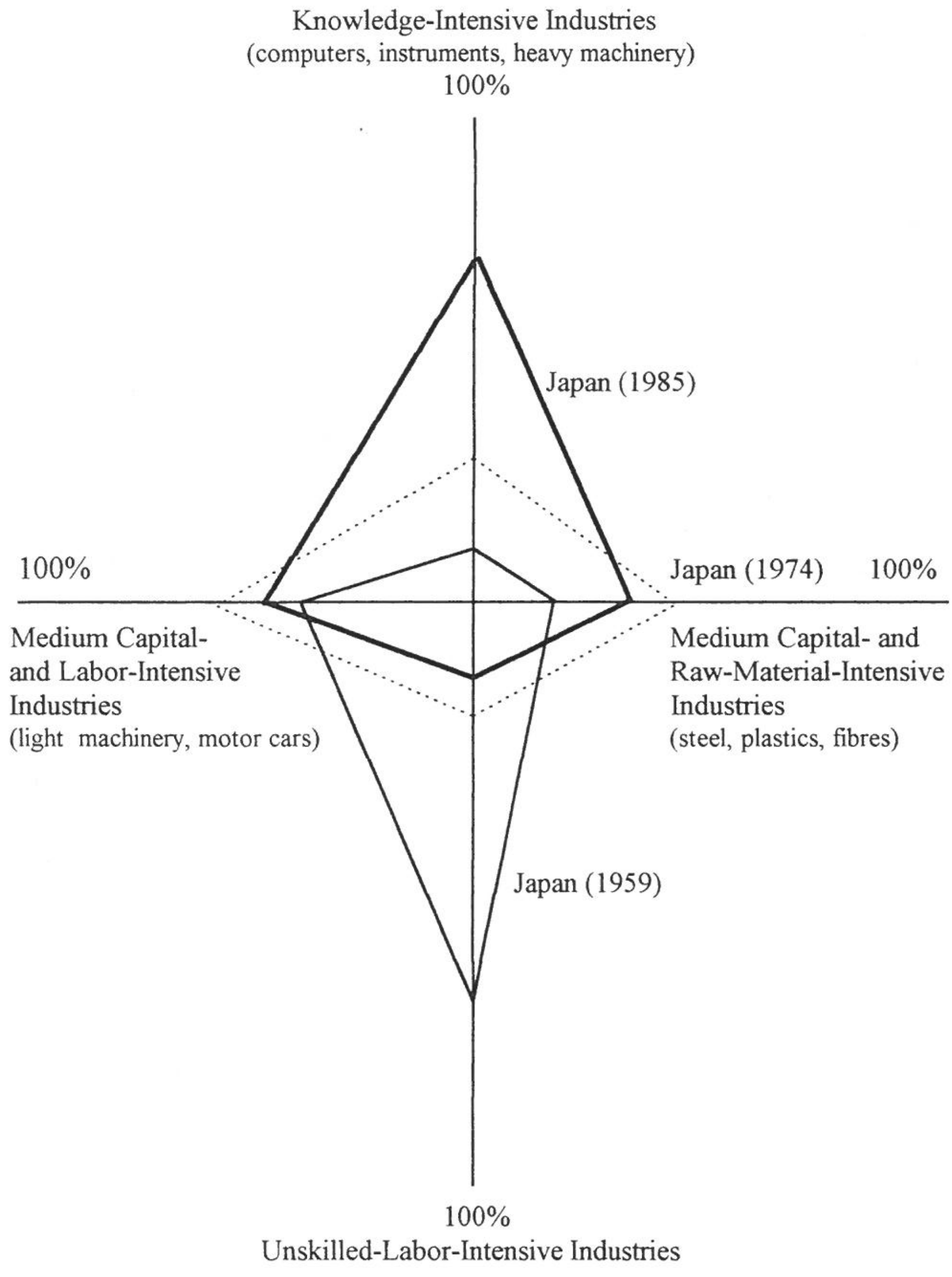

Figure 1: Evolution of Japanese Industrial Structure

Source: Japan Economic Survey, Economic Planning Agency, 1974-5; cited in Magaziner and Hout, 1980, p. 7.

activities. Higher wages and shortages of labor suggest that even the semi-conductor and consumer electronics plants will not continue their past level of investment in Malaysia unless they can automate fast enough to substitute machines for workers. But this may add to pressures on the balance of payments and, ultimately, reduce the advantage of investing abroad by companies like Seagate altogether.

They have been staying, in part, because an industrial infrastructure is in place after nearly three decades of electronics production. The managing director of an American company explained that his company take over a decade to build a loyal, and talented staff of 30-50 mid-level technicians and managers. This local management team would be hard to replicate in short notice in lower wage regions and the total compensation would be three to four times more for a equally capable team in the United States. A major capability of the local team is its ability to manage effectively a low paid labor force in the thousands. This strategy generates a demand for low-skill jobs but does not depend upon developing a multi-skilled labor force capable of running a flexible production system. This particular company, like most, does all of its product design and development work at its home base. The product is only transferred to Malaysia after it has been manufactured successfully in a pilot plant. Both of these features of FDI in electronics, if general, suggests future industrial growth in Malaysia will be limited under the current conditions. Growth from productivity gains will be limited because high value-added activities are done elsewhere, and, with unemployment at 2 percent, the potential to drive growth with increased manufacturing employment of low-skilled workers has become limited as well.

