MIT Japan Program
Working Paper 01.06

ECONOMIC CRISIS AND TECHNOLOGICAL TRAJECTORIES: HARD DISK DRIVE PRODUCTION IN SOUTHEAST ASIA[1]

Rick Doner
Professor, Department of Political Science
Emory University
Atlanta, GA 30322
rdoner@emory.edu

Bryan Ritchie
Graduate Student, Department of Political Science
Emory University
Atlanta, GA 30322
britchi@emory.edu

[1] This is a revised version of a paper presented at the Workshop on Innovation and Crisis – Asian Innovation After the Millenium," Cambridge, Mass., M.I.T., September 15-16. We wish to express special thanks to Greg Felker whose knowledge and comments are evident throughout this paper. He is not responsible for the paper's flaws.

MIT Japan Program
Working Paper Series 01.06

Center for International Studies
Massachusetts Institute of Technology
Room E38-7th Floor
Cambridge, MA 02139
Phone: 617-252-1483
Fax: 617-258-7432

Date of Publication: June 20, 2001

Introduction

Technology policies, and economic policies more generally, are means by which countries can maintain or increase their autonomy within the international political economy. Concretely, autonomy in this sense refers to a country's capacity to adapt to or insulate domestic industry from external shifts. An important component of this capacity for more advanced developing countries is the ability to sustain technological upgrading, independent of foreign control. This paper explores two propositions. One is that, owing to increasingly international production structures, the range of growth-promoting technology strategies has narrowed for the developing countries of Southeast Asia over the past decade or so. The second is that the institutional and political challenges of pursuing indigenous technological development and industrial upgrading within the constraints of global production structures are significant. Strategic policy decisions made by political and economic elites have had an important influence on indigenous technological upgrading in Southeast Asia. The significance of such decisions is reflected in the ways in which the three countries explored in this paper – Malaysia, Singapore and Thailand – differ with regard to indigenous technological capacities.

With the exception of the Philippines, all of the market-based Southeast Asian countries were included in the World Bank's "High Performing Asian Economies" (HPAE) along with the Northeast Asian Newly Industrialized Countries (World Bank 1993). Yet these countries pursued different degrees of autonomy through different kinds of technological trajectories. Each trajectory involved varying degrees of protection for indigenous firms and efforts to promote and diffuse indigenous technology.[2] And each trajectory implied both varying degrees of sector specificity in policy and different levels of institutional challenges. Finally, each set of policies and institutions reflected and reinforced a set of political arrangements.

Shifts in global production structures are raising the bar for sustained growth in two ways. First, growth now requires a greater emphasis on technological upgrading, especially for the market-based countries of Southeast Asia who can no longer rely on cheap labor to attract new investment. Second, in the past, developing countries could pursue more purely techno-nationalist development strategies where upgrading of indigenous firms could occur through various types of "hot-house" modes prior to exposure to global competition[3], and where absorption and diffusion of technology could be carefully managed over substantial periods of time. Now, protectionist options have diminished while technological pressures have steadily increased. Upgrading increasingly requires a more techno-globalist approach wherein firms become an active, indeed a proactive cog in a globalized production network. Autonomy requires that countries be able to garner and maintain new rents in globalized value chains (Kaplinsky 1999; Gereffi and Tam 1998).

---

[2] For useful reviews of differences among the NICs, see Wong (2000); Noble (1998); Chu Yun-han (complete cite).

[3] Greg Felker suggests two "traditional" approaches. One is to follow comparative advantage-type sectoral development, whether or not the state led or followed shifting comparative advantage. This typically involved ISI followed by EOI in consumer goods, ISI followed by EOI in intermediates, etc. (Gereffy and Wyman 1990) A second approach was the "reverse product life-cycle" in which firms entered advanced industries, but in mature product segments, then attempted to close the gap by entering production sooner and sooner in the product cycle (e.g. Hobday 19..) (Personal communication, Felker, August 2000).

This does not deny the importance of openness and macroeconomic stability. But it highlights the need for a combination of generic and sector-specific policies that not only regulate markets but also promote them. Concretely, this translates into an active focus on the promotion of indigenous suppliers and technical personnel. But in dynamic industries, such policies involve extensive transaction costs, principal agent problems, collective action dilemmas, and distributional difficulties. As such, their implementation requires strong local institutions and political supports. In our view, these policies and institutional capacities have been evident in Taiwan, but especially in the Singapore government's "facilitation of MNC-induced technological learning" (Wong and Ng 2000: 17).

This concept of "MNC-induced technological learning" implies a hybrid of technonationalism and technoglobalism based both on ends and means. With regard to ends, nationalism can be understood as an effort to increase autonomy by capturing new rents within globalized value chains. Such ends require the nationalist means of promoting indigenous firms and diffusing technology through indigenous personnel. But indigenous promotion and diffusion can occur through the medium of foreign firms induced to operate in the local economy in part by attractive financial incentives but also by the availability of capable firms and personnel. (See chapter by Doug Fuller in this volume.) As John Dunning has noted, the creation of strong local capacities helps foreign producers to make better use of their own assets (1998).[4]

This argument carries a certain irony: Effective participation in a clearly more globalized production structure requires a more developed set of local institutional strengths. If there is pressure for convergence, it is towards enhanced local capacities that go well beyond what has been called the "second Washington consensus" on the importance of open trade and investment regimes, macroeconomic stability, and secure institutions such as property rights, corporate governance and financial regulation (Burki and Perry 1998). However, owing to institutional histories and a range of political factors, some will succeed in developing such capabilities, others will not.

We explore these arguments through a cross-national examination of the hard disk drive (HDD) industry in three Southeast Asian countries – Singapore, Malaysia and Thailand. The disk drive industry exhibits, albeit in a relatively extreme way, the pressures for high quality, low price, and rapid delivery within international production networks increasingly evident in other industries. Indeed, the CEO of one of the industry's leading firms calls disk drive production the "extreme sport" of manufacturing.[5] If there is any industry in which the benefits of local technological activism within global networks should be obvious, it is hard drives. Singapore, Malaysia and Thailand have been the center of global disk drive production since the 1980s.[6] For each nation, the industry has become a key source of economic growth. Yet if each of the three has clearly succeeded in the industry, Singapore occupies a higher and, we suggest, more sustainable rung

[4] This model of "MNC-induced technological learning" differs in important ways from the Japanese experience. It does not involve efforts to replace MNCs or to position indigenous producers at the top of a value chain. And although Singapore is quite picky about the foreign firms it encourages to operate within the city-state, those firms have much more leeway in their operations than was traditionally the case in Japan.

[5] Comments of Steve Luczo, CEO, Seagate Technologies, Stanford Graduate School of Business, November 1999, cited in MDH (2000: Chapter 2).