Thus, the competitive advantage enjoyed by Malaysia in earlier decades is disappearing: the combination of low wage followers and the increased diffusion of manufacturing exports. In South Korea, SMEs share in total manufacturing employment rose from under 38 percent in 1976 to 51 percent in 1988 and as a share of value-added in manufacturing from 24 percent to 35 percent over the same period (World Bank, pp.162-3).

2. The Production-System Transition

Sustained industrial development, in today's global economy, requires moving up the production capabilities spectrum in steps. As noted, once anyone transition is accomplished, the nation or region will enjoy a new period of growth as the new practices diffuse across firms and open up new sectors for domestic production. But eventually wages will rise, followers will imitate and continued growth will require making yet another transition along the production capabilities spectrum. Along the way a transition in business organization and in the composition of industrial output transforms a region or nation from a price-led to a product-led competitive dynamics. The price-led competition is based on producing the same product indefinitely; the new competition is based on the development of a set of organizational capabilities that enable business enterprises to compete on the basis of a more comprehensive performance criteria. Henry Ford's mass production system drove down costs of production by an order of magnitude. This was price-led competition based on combined organizational and technological innovation. The performance criteria of the New Competition of today is not one dimensional; firms must achieve world class standards in cost, quality, time, and innovation.

The time dimension is fundamental and includes production lead time and new product development time. Leaders in an industry are firms that can introduce new products more rapidly. Firms that can develop new products more rapidly are flexible production systems in the leading industrial regions is closing the avenue that Malaysia has so successfully traveled the last three decades.

Moving to a new high growth path means making the transition from level 4 to level 5 along the production capabilities spectrum shown in Appendix A. This means developing a competitive advantage in complex production process activities. The successful newly industrialized economies that have all made the transition to indigenous production of a range of electronic components and intermediate goods have done so by building variants of the Toyota production system, usually in the form of cellular manufacturing system in which teams of workers produce a range of products in the same cell. Other features include plant organization according to the logic of the process (not functional specialization), an understanding of one-piece flow, quick changeovers, quality-first, *kanban* scheduling systems, and group bonus systems.

While a few companies will have developed these production capabilities, a transition requires the rapid diffusion across a critical mass of enterprises. Thereafter the transition will be self-organizing as new generations of managers take the new principles and practices for granted.

The diffusion was driven in Japan by the leadership of lead manufacturers seeking to upgrade the capabilities and performance standards of large supplier bases. The result was the development of a dynamic domestic production system composed of integrated big enterprises interacting with a broad small and medium-sized enterprise (SME) industrial base. While the contribution of the big enterprises are widely known, the SME base is less familiar. For example, the Keihin region outside of Tokyo and home to 200,000 SMEs employing 1.7 million people is the heartland of the Japanese electronics industry. In Taiwan, over 98 percent of manufacturing enterprises are SMEs which account for 60 percent of Taiwanese the firms that can also introduce new technologies more rapidly. It is this virtuous dynamics that drives the leading industrial regions of today.

Fundamental to the success of Japan and the East Asian NIEs has been the development of organizational capabilities to manage the transition to the new performance criteria. All five used the low wage, high growth period to drive an industrial transition from low skill- and raw material intensive business strategies and industrial sectors to complex production process- and knowledge-intensive strategies, activities and sectors. In the process they developed the institutional capability to flexibly restructure within firms and across sector or industry lines. Singapore and Hong Kong demonstrated that foreign direct investment can be a catalyst but sustainable growth demands the development and diffusion of production qualifications across a wide range of firms. Crucial to the diffusion process is the development of a broad class of product and process engineers and multi-skilled production workers.[3]

In the past, electronics suppliers could be successful by offering world class performance in cost, quality, and delivery times. Today, the same supplier must meet technology related service requirements as well. For example, Cary Kimmel, a Xerox executive, lists the engineering services demanded of a "model" supplier: design services, test engineering and equipment design, component qualification, failure analysis, value analysis/value engineering, and prototyping (Kimmel, 1993, p.156). Kimmel reports that a Xerox survey of suppliers in East Asia conducted over the 1985-87 period revealed the following:

[3] A Xerox executive lists the engineering services demanded of a "model" supplier: design services, test engineering and equipment design, component qualification, failure analysis, value analysis/value engineering, and prototyping

> companies that provide S&T [factors related to service and technology] experienced a growth rate of over 400 percent during the three-year period compared with only 30 percent for the more traditional contract manufacturing companies. It is of more than passing interest that the greatest growth was experienced by those companies located in countries with well-defined national policies that encouraged the growth of S&T capabilities (p.158).

Singapore built a targeted skill upgrading infrastructure to match the physical infrastructures. The heart of the skill upgrading infrastructure was a network of training centers composed of craftsmen centers, technical institutes and programs such as Continual Upgrading Training and the Skill Development Fund. Since the curricula was formed in partnership with technologically advanced business enterprises, foreign enterprises found they could transfer increasingly complex production activities to Singapore. Micropolis, for example, used the national training network to introduce disk drive production and open a regional R&D center in Singapore. By the late 1980's, Apple Computer's Singapore Division was engaged in concurrent engineering projects for components that affected the design of Apple computers in a state-of-the-art plant (Magaziner, p60).