[6] Indeed, there is strong evidence that their combined attributes constitute an important source of the industry's growth and the dominance of U.S. producers (Mckendrick, Doner and Haggard [MDH hereafter] 2000).

on the technological ladder than do Malaysia and Thailand. This is due to Singapore's conception of autonomy as the capacity for constant movement up and across value chains, a set of market-based industrial policies designed to overcome key market failures, and a concomitant set of institutional attributes. Neither Thailand nor Malaysia approaches Singapore's technological objectives and institutional capacity for implementation.

But if the disk drive industry is so demanding, how have Thailand and Malaysia done so well in it? Regional spillovers and generic policy convergence have been key. Malaysia and Thailand expanded as open, stable and proximate locations for more labor-and less skill-intensive activities no longer feasible in Singapore. But these two countries were not simply export platforms for the low-end activities of disk drive producers. Agglomeration economies, in the form of pools of technical personnel and suppliers critical to the industry's dynamic performance, have emerged in both countries. These agglomerations are largely the result of corporate initiatives and externalities rather than Singapore-like public policies, although such policies have been somewhat evident in Malaysia's Penang.

The Malaysian and Thai cases thus imply that even the hard disk drive industry has room for countries lacking the interest and capacity for upgrading. But they also suggest limits to such room. Although the 1997 crisis did not significantly hit the hard drive industry, disk drive producers have moved to consolidate operations in the past five years into the lowest cost and most efficient sites. As evidenced by Seagate's reduction of its Thai workforce from over 70,000 to less than 35,000 workers in the past three years, and a concomitant reduction of its Malaysian workforce by almost half, there is no guarantee that the industry will continue to generate the jobs and foreign exchange it has in the past.

In addition, there is evidence that disk drive production in these two countries occupies a sort of enclave, providing few spillovers in terms of indigenous suppliers and technology development. The 1997 financial crisis highlighted just such weaknesses in the "real" economies—declining terms of trade, overcapacity and lack of value added—as well as the more publicized problems in the financial realm. In the case of Thailand and Malaysia, these reflected technological weaknesses (Lall, 1998). However, technological reform responses to the crisis have varied—strong and effective in Singapore, extensive but not necessarily effective in Thailand, and relatively weak in Malaysia.

In the following section we review shifting pressures in the external context, with an emphasis on challenges of the hard disk drive industry. Section II assesses the three Southeast Asian countries' performance in the industry, with special emphasis on the development of indigenous technical personnel and suppliers. Section III reviews the objectives and policies accounting for cross-national performance differences prior to the crisis. Section IV assesses the impact of institutional capacities on technology performance. Section V explores the factors influencing policy preferences and institutional capacities. Section VI reviews the three countries' response to the 1997 crisis. Our conclusion explores forces influencing cross-national differences in responses to the crisis.

I. Challenges of Globalized Production Networks

Until the 1990s, developing country firms in a range of industries could prosper by producing large volumes of standardized goods at price and quality levels below world standards, often for protected markets. Such a trajectory is less and less possible with liberalized trade in industries increasingly characterized by at least four features: reduced importance of cheap labor; final consumer markets that are both more fragmented and more demanding on price, quality and delivery; shortened product cycles; and increasingly rapid technology change.

These pressures are evident even in a traditionally labor-intensive industry such as apparel. As market segments have become more fragmented and shifted away from price toward style and quality, "...the size of production runs has steadily declined along with the time available for manufacturers to respond to market demand" (Winterton and Taplin 1997). Southeast Asian apparel producers are now under increased pressure to improve price, quality and delivery through better supply chain strategies, use of new technologies and more extensive technical training ("Textile Exporters" 1999). Requirements for developing countries in the automobile industry are also becoming much more rigorous. As part of their shift away from production for protected domestic markets to global sourcing strategies, global automobile producers are concentrating on a smaller number of suppliers. Such suppliers must not only be linked to final buyers, they must also be capable of producing and even designing components at world class prices, quality and delivery times. Requirements are so stringent that some express doubts as to whether developing country participation in the global auto industry is worth the investment (Kaplinsky 1999: 24; Humphrey 1998).

Such pressures are even more extreme in the disk drive industry. Firms must confront difficult and dynamic technologies in both product and process.[7] A disk drive is composed of a large numbers of highly advanced components and parts that must operate together in tolerances several orders or magnitude closer than those required in textile or auto manufacture. For example, to store and retrieve information, the disk drive's "read/write head" must move rapidly over a disk at a distance less than the thickness of oil on a person's skin while the disk is spinning at up to 15,000 rpm. Industry experts compare positioning the head over the disk to flying a Boeing 747 .025 inches above the ground while maintaining a course of flight directly over the center-dividing stripe on a road . These kinds of high speeds and almost unimaginably close tolerances indicate the daunting challenges of disk drive manufacture. For example, just a few specks of dust can cause the heads to touch the surface. If this impact is too severe, they will "crash," resulting in damage to the heads or data surface, lost data, and, in the most extreme cases, destruction of the drive. In addition, disk drive firms must contend with continuing pressures for price cuts from computer makers and with product cycles of less than a year. Failure to move large numbers of specific models to market precisely when buyers want them results in major losses. Successful firms are those capable of reducing costs, increasing yields, bringing out new products, and getting those products to market in high volumes just when they are in demand.

Given these kinds of demands, how have Singapore, Malaysia and Thailand succeeded in becoming key disk drive manufacturing sites?

[7] For a review of disk drive components and technology, see MDH (2000: Chapter 2).

II. Different National Capacities Constitute One Regional Industry

By the late 1990s, Southeast Asia – especially Singapore, Malaysia and Thailand - accounted for roughly two thirds of global disk drive production.[8] Foreign, mostly U.S., firms accounted for almost all HDD shipments and most major components such as read/write heads, disk media, and motors. But if foreign producers dominate the industry, its growth and the success of U.S. firms in particular owe much to the "location-specific" assets found and developed in Southeast Asia. This is a regional as well as a national story.

Over time, the region came to constitute a network that offered two important advantages. First, assets found in different countries allowed firms to build redundancy into their production. Geographic redundancy in suppliers, managers and technical personnel mitigated risks linked to exchange rates or other cost changes, labor shortages or plant-level problems in production. Redundancy allowed the industry to raise or lower production in specific locations depending on changing requirements.

Second and more critical for our purposes were gains from trade among differently endowed production sites (again, facilitated by common adherence to open trade and investment regimes). Southeast Asia provided a proximate heterogeneity of locational assets that gave foreign firms a portfolio of cross-national investment sites to meet shifting production needs. This portfolio includes skill-intensive, specialized services such as process engineering, clean room services, product testing and failure analysis; sophisticated technology- and capital-intensive production processes such as disk sputtering or ion milling of recording heads; specialized and precision metalworking such as casting, surface treatment and machining; routine but still-advanced high-volume manufacturing of products such as printed circuit boards; and labor intensive subassemblies and final assembly of drives.