Today, Japan, while the industrial leader in many sectors, is struggling to make the transition to research intensive, new base technologies including biotechnology, advanced materials, and photonics (see Magaziner, pp.367-372). The four NIEs are developing strengths in integrating production with rapid new product development, in driving down technology diffusion cycle times and targeting technological RD&E to potential high growth areas. Taiwan, for example, is becoming a world leader in advanced material composites. The Republic of Korea was the third country in the world, after Japan and the U.S., to introduce and export 256K memory chips (Freeman, cited in Singh, p.44).[4]

[4]Globally, the semiconductor industry is being restructured at a breathtaking pace. Korea's top three semiconductor makers, Samsung, Hyundai, and Goldstar Electron Co., are grabbing dominant

The challenge for Malaysia is to shift to the new competitive dynamics, from one that competes on the basis of low cost labor and scale economies applied to raw materials and single product plants to one that meets the new comprehensive performance criteria. This entails integrating product design, technological change and production up and down the industrial food chain. This transition is as dramatic and far reaching as the demographic transition that occurred in East Asia. East Asia went through the steepest demographic transition on record as birth rates declined by 40-50 percent in the 1965-80 period (World Bank, p.39).

From this perspective, the four leading East Asian NIEs, following Japan, have passed through a business system transition that is analogous to a demographic transition. It was this transition that enabled the four leading Asian NIEs to transcend the critical impasse facing Malaysia today. The development of a vibrant vendor base supplying intermediate, component, and capital goods is itself part of a deep-seated reorganization of industry according to new principles of production and organization. But unlike the demographic transition, which is based on a sharp reduction in the population birth rate, the production-systemic transition is accompanied by a dramatic increase in the population of SMEs. The output to labor ratio jumps upward in the new plants but the number employed, directly and indirectly, increases as market share and the size of the production pie expand.

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market share from the Japanese in the $22 billion memory-chip market just as Japan had done to America in the 1980's when Japanese share rose to 80% and America's fell to 15%. Japan' memory chip business could go the way of her steelmaking and shipbuilding industries: lost to the more aggressive investments by the Koreans. The big three Korean companies are also targeting the liquid-crystal display market with a similar strategy.

Intel, however, is dominating the microprocesser market with the most expensive industrial facilities in America. Intel's Rio Rancho, New Mexico plant will cost $1.8 billion, or 600 times as much as Intel's $30 million initial microprocessor factory. Intel is also building a $2.2 billion facility in Oregon to fabricate the P-6 chip. Business Week (Dec. 2, 2996) reports that Taiwan is building a dozen new $1 billion silicon-wafer plants and Singapore "wants to lure 20 wafer fabs".

3. The New Malaysian Business System

The challenge that will confront Malaysian manufacturing in the next few years is to make the transition to levels 5 and 6 along the production capabilities spectrum. The starting point for the new business systems are a series of organizational innovations that began in Japanese manufacturing plants, particularly in automobiles at Toyota. These include process integration, multi-product flow, cellular manufacturing, quick changeovers, *kaizen* or continuous improvement, self-directed work teams, concurrent engineering and the *kanban* scheduling system. These new production capabilities are a prerequisite to developing the new competitive dynamics. The problem for Malaysia is that FDI has not, to date, been a catalyst for diffusing these production activities in Malaysia.

But Japan's organizational innovations did not stop on the production floor. The idea of process integration and short cycle times spread from production, to new product development and to technology diffusion. Japanese consumer electronics companies became world leaders by extending the production innovations from Toyota and integrating and synchronizing production, design/manufacturing, and technology diffusion cycle times.

A new business organization emerged to facilitate the expression of the new production principles and spread them to other business activities within the firm such as order-delivery and new product development. The new firm is organized around processes and not business functions. Process organized companies enable inter-functional teams to pursue new product development projects. However, the logic of the new process integrated business enterprise does not stop at the factory gate; it also applies to the "system of firms" along the industrial food chain.

The old hierarchical supplier chain was a logical extension of the hierarchical enterprise: the vendor supplied parts that were designed by the engineering staff of the assembler. In the new business system the vendor supplies design ideas which become embedded in the parts and components. Such a supply chain is coordinated by inter-company design-build teams and validated by purchasing managers.

Boeing estimates that the design-build organization for the 777 eliminated half of the parts "rework" costs that plagued new planes in the past and cut the "order to delivery" cycle time in half. A respected consulting firm estimates that bills for purchased parts and services can be cut by 30 percent by effectively integrating suppliers into the new product development process (WSJ, 12-19-94,pA8).

The competitiveness logic of the new business system is not simply that a specialist vendor can generate economies of scale by selling components or parts to an entire industrial system composed of many end users. The deeper logic is that such specialists at each link in the industrial food chain become diffusion agents for technological innovations that emanate from any one of the end-user and vendor partnerships. In this way the whole district of firms becomes more dynamic. This simple logic is one of the secrets to the success of the dynamic small firm districts of Northern Italy and of the German "mittlestand" or SMEs. Vertically integrated firms simply lack the exposure to end-user sources of innovation that is enjoyed by a group of flexibly specialized enterprises.