The heterogeneous nature of this network highlights the national part of our story. This range of capacities is spread across the region roughly in line with national levels of development. Singapore, Malaysia and Thailand have all developed agglomeration economies of pools of technical labor and specialized suppliers. But Singapore is clearly more developed than its two neighbors. As the core of more skill-intensive operations and decision-making, Singapore has led the industry, accounting for 45-50 percent of global HDD shipments between 1986 and 1996. Qualitatively, the city-state is also dominant as the leader in regional administration, process engineering, and product engineering. Historically, Singapore facilities ramped up and debugged drives developed in the United States and then handed the product off to Thailand or Malaysia. Seagate's Singapore facilities are the site of the first disk drive designed in Southeast Asia (the U-4). Singapore is also the production center for the industry's highest-performance products—the high-end server drives manufactured by Seagate and IBM. Thailand is the core of motor production, heads assembly, and the assembly of notebook or mobile drives. Malaysia straddles the two, mixing drive assembly, media production, heads machining and printed circuit

[8] The U.S. accounted for 4.6%, Japan 15.5%, "other Asia" (mostly s. Korea) 5.7%, and Europe 10% (Gourevitch, Bohn and McKendrick 1997). Unless noted, the rest of this review of this review is drawn from MDH (2000), especially Chapter 6.

board assembly.[9] This hierarchy is far from rigid. For example, Thai and Malaysian facilities now ramp up products directly from the U.S. and Japan rather than receiving mature products for their end-of-life manufacture. And both Thai and Malaysian facilities support drive facilities in China. But overall, Singapore remains at the apex of this system.

It does so in part by virtue of its pool of its indigenous technical personnel. Consider the manufacturing requirements for high-end server drives, produced only in Singapore.[10] The complexity of these drives means that their assembly demands more technical support for equipment in areas such as head positioning and head-disk assembly. In addition, the greater number of components, the more complex electronics, and greater variation in interfaces expand the possible sources of failure. Conducting failure analysis consequently requires that engineers understand how a drive works as well as how to produce it. Finally, server drives require a range of other specialized skills, such as development of advanced error correction code algorithms. Singapore's engineering capabilities in all of these areas exceed those of any other country in the region.

Singapore's position at the apex of the regional hierarchy is also a function of the best-developed cluster of suppliers, numbering over one hundred firms. Certainly, many of these firms are foreign, especially in the more complex areas of read/write heads, disk media, and spindle motors. But the number of indigenous suppliers is significant. Local producers dominate in the key area of precision engineering services (machining, metal stamping, surface treatment, die casting), as well as in cleanroom design, and printed circuit board assembly (PCBA). Three local PCBA firms now rank among the global top ten electronic contract manufacturers. And several local precision engineering firms have expanded to Malaysia and China along with their final customers.

Disk drive production has expanded significantly in Malaysia and Thailand in part due to spillovers from neighboring Singapore. Numerous foreign disk drive firms opted to move operations out of Singapore for reasons of labor costs and availability. However, Malaysia and Thailand each developed their own agglomeration economies, albeit not nearly so extensive as Singapore's. Malaysia, especially the state of Penang, offered a growing pool of technical personnel that facilitated initial transfer of operations from Singapore and allowed joint problem solving between the two production sites. Over time, local expertise allowed Penang to undertake functions previously monopolized by Singapore. Seagate's Penang facility, for example, served as a stand-alone production facility for certain products and functioned as a transfer point for China. Implementing this strategy required the creation of a New Product Introduction Center. And while yields in Seagate's China facilities were actually higher than

[9] Malaysia's median position is deteriorating, however. With the closure of Seagate's Ipoh plant, only the Kedai plant manufactures drives. The remaining plant in Penang manufactures head gimble assemblies. Most of Seagate's low-end drives are manufactured in China while the mid- to high-end drives are manufactured in Singapore.

[10] Server drives "are an order of magnitude more complex to make than are drives of an earlier generation: they have more disks, more heads, more complex electronics, greater variation in interfaces, and consequently lower yields. The coordination challenges are also more demanding. High-end server customers demand a small lot and different interface configurations, and components have less commonality. Because customers also pay a premium for these drives, they are even more demanding about service and delivery times" (MDH 2000: Chapter 7, p. 167 [written with Wong Poh-kam]).

those in Penang, this was because the Penang engineering team, trained by Seagate expatriates, had already performed substantial failure analysis and debugging.[11]

A group of indigenous suppliers also developed in Penang, although not as broad or deep as Singapore's. Some of these firms were joint ventures with Singapore component producers who had moved to Malaysia. But many were local firms who had gotten their start in other electronics segments and used their engineering, design and production capacities to diversify into the disk drive industry. For example, several local firms played a growing role in line modification, tooling and automation for Komag, a U.S. media producer (MDH 2000: Ch. 9).

Thailand's strengths lay largely in its pool of technical personnel. One measure of these strengths is the accumulation of local expertise within disk drive producer Seagate, the country's largest employer. As of 1999, Seagate employed 33,000 people of whom all but10 were Thai nationals.[12] Seagate's newest facility in Northeast Thailand has only a few permanently assigned expatriates out of some 8,000 regular employees. Yet there are clear limits to the depth of Thai technical personnel. One producer of very high precision parts was forced to recruit the core of its new tool and die shop from a training institute in India after failing to find sufficiently qualified Thai machinists. The situation is considerably bleaker with regard to indigenous suppliers. As of summer 1999, a survey of disk drive producers, component and service providers turned up very few indigenous firms (and these were found largely in low value added areas).

III. Goals and Policies

In this section we explore the roots of the region's disk drive-related hierarchy of capacities discussed above. We begin by assessing cross-national variation in capacities in light of the three countries' broader goals in high-tech industries.[13] We then examine the policies through which these objectives have been pursued.

Goals / Performance:

Acknowledging the vast literature on economic development, we can think of three different kinds of economic growth – static efficiency, structural change, and upgrading — each of which translates into an approach to high-tech industries. Static efficiency involves maintaining productivity while expanding profitability and capacity utilization in an *existing* product range and/or economic role.[14] Structural change refers to intra- and intersectoral changes, including

[11] See MDH (2000: Chapter 9), which also provides other examples.

[12] This does not include expatriate employees temporarily assigned to Thailand for specific problems or new product launches.

[13] Countries of course vary with regard to their emphasis on high-tech sectors. Certainly Singapore is most aggressive in this regard, Thailand the least, and Malaysia in the middle. We are grateful to Greg Felker for emphasizing this point.

[14] Economic roles refer to activities characterized by specific bundles of goods and services. One useful categorization of economic roles involves a continuum of activities ranging from assembly, to assembly and testing, to OEM (original equipment manufacture) production, to ODM (original design manufacture), to OBM (original brand manufacture). Role differences "imply different kinds of linkages to tangible inputs and intangible services" (Gereffi 2001: 3).

shifts from agriculture to manufacturing, diversification within agriculture and/or manufacturing, expansion from downstream products to upstream intermediates and capital goods, and moves from labor-intensive manufacturing to more capital-and technology-intensive production. In terms of high-tech industries, structural change tends to be extensive in the sense of vertically expanding or integrating the value-chain within the national boundaries.

By contrast, what we are calling upgrading is more intensive, referring to the capacity for efficient use of new investments in order to generate higher value added. At one level, upgrading is indicated by firms' capacity to reduce prices, increase quality and shorten delivery times not simply through increased inputs but through more productive use of such inputs. A key indicator is thus total factor productivity. At another level, upgrading is indicated by the capacity to move within a value chain into more sophisticated products and economic activities, e.g. from simple assembly, to original equipment manufacturing (OEM), to original brand manufacturing (OBM) to original design manufacturing (ODM).[15] These shifts in turn require capacities in areas such as research, product development and design, and marketing.

Upgrading requires the ability to promote inter-sectoral linkages and to develop technology. The former refers not simply to the creation and coexistence of upstream and downstream sectors, but to dynamic complementarities in which upstream firms supply higher quality and cheaper inputs that promote the competitiveness of downstream producers (e.g. Gore 2000: 797). Technological development, although a vast topic, can be understood through three dimensions (Felker and Weiss 1995): *Deepening* – the capacity to perform progressively more demanding functions related to the production process (e.g. maintenance, quality control, product development, equipment design); *Proximity* – the distance to an industry's most productive or sophisticated technology; and *Indigenization* – the degree to which local personnel have mastered production, management, design and innovative tasks.

Although for clarity's sake we have characterized the three types of economic growth as functioning distinctly and separately from one another, in reality there is significant overlap and fuzziness among them. It may be helpful to consider the types of growth as occupying points along a continuum of technological progress and development with static efficiency at the low end, structural change toward the upper middle, and upgrading requiring the most intensive levels of technological change and innovation. It is clear from this conception that multiple types of growth may be functioning simultaneously within the same economy, indeed, the same industry.

Nevertheless, in spite of inherent overlap, these categories are useful for characterizing the core objectives of the three countries under study. In high technology, Thailand tends toward static efficiency objectives within a structural shift to upstream and high technology sectors. From 1985 to 1993, medium-high technology manufactured goods such as computer parts, electronics, and electronic appliances, grew at 30 percent whereas the growth of more labor-intensive products such as garments slowed to an average of 14 percent. By 1995, exports of medium-high tech products were roughly 40 percent greater than labor-intensive products (Chalongpop 1997: 7). But by 1996, exports stagnated and the current account deficit reached 8 percent. In

[15] Gereffi and Tam (1998: 8), from which our discussion of upgrading is adapted and modified.

one short decade Thailand had lost its comparative advantage in labor-intensive manufactured goods.

The country's lack of ability to *manufacture* as opposed to assemble medium-high technology products was becoming obvious. In a 1998 study, Lall concluded that, despite its intensive growth during the 1980s, Thailand's export structure was closer to that of the Philippines than Taiwan, Singapore, South Korea or even Malaysia. And while the Thai export structure was more advanced than that of China or Indonesia, "it is not evident that Thailand is operating at much higher technological levels in the production process" (1998: 4). Indeed, the World Bank has emphasized the "rapid reduction in the growth rate of total factor productivity since the late 1980s, and strikingly low levels of R&D in the private sector, one of the lowest in the region as a proportion of GDP" (2000: 42-43).[16]

Thailand had remained an assembly platform whose cost advantage was likely to prove as temporary as its success in lower-technology exports. The underlying problem was Thailand's weak engineering base. The country's ability to absorb new technologies and to raise the capacities of indigenous firms was "far more limited than it was in the newly industrialized countries at a similar stage in their development." Thailand's more sophisticated manufactured exports came from foreign, not domestic firms; the latter are well protected, heavily oriented to the domestic market, and have much lower technical capabilities (Coloco 1998: 12-14). In sum, Thailand is characterized by a de-linked dualism in which a foreign-dominated, technologically-rich export sector functions alongside, but is largely detached from, the indigenous, technology-poor, import-competing sector (Nipon and Fuller 1997; Nipon and Pawadee 1998; Felker 1998).

Like Thailand, Malaysia has undergone an impressive structural transformation. Between 1971 and 1993 the manufacturing share of GDP rose from 14 percent to 30.1 percent. In dollars, manufactured exports rose from $122 million in 1970 to US$2.3 billion in 1980 to $US 20.7 billion in 1991 and then doubled again to US$42 billion by 1994. The annual rate of growth over this period was 27.7 percent per year. The highest growth was recorded between 1970 and 1980 when exports grew at 34.2 percent (Lall, 1999:153).

In addition to promoting structural shifts, Malaysia has placed greater emphasis on technological upgrading than has Thailand. Lall (1999) characterizes this emphasis as shifting from light (easy, traditional) to heavy (complex, capital-intensive) activities. During the 1980s the pace of industrial deepening accelerated as exports of semiconductors were quickly followed by electricals and electronics exports. By 1990 Malaysia was far ahead of Thailand with an advanced industrial structure only marginally lower than for both Korea and Taiwan. With regard to electricals and electronics, Malaysia's industrial structure was higher even than most OECD countries (Lall, 1999:151-152).

Nevertheless, these statistics do not reveal the underlying weakness of the Malaysian industrial structure. First, much of the advanced electrical and electronics industries is concentrated in final

[16] There is of course extensive controversy on TFP estimates. Wong's review finds a consistent pattern of higher values for the Asian NICs than for the ASEAN-4, but notes that Thailand seems to be an exception in some of the studies (2000: 11).

assembly, incorporating little in the way of design, development and other advanced technical and marketing skills. Second, many heavy industries in Malaysia depend on imported components and have very few local supply linkages. Third, the industrial structure lacks local capital-goods industry, which could seriously hinder the machinery-manufacturing sector, normally considered the "hub" of technological diffusion and progress. Fourth, like Thailand, Malaysia is characterized by a strong dualism. That is, the large numbers of SMEs, which comprise the majority of industrial employment, are effectively disconnected from the high-technology production structure geared to export or to heavy industry (Lall, 1999:153).

Unlike Thailand, however, by the 1990s Malaysia had developed a core of firms that specialize in technologically advanced electronic processes and products, such as highly-advanced thin-film disk manufacture and semiconductor testing and assembly (Hobday, 1999:100). Moreover, Hobday argues that a new group of fast-growing, large local firms are beginning to compete technologically in the world export market. (1999:82). The most impressive developments, however have occurred in Penang. There, dynamic backward linkages from foreign semiconductor assemblers have generated a strong set of indigenous machine tool firms, several of whom have gone on to produce for the disk drive industry (Rasiah 2000/forthcoming). As we shall see, this is an exception that proves the importance of institutions and politics.