The development of flexible production capabilities enhances product-led competition in a second way: enterprises that develop the production flexibility capabilites to compete on the basis of more rapid new product development become magnets for technological change. Such firms can take advantage of the worldwide pool of technology to operate, adapt, reengineer, and eventually engage in product innovation. The firm is no longer thought of as a producer of parts or components but as a generator of projects which link internal and external resources.

Thus, the driving element that distinguishes the new competition is the learning or entrepreneurial firm with the capability to combine continuous improvement with rapid new product development by tapping the collective problem-solving capacities of teams. The entrepreneurial firm can be big or small but in most cases it is a specialized member of a system of firms which compete together in the global economy. Their collective strength is in driving down new product development times.

The emergence of SMEs is built into the logic of a dynamic industrial base in which large firms and SMEs interact. The seedbed of new firms can be the advanced manufacturing practices that exist in transplanted foreign firms. It can be the logic of applying cellular manufacturing practices and the principle of flow which inevitably focuses production and creates an imperative to cooperate with specialists in complimentary activities. The challenge is to convert the seeds into a healthy crop of locally grown enterprises which are organized into dynamic, flexibly specialized industrial districts.

4. Intermediary Organizations as Agents of Diffusion

In the first industrial revolution, machine tool companies that served a range of sectors were "transmission agents" of technological innovations. A highly developed machine shop that designed a machine to enhance the productivity for one industrial user would seek applications for other end users in the same and technically related sectors. In this way innovations were rapidly diffused. Henry Ford's mass production system built a supplier base capable of synchronizing parts production with Ford's assembly line and in so doing diffused the principle of flow to the emerging automobile supplier base.

Follower nations in the industrialization process developed functional equivalent diffusion agents to that of a dynamic machine tool industry or a technological innovator on the scale of a Henry Ford. In fact, intermediary agencies, between traditional government and profit-seeking enterprises, that specialize in diffusing "best practices" are an integral part of the new competition.[5] Their task is to diffuse the new practices to maintain a healthy SME base which, in turn, will advance the regions capabilities to seize technological and organizational opportunities rapidly.

An SME base both depends on and feeds the development of manufacturing engineering and production skills within the populace. This skilled pool is the life-blood of manufacturing enterprises; the enterprises and talent pool interact to generate an indigenous, innovative industrial system. The infrastructure of skill upgrading institutes and programs in Singapore referred to above is one example of an intermediary institution: Its function is not merely to educate people but to foster the rapid diffusion of technological and organizational innovations across a whole range of firms. The diffusion process is mediated by the technical and skilled labor pool which flows across business enterprise and advances their capabilities in the process.

[5] A system of flexible specialist enterprises is itself a transmission agency for the inter-firm diffusion of organizational and technological innovations. But even here the common good of an industrial district can be managed by intermediary agencies. Clearly, individual firms can have an interest in seeking to limit the pace of diffusion even though the public interest is clearly enhanced by rapid diffusion.

The training within Industry program in Japan provided a similar function although it was more in-plant focused. The Japanese Union of Scientists and Engineers developed and promulgated the plan-do-check-act core of total quality management. Japan's MITI played a key role in promoting the concept of fusion after the success of mechatronics in integrating the machine tool and electronics industry in the form of standardized, user friendly electronically controlled machine tools which, in the late 1980's, moved Japan from the fourth to the first largest exporter of machine tools.

The Kohsetsushi Centers of Japan, the Fraunhoffer Institutes of Germany, the real resource centers of Northern Italy, and the Manufacturing Technology Centers of the U.S. all have the mission of promoting the technological capabilities of SMEs. Such institutions, properly organized, are catalysts for enterprises pursuing product-led strategies.[6] Critical to the production-systemic transition is the rapid diffusion of technological and organizational innovations across a whole range of firms.

The idea of a regional industrial district or production system does not mean that every SME has the capabilities to identify, adopt, and adapt new technologies, and to design new products but that a critical mass of firms have such capabilities. Such hub or focal firms, in turn, organize surrounding networks. Without such product design capabilities built into the region, SMEs are left to compete for existing designs and the region does not advance to product-led competition. Successful intermediary institutions target the focal firms to have a leveraged effect on competitiveness.

[6] A criteria for success of intermediary agencies in the U.S. is developed in Forrant and Flynn, 1995.

Intermediary organizations are vehicles of strategic industrial policy making, the fourth institution in the production system. The purpose of sector strategies is to strategically reposition a regional group of firms in global markets. The challenge is to develop sector strategies which, in turn, shape the form that competition takes within a regional group of firms to advance their competitiveness against regional groups located elsewhere. A region in which firms are competing on the basis of technological advance and in which intermediary agencies act to rapidly diffuse technological advances will be well placed to compete against region in which the competitors do not cooperate strategically. Such competitors tend to define their obstacles to success in terms of local competitors and compete on the basis of lowest costs. Equally important, without inter-firm networking, enterprises do not develop the capabilities required for rapid new product development.

Together, this four-part institution complex (entrepreneurial firms, networked supplier relations, intermediary agencies that promote best practices, and strategic industrial policymaking agencies) constitutes a business system or proactive industrial district with the capability to drive down and integrate three cycle times: production, new product development, and technology diffusion. A fully developed version means establishing a top quadrant presence (see Figure 1) in which design intensity is integrated with technological advance in the strategic redefinition of old, and creation of new, sectors.[7]

[7]Note that moving across the sectoral pyramid of Figure 1 is not simply about shifting into the assembly of the range of end use products associated with each sector but developing the vertical and diagonal linkages that support each end-use product.

5. The Malaysian Electronics Industry: Building on an Emerging Production Dynamic

Malaysia has reached a turning point. The task is to develop a electronics industry strategy to negotiate the transition to the multi-product flow, a prerequisite for rapid new product development. The foreign direct investment strategy can no longer drive industrial growth although it can be a hugely valuable partner. The problem is not FDI per se. Both Hong Kong and Singapore relied heavily on FDI to provide foreign exchange, market access and from which to learn world class management practices; South Korea and Taiwan were much less successful in attracting FDI. They more often purchased directly the most advanced technologies with debt and built strategic business capabilities, including engineering and production teams around them. But all made the transition to product-led competition.

Why has the transition not been made in Malaysia? It has not been for lack of high tech sales in the U.S.. Malaysia's 1991 high tech sales of $2.3 billion were two/thirds that of South Korea and Taiwan, over twice that of Hong Kong, 150 times that of India, and 25 times that of Indonesia (Rausch, NSF, p25).

The immediate answer is the lack of inter-firm and inter-industry linkages. Local firm involvement in electronics production is minimal. Local firms are active in materials handling equipment and electrical parts and in machine shops. Wafer fabrication is virtually non-existent (one dated plant) and no locally assembled chips are inputs into downstream domestic products. Consequently, the foreign electronics sales have a high import component and Malaysia is primarily reexporting. But why the limited linkages?

First, key inputs in electronics production involve sophisticated technical capabilities, for example, chip fabrication. These plants are state of the art for only 2 years, as Moore's Law (that the power of chips will double every 2 years) demands new process technologies with each generation of chip. Second, fabrication facilities are costly. Intel's Pentium chip plant in New Mexico cost $1.8 billion; Intel's new facility in Oregon is projected at $2.2 billion. Third, Malaysia has been used by foreign direct investors to supply only simple, labor intensive links in a product chain that begins and ends outside of Malaysia. This has changed little even though production has been made more flexible. Fourth, the industrial development strategy of Malaysia has not focused on developing the technological absorptive capacity of local firms and promoting technological transfer with tough local content rules.

A deeper answer is that Malaysia has not developed a critical mass of business enterprises with the capabilities to move from assembly, low-skill labor activities to complex production activities. Without such organizational capabilities the opportunities to learn from FDI was not converted into indigenous production and innovation capabilities. Fortunately, however, certain recent organizational developments in electronics manufacturing give reason for optimism and provide some promising opportunities on which to build a strategy.

While Malaysian component electronics is narrowly focused on post-fab semiconductors and disk drive components, these are rapidly growing industries on a world scale and here we find encouraging signs. The potential for continued growth is enormous. Market researcher Dataquest Inc. projects worldwide chip sales to rocket from US$110 billion in 1995 to US$273 billion in 2000 (BW, Aug.7,'95, p64).

Malaysia has built a competitive advantage in the assembly and testing of chips of different types. Capabilities in both of these activities run a spectrum from simple mass production operations to complex multi-product processes. Most of the production organizational innovations made famous by Toyota such as JIT, one-piece flow, single-minute-exchange-of-die (SMED), *kanban*, continuous improvement have analogs in chip assembly and testing which enable companies to achieve the new more comprehensive performance criteria: drive down production lead times, enhance design quality into the system, produce a range of products without increasing inventory and lead times.

After 20 years of assembly and testing chips, Malaysia has built the capabilities to counter balance low wage competitors. Even though wages are seven times that of China semiconductor assembly and testing companies, Japanese and American chip manufacturers are still using their Malaysian facilities for chip testing, assembling, and packaging (Ohmae, 121).

That individual plants are making the transition is suggested by the fact that to date, the multinationals have stayed in Malaysia even though labor costs have been rising 8-10 percent annually. Instead of moving to lower wage areas, some companies are pursuing a two pronged attack. The first is moving toward more automated equipment. For example, a recently opened Motorola-Philips collaboration in Seremban is a highly-automated semiconductor assembly plant from die bonding to electrical classification, fed by a continuous leadframe. The plant requires no operators and has a staff one-tenth the size of similar size plants elsewhere in Malaysia.

The second prong is the move to world class assembly practices involving intensive worker training, TQM, and more flexible assembly and testing equipment (for details see Rajah, 1994). This shift is showing up in growing demand for more "capable and flexible equipment at all phases of test and assembly, in particular machines which permit a single operator to control multiple machines, and with limited requirements for technicians for backup" (Hawes, p.4). "There is, for example, increasing demand for high quality high volume automatic testing equipment which can rapidly examine finished semiconductors and compare them with predetermined specifications, determining whether leads are properly aligned and spaced, with minimum time required for changing from one kind of end product to be tested to another" (Hawes, p.4).