Singapore conforms most closely to the upgrading ideal. While the economy grew at an average annual rate of 8.3 percent during the 1960-98 period, manufacturing expanded at an even faster rate of 9.9 percent. Along with this expansion, technological upgrading in manufacturing has been impressive. From roughly half the OECD average in 1980, Singapore's labor productivity almost equaled OECD levels in 1994 and exceeded levels of the other Asian newly industrialized countries (Wong 2000: 15). These achievements are qualified by Singapore's extensive reliance on foreign firms for the bulk of manufacturing output. The foreign presence is especially high in electronics where majority foreign-owned firms accounted for 56 percent of the number of firms and foreign equity accounted for 85 percent of the industry's total capital (Ibid., p. 33). Yet unlike Thailand and Malaysia (with the Penang exception), the presence of foreign firms has stimulated the emergence of indigenous electronics producers and related suppliers, at least 30 of which had annual sales of $100 million or more in 1997. Many of these firms were founded by former MNC employees and, unlike their Thai counterparts, all must face global competition since Singapore provides no protection against foreign competition (Ibid.)

Policies:

It is often difficult to determine whether cross-national differences in growth outcomes reflect variation in goals and preference intensities or in the ability to implement policies designed to achieve those goals. Comparing policies can shed light on the relative weight of goals and preferences since, at a minimum, the absence of upgrading-related policies suggests a lack of attention to such objectives. The three countries under study converged on generic, sector-neutral policies, reflecting their common belief that FDI was critical for economic growth. With regard to high-tech exporting industries such as disk drives, each was characterized by free labor market policies, free trade regimes, solid physical infrastructure, macroeconomic stability, an open investment regime (full ownership rights, absence of local content or export requirements), and highly attractive incentives, especially tax exemptions (MDH 2000: Chapter 10).

The three countries did differ on the degree to which they even formulated policies designed to promote indigenous capacities in high technology, especially electronics, and in the disk drive industry in particular. Our overall argument is that, prior to the 1997 crisis, Thailand's leadership was simply not that concerned with upgrading. Malaysia, in contrast, has paid systematic attention to upgrading and technology issues. But the intensity of this attention was offset by other, more redistributive concerns. Singapore's policy focus on technology has been the most systematic as redistributive concerns jived with efficiency goals.

A 1996 report concluded that Thailand's science and technology environment "was characterized by mismatches in S&T human resource supply, very low levels of R&D activity, a private sector with strong manufacturing capability but weak research, development and engineering capability, and an information technology that is growing but remains insufficient" (Brooker 1996: 96). This state of affairs is in large part a function of a policy regime and underlying set of beliefs that autonomy does not require extensive upgrading and technology development. The policy emphasis has been on quantitative growth in jobs and exports, often relying on cheap labor and/or protection. A Thai quality assurance director at one drive firm (Micropolis) summed up the impact of public policies in stating that Thai government incentives "are for investors, not technology developers." A Chinese manager at another firm (Magnecomp) said that when he worked in Hong Kong, his main focus was on engineering issues. In Thailand, he spent most of his time on personnel and regulatory issues.[17]

These weaknesses are evident in human resource development, local vendor/supplier development, and technology diffusion and absorption. Thailand's skill development efforts are notoriously weak. The country's rapid economic growth since the mid-1980s resulted in significant shortages of technical personnel. The government responded in the 1990s with a skills development program based on a Singapore program and a set of tax exemption programs. In addition to fragmented implementation (see below), neither of these was designed in close consultation with representatives from electronics or disk drive firms. A striking illustration of the government's lack of attention to human resource issues is that relevant officials showed no awareness of a certification program in basic disk drive competence initiated in Singapore by the International Disk Drive Equipment and Materials Association, until notified by foreign researchers (author interviews).

Thailand's weak supplier base reflects tariff and tax policies that discouraged subcontracting between foreign exporters and local producers, and vendor development programs that did little to support indigenous suppliers. Until the early 1990s, export-oriented reforms were grafted on to protection for local firms producing for the domestic market and effectively discouraged them from supplying exporting firms. Tariff protection for upstream investors raised the costs of downstream firms using such inputs. Exporting firms, such as Seagate, could of course avoid these costs by importing cheaper inputs and obtaining duty rebates or not paying any tariffs by locating outside of congested Bangkok. But for indirect exporters, i.e. firms producing in

[17] Unless otherwise noted, this policy review draws directly from Doner and Brimble (1999: Section III).

Thailand for sale to final exporters, the burden was heavy.[18] Reinforcing these tariff policies were a series of levies that encouraged vertical integration by exporters.[19]

In addition, Thailand's vendor development programs were close to nonexistent until the late 1990s. A 1990 report found that Sharp and Seagate had tried but failed to find even simple metal and plastic injection molded components from local firms (Dahlman and Brimble 1990). Other firms in the disk drive industry (IBM, Fujitsu, ADFlex, and Nidec) also failed to find suppliers for more complex tools. The lack of a supplier base also become a concern since the influx of FDI in the late 1980s had expanded the current account deficit to 8.5 percent of GDP in 1990. (Lauridsen 1999: 3). After a half-hearted effort to impose stronger local content criteria on new foreign investments in 1991, the Thailand Board of Investment initiated a non-incentive-based vendor development program to encourage technology diffusion and subcontracting linkages between MNCs and local suppliers - the BoI Unit for Industrial Linkage Development program (BUILD). Despite positive responses from long-established firms such as Minibea, the program basically faded, even after it was upgraded to a "National Supplier Development Program" involving all major agencies responsible for small and medium-enterprise development. Part of the problem was the government's general neglect and ignorance of the country's small and medium sized enterprises. Indeed, government agencies could not even agree on a basic definition of SMEs until the financial crisis of 1997. (Sevilla and Kusol 2000).

Thailand also paid insufficient attention to technology diffusion and absorption. The investment regime has contributed little to technology promotion. Led by the board of Investments, it has tended to ignore what might be called the "quality" of investments. Instead of focusing on the potential for technological spillovers, the BOI emphasized numbers of firms promoted, the financial value of promoted investment, and numbers of jobs generated (e.g. Westphal et al 1990: 123). Institutions explicitly devoted to technology promotion have been weak and fragmented. The lack of linkages between universities and industry has been a concern for several years (Brooker 1996), resulting in the loss of opportunities to diffuse and commercialize useful innovations.[20] Thailand has also been weak in both direct and indirect provision of diffusion-oriented technical services. Despite efforts to consolidate since the mid-1980s, Thailand's industrial standards agency has been unable to move quickly to establish mutual recognition agreements with standards authorities in major export markets. There have also been

[18] To remedy this problem, the government extended duty offsets to indirect exporters in the late 1980s. But despite progress, significant delays in document processes, leading to delays in rebates and added costs for imported raw materials, continued to occur. This resulted in significant cost for local SMEs, but even for foreign-owned suppliers operating in Thailand. One Thai-based supplier of wire to Seagate's Thai facilities regularly sent its product to Singapore and then re-exported it *back* to Thailand the same day due to avoid the paperwork and related delays involved in tariff rebates for indirect exporters (author interviews).

[19] Examples include a business tax that imposed a higher burden on inter-firm subcontracting than in-house production. This was replaced by a VAT tax in 1992, but the refund for exporters remains a slow process.