The challenge, then, is to diffuse the new production capabilities across a broad range of indigenous business enterprises and product lines, and up and down the industrial food chain. This is not a minor challenge. It means mobilizing the energies of an entire industrial complex around a common goal: making the transition to world class manufacturing capabilities such as the following:

- *kaizen* or continuous improvement production capabilities on the shop floor. The plan-do-check-act wheel promoted throughout Japanese industry by the Japanese Union of Scientists and Engineers is a powerful instrument for developing a problem-solving capability into the cellular structure of production.

- moving from reverse engineering to adaptive to technological innovation and independent product design capabilities. Business enterprises can be distinguished in terms of four progressive capabilities to absorb technology: acquisition, operation, adaptive, and innovation.

- new product development capabilities. This requires the development of design/ manufacturing capability (idea to product to market) and its integration with ever shortening product life cycles.

- technology fusion capabilities. Innovation often involves re-coupling technologies in new ways. Mechatronics, the marriage of machine tools with simple, standard electronic controls, redefined the machine tool industry to the major benefit of Japan.

- short domestic technology diffusion cycle times.

- an SME base that supports a range of industries and enhances flexible specialization.

- a responsive skill upgrading system that enables individuals to upgrade their skills over career and firms to emerge that tap into the existing pool of skilled workers and engineers using new combinations.

The refinement of these capabilities propelled Japan into a leadership role in consumer electronics, automobiles, machine tools, cameras, etc.. They were imitated in each of the NIEs and are common elements in the leading enterprises and regions of the world.

6. Intermediary Agencies in Malaysia[8]

In both business enterprises and intermediary organizations, Malaysian success stories exist which form the basis for developing a strategy to promote the production-system transition. The Vendor Program of the SMI Division of MITI is an example.

[8]A recent survey of institutions supporting innovations in firms in Malaysia conducted by Rajah Rasiah (1997) came to my attention too late to be incorporated into the text.

The Vendor Development Program is a marketing/finance program for SMEs that involves lead manufacturers (anchor companies), banking institutions, and is coordinated by the SMI Division. Presently, 13 banking institutions and 42 anchor companies, mostly in electronics, and 71 SMEs vendors are involved. In tripartite meetings organized by MITI, the SME's bank queries the anchor company, to whom the SME supplies, a series of questions about the appropriateness of the machine being purchased, the demand or volume that will be purchased, etc. If the desired loan makes sense to the banker, an agreement is signed by which the anchor company pays directly to the bank.

The Vendor Development Program is but one of a range of possible supplier development programs that could be promoted to upgrade the production capabilities of SMEs. Motorola's supplier upgrading program in the US is a model. Matsushita and Sony, as well, have successful records in developing supplier firms.

Proton has largest with 19 "memoranda of understanding" (none of which are electronics/electrical companies; Sapura has 9 none of which are registered electronics/electric companies; General Lumber Furniture has 13 (none in electronics/electric sectors); 13 electronics/electric companies are anchor companies but here, again, the vendors are not in electronics/electric sectors but mainly in plastics, metalworking, die casting, etc..

This is not the only success story. The Penang Skills Development Corporation, supported by over 50 foreign firms, has upgraded the skills of over 10,000 people to whom it has offered instruction (Rasiah, 1995, p.204; The Economist, August 26, 1995, p.52). Proton, the Malaysian car company has 200-300 vendors. The Technology Park Malaysia is another promising catalyst for the transition.

However, when compared with the panoply of strategically targeted intermediary organizations in Japan, Singapore, South Korea, and Taiwan it suggests that considerable opportunity for organizational development, if organized according to best practices, could be crucial for achieving the goal. To date, the transition enhancing intermediary institutions in Malaysia impact only a small percentage of the nation's 12,000 enterprises. The very lack of a SME industrial base indicates the size of the challenge.

Poorly organized intermediary agencies can become part of the problem and not the solution. The role of intermediary organizations that target specific bottlenecks to the scaling up of such capabilities is crucial. Intermediary organizations without a strategic orientation rapidly become elements of institutional inertia. Leadership in focusing and mobilizing the latent energies in such organizations is as crucial as it is in business enterprises.

7. The Missing SMEs

Policy measures that develop and nurture a growing population of industrial SMEs is one important means of fostering organizational and technological innovation. Focusing on SMEs means, as well, targeting focal firms, inter-firm linkages and intermediary organizations. Focal firms are design intensive enterprises that focus on new product development, and organize supplier networks. They develop a core competence which often involves combining technologies but, rather than integrating vertically, they network with complementary specialist enterprises. Focal firms are like the server computers which coordinate local area networks on the internet. However, the analogy tends to break down in vibrant industrial districts in which the design and new product development capabilities become widely diffused.

In different national contexts many paths to increasing the population of SMEs can be distinguished, including:

- spinoffs from private enterprises (Fairchild),
- spinoffs from government sponsored R&D centers (the Engineering Research Service Organization of Taiwan),
- skilled workers trained in private enterprises (FIAT's tractor plant in Modena, Italy spawned numerous small firms,
- skilled workers from government factories (the Springfield Armory in Massachusetts was the seedbed of America's first metalworking district),
- university spinoffs (DEC and dozens of others from MIT labs),
- apprenticeship programs (Germany),
- retired managers from big enterprises (Japan),
- sub-divisions of family firms (Italy),
- modernization programs which lead to specialization andcooperation (A to Z in Cyprus),
- supplier develoment programs (Motorola).

The task is to convert existing impulses to the transition into focused goals and scale them up so that a critical mass of firms are involved. In the case of local machine tool sourcing for the electronics industry, rapid growth occured in the 1980s. Rasiah's study indicates that whereas in 1981 domestic sourcing of machine tools was non-existent, it had risen to over 30 million ringgit by 1990. The growth is attributed to the "introduction of flexible production systems and the rapid increase in machinery modifications and production reorganizations" (p.167) which "transformed links between local machine tool firms and foreign firms." This is precisely the stimulus that product-led competition generates on suppliers by the processes of continuous improvement and the imperative of rapid new product development.

Nevertheless, much of the machining services being offered is still limited to simple activities. The challenge is to build the infrastructure to convert the stimulus into flexible production capabilities that can combine short production cycles with design/manufacturing capabilities. As noted above, intermediary agencies as catalysts for upgrading such capabilities are part of the industrial landscape in the Third Italy, the Badem Wurtemberg region of Germany as well as in the high performing East Asian economies.

8. Advancing SME Electronics Production Capabilities

The goal is to develop an industrial system in Malaysia that is capable of sustained growth. The electronics sector has been a powerful driving force but future growth is in danger of being choked by a bottleneck in the trade balance. The rapid growth of the links in the global production chain targeted by the multinational investors in Malaysia has not been matched by the emergence of complementary domestic links. The trade bottleneck, combined with the success of the labor intensive, FDI strategy in employing people and increasing wages, has created a production system impasse: Malaysia must transform its production base from one geared to price-led competition to one driven by product-led competition.

SMEs are crucial to the transition for several reasons: one, as a carrier of the new production practices; two, a base for sustained innovation to counter the social enertia of bigger firms; three, as a seedbed for future big firms; and fourth, as a source of employment alternatives to undervalued employees. The development of a dynamic, production oriented SME population is a hallmark of traversing the production system transition. Several questions follow. Why is the SME base so small in Malaysia, particularly in electronics? Are pressures building in Malaysia for the emergence of SMEs? What are the barriers to SME development? How can SMEs be promoted in Malaysia?

9. Conclusion: Production Capabilities, National Technology Management and Rapid Growth

Successful technology management enhances growth potential. The East Asian economies that have achieved high rates of growth have a critical mass of industrial enterprises with the capability to adopt, adapt, and diffuse technologies that originated in the most technologically advanced nations. Japan, South Korea, and Taiwan-China have developed the capability to develop new products and processes based on refining, fusing and advancing generic technologies. Together these are attributes of a national system of production and technology management.[9] Sustained high growth rates depends upon making the transition along the production capabilities spectrum summarized in Appendix A.

Making such transitions is not easy. The rapid pace of introduction of technologies in the success stories is a consequence of the prior or simultaneous development of requisite production capabilities. The high performers started with the idea of cutting edge technologies, not with the idea of a rapid pace of absorption of technologies. The latter was a consequence of driving down cycle

[9] Slow growth followers, on the other hand, lack the capabilities to tap the world's pool of technologies. This is not surprising. Successful technology management itself requires the development of three distinct but interrelated capabilities: strategic, organizational, and production. Successful technology management, like the establishment of price for Alfred Marshall, depends upon both blades of a pair of scissors; supply must be matched by effective demand. While demand in price theory is mediated by income, demand in technology management is mediated by production capabilities.

times first in production and second in new product development. Other East Asian nations have followed Japan, particularly in driving down production throughput times. But making the transition to multi-product flow requires development of corollary organizational capabilities variously named *kaizen*, continuous improvement, high performance work organization, total quality management, self-directed work teams, and plan-do-check-act. This means considerable investment in human capital to achieve the requisite performance standards.

Articulating a technology management strategy is central to economic policy making for a developmental state. Distinctive technology management strategies in each of the high growth East Asian countries can be identified. In fact, the idea of national technology management is to the theory of the developmental state what demand management was to Keynesian economics or money supply management is to monetarism.

Appendix A: The Production Capabilities Spectrum and Industrial Growth

The idea of a production capabilities spectrum combines the principles of production and organization described above with a variation on Nakame Akumatsu's notion of sectoral transitions. The production capabilities spectrum in suggests a criteria for locating a country in the international production order and for identifying the challenges at any point in time.

1. **Pre-flow, pre-interchangeability**: Jamaica and Honduras. This means, for example, that each drawer in a dresser is a particular fit. Craft production, by itself, offers no basis for flow. The task is to develop product engineering skills.

2. **Interchangeability without flow**: Cyprus and Slovenia in the 1980's. Both countries enjoyed good product engineering but lacked process engineering, hence low inventory turns and working capital productivity.