[20] A disk drive engineer in Bangkok contrasted the Thai situation with a case in Singapore involving the development of head cleaning technology. Read-Rite uses a water-based process which obviously can introduce impurities. While in Singapore, this engineer learned of laser-based cleaning equipment developed by NUS researchers. But the researchers were not able to make the shift from equipment that would clean a few heads to those cleaning millions. With support from Japanese investors, a spin-off resulted that did develop higher volume equipment. Fujitsu is reportedly using the equipment and RR is considering it (author interview, Read-Write).

problems with regard to testing laboratories and services, despite requests for an expansion of such services from both local and foreign firms. [21]

Thailand's inattention to high technology is reflected in the electronics industry. As late as 1997, an individual with over 20 years experience in Silicon Valley, said that "the industry was confused by the government's policies" and that Thai governments "had never had firm policies to develop the electronics industry despite its high potential" (Yuthana 1997).

In contrast to the Thai case*, Malaysia's* weaknesses are not a function of public neglect of technology and upgrading. Beginning in the 1980s, science and technology policy became "progressively more institutionalized and integral to government development planning."[22] An Industrial Master Plan and Technology Action plan provided detailed surveys of the technical strengths and weaknesses of specific sectors and targeted several technology priority areas: electronics, biotechnology, information technology, advanced materials and automated manufacturing.

As early as the 1980s, Malaysia began to address shortages of technical personnel. After a disappointing response to a double tax deduction for training expenditures (1986), the government created a Human Resources Development Fund – an industry sector-wide payroll levy and subsidy scheme in the early 1990s modeled on Singapore's Skill Development Fund. Moreover, in the early 1990's, the government initiated reform efforts in higher education. These included an expansion of science and technology programs, permission for foreign universities to open Malaysian branch campuses, speeding the entry of engineering graduates into the workforce, and encouraging the state-owned telecommunication firm to set up a degree-granting institution. In a further effort to promote university-industry linkages, the government launched a project in 1997 to create a Malaysian Science and Technology University with assistance from the M.I.T.

In vocational education, weaknesses in initiatives such as a National Apprentice Scheme and a Trade Skill Certification Course prompted a shift to joint ventures with the French, German and Japanese governments to set up technical training institutes, and the encouragement of industry-operated skills development centers modeled on the successful Penang Skills Development Centre (PSDC). Penang's efforts merit special note since they began earlier and have been more successful than any other Malaysian training effort. The PSDC was essentially a local initiative whose success drew the attention of the Malaysian Federal government. In 1994, the government encouraged other states to emulate the PSDC model.

Yet in the final analysis, the return on these initiatives has been less than stellar. First, of the funds contributed to the Human Resource Development Fund (HRDF), less than half were claimed for training expenses. Also troubling, only a tiny fraction of SMEs have registered with the HRDC or participate in its programs. Second, fragmentation and duplication are rife among university and vocational education institutions, at both state and federal levels. The lack of

[21] In 1987, Thailand's peak business association urged the government's major lab to accredit private laboratories to perform testing services, but only 25 firms were accredited by 1994 (Felker 1998).

[22] Felker (1999: 11), from which, unless otherwise noted, this review of Malaysian policy is drawn.

qualified instructors has been a clear impediment, especially for technical and engineering subjects. Third, linkages between academia and training institutes and the private sector remain scarce. Training centers established on the PSDC model have yet to achieve the same level of private firm participation as in Penang. Finally, as the economy shows signs of recovering, promising initiatives have lost government interest and support and faded away. For example, the effort to create the Malaysian Science and Technology University with MIT's help has been abandoned in favor of other initiatives.[23]

Malaysia also initiated ambitious programs as early as 1988 to promote subcontracting links between indigenous and foreign firms. The first program was a vendor-development effort, initiated by the government-owned auto firm Proton, to bring indigenous Malay (Bumiputera) suppliers into the formerly exclusively ethnic-Chinese autoparts industry. This was expanded in 1993 to the Vendor Development Programme through which large local firms and MNCs, in cooperation with state agencies and local banks, would help local firms with technical assistance, subsidized finance and procurement contracts. Over 50 foreign firms signed on as "anchor companies," with the electrical/electronics industries accounting for the overwhelming majority of companies. Yet, as of 1995, the program had "yet to register a major impact on technology transfer through industrial sub-contracting networks" (Ibid. 19). Part of the problem involved lack of clear performance measurements and monitoring. Part reflected the weaknesses of the country's long-standing SME-assistance schemes. Again, however, Malaysia's state of Penang stands out as the exception. There, the Penang Development Corporation forged subcontracting linkages between foreign semiconductor firms and local machine tool firms resulting in a high-tech cluster in semiconductors and, as noted earlier, in disk drives and related industries.

Finally, Malaysia has been quite active in broader technology promotion and diffusion efforts. With regard to FDI, Malaysia traditionally eschewed any selective emphasis on high-tech investment. By the early 1990s, when the lack of technology transfer was becoming evident, the government began to implement positive incentives, including requirements that foreign firms achieve certain levels of R&D expenditures and percentages of workforce composed of science and technical graduates (Felker 1999: 16). Yet it is unclear if these incentives have had any real impact; even after the crisis, levels of R&D in the foreign-dominated electrical and electronics sector is virtually non-existent. [24]

The government has also attempted to stimulate technology creation by establishing specialized technology parks, essentially ready-made clusters of private research facilities and technology-intensive companies. These began in 1988 with the Technology Park Malaysia as an incubator program for micro-enterprises in information technology and electronics. It continued with the Kulim High-Technology Park in the northern Kedah state, a facility with specialized infrastructure, public research institutes, technical universities, and special lots for SMEs. This facility now houses a number of disk drive and related component firms. The most ambitious project is the Multimedia Super Corridor – a multi-billion dollar effort offering special facilities and incentives to promote the growth of information technology research and development. All of these efforts were buttressed by a range of financial incentives for industrial R&D and by standards and productivity institutions devoted to offering special assistance for SMEs.

[23] Author interviews in Malaysia, October 2000-January 2001.
[24] Author interview.

Singapore's technology development efforts, both in general and in relation to the hard disk drive industry, have been both extensive and effective. The government has emphasized both quality and quantity in human resources. Given the city-state's small population, the government has implemented a highly liberal and active policy of drawing on high-skilled, foreign personnel. Singapore's Economic Development Board (EDB) is surely among the few government investment promotion agencies to set up an International Manpower Division to attract foreign talent.[25] The distinctly "technoglobalist" nature of this personnel policy should be noted. For Singapore, if the reduction of external vulnerability requires foreign support, so be it (as reflected in the hiring of an expatriate to head the government Development Bank of Singapore).[26]

Public policies to improve the quality of labor devoted to high technology have been the most substantial in the region.[27] In the 1970s, the government initiated efforts in vocational training, efforts that expanded to include a whole range of sectors and skill levels. The EDB established industrial training centers, actively seeking out foreign firms and institutions to co-sponsor training programs. A Skills Development Fund based on a compulsory payroll tax was developed to train less-skilled workers. Companies can use this tax only by sending workers to approved training programs. Interviews with HDD producers and suppliers indicate that most if not all have used this program for worker training (MDH 2000: 175). Direct public assistance went to workers pursuing training in specific technical skills, such as CNC machining. And as required skills became more advanced, the government responded with new programs in both polytechnics and universities, both at the undergraduate and graduate levels. Although these do not necessarily target the HDD industry, these programs have expanded the reservoir of disk drive manufacturing process-engineering skills.

Disk drive producers have also used other subsidized skill upgrading programs. In the mid 1990s, for example, several hard disk drive majors were using automation promotion incentives to adopt computer-integrated technologies and to send engineers abroad to be trained in advanced automation technologies. Finally, the government has recently collaborated with IDEMA, the international disk drive trade association, to provide specialized certification training for the industry.

Support for indigenous producers really developed following the recession of 1985. Several precision engineering firms serving the hard disk drive industry grew through a variety of public financial and technical assistance programs. The most important, at least for the hard disk drive industry, has been the Local Industry Upgrading Program launched by the Economic Development Board in 1986. Several features of this effort have contributed to its success. First, the Economic Development Board pays the salary of experienced multinational managers who identify and work with local suppliers with competitive potential. Second, the Local Industry Upgrading Program managers from different multinationals meet regularly at the

[25] Wong and Ng (2000: 18).
[26] We are grateful to Greg Felker for this fact and for noting that when some people objected to this hiring, the government responded that Singapore could not afford nationalist protection. (Personal communication).
[27] Unless noted, this review of Singapore policies is drawn from MDH (2000: Chapter 7, written with Wong Poh-kam).

Economic Development Board to combine their knowledge of problems facing local suppliers. In doing so, they leverage resources beyond their own firms even as they provide Economic Development Board officials with a full picture of supplier and multinational needs, thus allowing for a fine-tuning of the program. Finally, the Local Industry Upgrading Program has provided valuable preferential financing.

The third component of Singapore's technology efforts involves R&D promotion. The National Science and Technology Board (NSTB) has initiated a number of incentive schemes which, while open to foreign and local firms in and outside of the disk drive industry, have been used by all the disk drive majors in Singapore. Government research promotions have grown more extensive and more industry specific in the 1990s. In 1992, the NSTB set up the Magnetics Technology Center to provide technical support to the hard disk drive industry *and* stimulate a virtuous cycle of local R&D activities. Despite initially minimal achievements, the government expanded the Magnetics Technology Center into a Data Storage Institute in 1996 to cover technology not just in magnetic storage but also optical and other storage technologies. The Data Storage Institute has a staff of 144 and an annual budget of $28 million. Over time, it drawn disk drive firms into collaborative agreements, leading to several approved patents, and the establishment of at least one company in laser texturing of magnetic disks and laser microfabrication. Finally, the government provides direct financial support for corporate R&D. Such funding encouraged Seagate to create a design center in 1984. The center began doing design work in 1994, in part due to pressure and incentive funding from the Economic Development Board. By 1997, the firm's R&D staff grew to 140 and, in 1998, came out with the first disk drive designed in Southeast Asia (the low-cost U4).

Until the beginning of the crisis, the Singapore government directed most of its resources to encourage R&D in foreign MNCs. The 1997 crisis, however, placed into stark relief the top-heavy nature of the economy, making it apparent that small, technopreneurial firms were not being created in the economy. In response, the NSTB set aside $1 billion US as seed capital to encourage spin-offs of indigenous technology firms from university incubators and the 13 public research institutes.[28]

Several points emerge from the preceding account. First, Singapore's technology policies are the most extensive and industry specific in the region. Second, these efforts are sustained over the long run, unless they are inconsistent with market performance.[29] Third, the policies are based on serving the needs of the industry, even as they reflect an effort to anticipate the kinds of skills and services Singapore requires to maintain its position in the high value added portion of the electronics value chain. Indeed, these policies reflect the belief that disk drives are an integral part of a broader electronics value chain. Fourth, the policies are designed to induce foreign firms to localize high-technology functions and to root them in dense, local institutions. Fifth, the policies are a reflection of Singapore's belief that local clusters or agglomerations constitute the best way to retain the country's position in electronics or any value chain. And sixth, the policies indicate that Singapore does not see a contradiction in pursuing national technological objectives through the simultaneous promotion of both local and foreign firms. As a result, these

[28] Author interview, Singapore July 2000.

[29] In 1996, Singapore Technologies, a government-owned, high-tech conglomerate, purchased a disk drive firm, Micropolis. The acquisition was a financial disaster and was liquidated in 1998 after significant losses.

policies have effectively generated not only a pool of technical expertise and reliable suppliers; they have also begun to generate technological spillovers among drive producers, something that has not (to our knowledge) occurred elsewhere in the region.[30]

An early event in Singapore's electronics history illustrates the country's efforts to draw on foreign firms to develop local capacities. The government recruited Rollei, a German camera maker with strong machining capacities, to Singapore in the 1960s. In conjunction with the Economic Development Board, the firm set up an in-house precision engineering training institute, which succeeded in training twice as many precision engineers as Rollei needed for their operations in Singapore.[31] When Seagate established its Singapore operation, it asked the Economic Development Board for help in finding local producers of basic metal parts and components. Several of the suppliers were founded by Rollei alumni. Several years later, Seagate's motor division opted to set up a precision tool and die operation in Singapore in part because of a government-sponsored institute headed by a German formerly employed by Rollei.

Preferences, reflected through policies, are not the only determinant of technology development. After all, Thailand and Malaysia have initiated or considered training programs patterned after those in Singapore. Thailand attempted to strengthen its supporting industries as early as the late 1980s; Malaysia essentially copied the cluster and value-chain concept from Singapore for its Second Industrial Master Plan; and Penang consciously followed Singapore's policies of " MNC-induced technological learning." Yet only Penang has successfully emulated Singapore's achievements in using foreign producers to generate a strong local technology cluster (Doner and Hershberg 1999). Explaining differential capacities for implementing similar policies suggests the importance of variation in institutional strengths.

IV. Institutional Capacities

Institutional Challenges of New Industrial Policies:

Singapore's technology policies, viewed through the disk drive case, belie the dichotomy between state- and market-led policies. They illustrated the importance of basing sectoral interventions on market criteria and on general openness in trade and investment regimes; they also suggest that sector-specific measures do not necessarily lead to the subsidies, protection and allocative inefficiency so often emphasized by critics of industrial policy. Indeed, in part for political economy reasons, a commitment to free investment and trade policies is critical for sectoral measures. These policies constitute a useful monitoring mechanism to ensure that business-government relations do not sink into rent seeking and that firms are exposed to global

[30] This involves mutual benchmarking as well as diffusion of process innovations. For example (the only one we have at this time), a disk drive official developed a way for drives to test themselves without specialized testers. Despite his patenting the technique, everyone in Singapore copied it and cut the amount of time sharply from the previous three days (MDH 2000: 180).