3. **Single product flow**: Multi-national electronics production in Indonesia. These plants enjoy economies of speed but are dedicated to a single product or range of products with dedicated lines. Workers are not trained in continuous improvement, rapid changeover, or blueprint reading skills.

4. **Single product flow with process innovation**: labor force includes maintenance and process control technicians who can identify and fix electronics problems in machinery. Next step is programming technicians and associate engineers that can identify and solve bottlenecks. This may involve reconfiguring design parameters at main office. Singapore in the mid-1980s, Malaysia in early 1990s.

5. **Multi-product flow**: the Toyota system which has spread to small and medium sized suppliers to MNC throughout East Asia. Kanban, JIT, and SMED are introduced in large plants. High throughput and flexibility are combined.

6. **Multi-product flow with continuous improvement**. This involves Plan-Do-Check-Act or TQM at shop floor level and self-directed work teams.

7. **Multi-product flow and new product development**: Japan and Taiwan both excell at concurrent engineering and design for manufacturability.

8. **New product development and technology management**: Japan's Toshiba and Canon are leaders in linking development to operations at the plant level and linking research in generic technogies to product development. Core technologies are developed, often via fusion in generic technology labs. Technology management involves world-wide sourcing of the existing technology base in pursuit of novel applications.

9. **New product development and fundamental research**: 3 M, HP and Motorola have developed new forms of networking to identify new technology drivers for product development. Radical breakthroughs are pursued but within an organizational context of process integration. These companies are learning firms that emphasize knowledge workers and education at all levels. Motorola has 7 phases in self-directed team development and supplier development programs that emphasize partnering.

Sustained industrial growth involves developing the organizational capabilities for a nation to make the transition across sectors shown in Figure 1, along the production chain, and along the production capability spectrum. Figure 1 is a representation of the sectoral composition of national production in terms of resource intensity: low-skilled labor; raw material and continuous flow; complex production; and knowledge. Economic growth is, in part, a consequence of making the transition along this spectrum or, in Figure 1, of pushing the diamond upward over time. While this figure was used by Japanese policy makers in the early 1970s, the idea is grounded in a conceptual framework developed in the mid-1930s at roughly the same time as the Keynesian demand management approach was being developed.

Nakame Akumatsu, a Japanese proponent of a unique theory of industrial development, described a process common to development literature but added an interesting twist. Countries would move from imports to import substitution to exports as they learned from foreign technologies. He described the process in terms of three waves of flying geese for each product. Imports would be represented by the first gaggle of geese in flying formation: increase, peak and fall off; production the second gaggle: increase peak and decline; and exports the third gaggle again representing an inverted V pattern. He described these patterns are occurring first in 'crude' products and later in 'refined' products; in final goods and later capital goods. Where a country is at a point in time is determined by the balance of forces between the level of development and wage rates. Higher development led to higher wages and a loss in exports of easier to produce goods.

The idea of a production capabilities spectrum combines the principles of production and organization described above with Akumatsu's notion of sectoral transitions. The production capabilities spectrum in suggests a criteria for locating a country in the international production order and for identifying the challenges at any point in time.

At each point along the way growth occurs as long as the ratio between wages and production capabilities is low compared to other countries but growth will advance wages until following nations make the transition to a new level of production capabilities and, enjoying a lower ratio between wages and production capabilities, undersell the market leaders. Having achieved a new, higher level of production capabilities a region or country enjoys growth as the new practices and technologies are diffused to old and new products by old and new firms. However, in the process, wages rise and opportunities for further diffusion diminish and growth becomes threatened as imitating regions and nations develop the requisite production capabilities to move into the same markets but with lower wages.

To sustain growth, enterprises in the region must be making the transition to the next higher level of production capabilities. Once and if a critical mass make the transition, a new range of opportunities open up as the region or nation becomes competitive in more technically and organizationally advanced activities and products. Growth reasserts itself as the opportunities are taken up until, once again, the wage rate to the respective production capabilities ratio rises above that of competitors. If a region or country successful makes the transitions along the production capabilities spectrum then growth rates will be high and sustained.

The dynamic process described starts with production capabilities moves to higher rates of investment, greater learning by doing, greater competitiveness and sustained high growth. Savings follows from high profits. In this story, high growth generates savings; the conventional view attributes high growth to high savings but does not satisfactorily explain the sudden surges in savings. The production capabilities perspective starts with the firm and thereby focuses explanation on organizational capabilities and competitiveness; the conventional view begins with the consumption and savings choice of individuals as the determinant of growth. Empirical evidence supports the production-oriented perspective (Singh, 1996).

The goals of a developmental state are to pursue industrial growth by facilitating and negotiating industrial transitions by addressing the challenges indicated by the production capabilities spectrum. This involves acting as a catalyst to advance indigenous production, innovation, and technological development capabilities. The means are to partner with entrepreneurial firms that are themselves the seeds and drivers of transitions, the promoters of creative destruction. The challenge for the developmental state is not one of initiating, but of shaping, responding to, enhancing and complimenting the entrepreneurial drivers, with the requisite infrastructure including transportation, energy, regulatory, and educational.

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