[31] The firm's decision to close its operations in 1981 was a traumatic event for Singapore, which was not used to such departures. Instead of criticizing the firm, a senior government minister went on television to praise the firm for the skills it had developed and the toolmakers it had trained. And in fact, several of its technicians went on to open their own precision engineering firms to service the new electronics MNCs.

market pressures. Protectionism and the lack of competitive pressure was one key factor in the failure of Brazil to sustain its early effort in disk drive production.[32]

But as recent research suggests, openness to both foreign trade and investment are not sufficient for the kinds of upgrading necessary for long-term growth (Rodrik 2000; Mody 1998: 13-14; 25). "The trick in the successful cases has been to combine the opportunities offered by world markets with a domestic investment and institution-building strategy to stimulate the animal spirits of domestic entrepreneurs" (Ibid., 8). But endogenous growth theory suggests that simple "animal spirits," even when new technology is available "off the shelf" (rarely the case), are themselves insufficient to generate growth in an entire sector or economy. This is especially true given the need to expand product variety, to improve product quality, and to reduce costs as outlined above (e.g. Romer 1990). Traditional objectives of capital formation, job growth and foreign exchange earnings are thus now supplemented by efforts not just to exploit current relative cost advantages but also "to promote investment and learning in economic activities where comparative advantage can realistically be expected to lie in the immediate future as the economy develops and as other late industrializing countries catch up" (Gore 2000: 797).

These goals require policy instruments focused on areas typically plagued by market failures: human resource development, technology diffusion, supplier linkages, and advanced infrastructure (Mody 1998; Peters 1998). Such instruments involve a combination of sector-specific and sector-neutral policies (Gore 2000: 797). This combination is driven by two factors. First, firms typically benefit from both generic and more industry- or product-specific services in areas such as training or advanced infrastructure and logistics. Second, the very definition of "sector" is now questioned as successful countries view their economies as sets of value chains. The capacity for sustained growth thus requires going beyond support for discrete industries to "fostering the growth of dynamic industrial 'clusters' of complementary assembly, component production, producer-services, skill-development and technology support" (Felker and Jomo 1998: 4).

These kinds of public policies are more difficult to implement than either sector-neutral or sectoral protectionist policies. The latter can—to exaggerate only slightly—be promulgated by the government with the stroke of a pen (MDH 2000: Ch. 10). By contrast, the formulation and implementation of industry-specific policies such as training and supplier development require that governments directly mobilize and draw on the specialized knowledge of private actors, including the sharing of proprietary knowledge that can exposes firms to risks of opportunism. Moreover, these informational requirements are highly dynamic; policies appropriate to one stage of the industry's growth may not be germane at another. [33]

[32] Brazil initiated local drive production by indigenous firms before HDD investment in any other developing country. For details, see MDH (2000: Chapter 10).

[33] The challenges have been captured by the New Institutional Economics literature (e.g. Clague 1997). First, transaction costs – the costs of searching, bargaining and enforcing deals – increase with the number of actors involved, the information-intensity of policy, and the extent of policy adjustment required to meet shifting industry requirements over time. Second, principal-agent problems become more acute when policymaking and implementation involve more layers of government and larger numbers of private actors. Third, collective action problems grow with the involvement of larger numbers of actors, each of which may be tempted to "cheat" – to free ride on the efforts and information provided by others. The tendency of firms to poach skilled workers from others rather than to contribute to training programs, whether in-house or industry-wide, is an obvious instance of such problems. And finally, because the resolution of differences within value chains typically results in winners and losers, growth-promoting measures can be undermined by distributive problems. These can in turn contribute to

Such problems typically defy resolution through simple arms-length or parametric interventions common to generic, "baseline" policies. They are rather "institution-intensive" (Clague 1997: 3), requiring arrangements that facilitate information sharing, mutual monitoring, implementation of collective goals, and compensating losers while empowering winners. What kinds of institutions? Competition-promoting policies require enhanced rather than minimalist states. Only states with expertise, flexibility and some degree of autonomy can appreciate, much less implement, sector-specific policies that promote private sector efficiency. But states cannot pursue such policies absent extensive contact with those most directly involved in the market. Systematic public-private consultation can improve information for public sector decisions, broaden ownership and enhance the credibility of such policies, improve accountability and transparency, and expand resources for policy implementation. And finally, such public-private sector exchanges can benefit from business itself being organized (although bilateral consultations with specific firms may be more suitable for policies involving highly proprietary information). [34]

Variation in Institutional Capacities

The three Southeast Asian countries differ significantly with regard to institutional capacities. *Singapore's* ability to implement as well as to formulate effective policies is a function of a network of well-coordinated agencies led by the Economic Development Board. These agencies benefit from strong political backing and insulation from democratic constraints by Singapore's dominant party system (led by the People's Action Party). As a result, officials are able to formulate policies with a view toward longer-term objectives nested within a vision based on dynamic clusters of related activities. These processes are themselves predicated on the assumption that the government's role is to catalyze, not replace, the private sector.

This requires monitoring of and engagement with the private sector. Government officials are sufficiently informed and organized to monitor and to hold firms accountable for their use of incentives and subsidies. The criterion of accountability is a firm or industry's capacity to succeed in the market. In the case of state support for local companies in the Local Industry Upgrading Program, market performance is interpreted through a local firm's success in linking up with and supplying export-oriented, foreign firms.

Such monitoring overlaps with engagement. At the sectoral level, there is evidence of extensive collective engagement with business on issues of human resources, supplier development, and technology diffusion. As noted, for example, the Economic Development Board actively sought out multinational corporations to establish industrial training centers, institutes, and programs in its promotion of electronics-related skills development. Similarly, the Data Storage Institute (whose chair is the head of Hewlett Packard in Singapore) is also highly attentive to demands

---

time-inconsistency on the part of political leaders who, because of political reactions, might discount the future gains of growth-promoting measures.

[34] Business associations can help to limit the pursuit of particularistic benefits by individual firms and facilitate the provision of critical industry-specific information from--and among—firms. However, the degree to which associations pursue such productive objectives seems to depend on their exposure to market pressures and the imposition of selective benefits by state officials (Doner and Schneider 2000).

emanating from the industry, which has been drawn into the Institute through its governance structure. In effect, the Data Storage Institute serves as a mechanism for organizing the disk drive industry in Singapore. And finally, the success of the Skills Development Fund is predicated on close ties with organized labor (National Trade Union Congress) as well as with business (Ritchie, 2001). Extensive input from business has ensured that participation in the Skills Development Fund is high; amazingly, as of 1999, 100 percent of firms with more than ten employees participated. Cooperation between labor and the Skills Development Fund has made it possible for the National Trade Union Congress to implement a new Skills Redevelopment Program using existing Skills Development Fund funds and infrastructure to train both union and non-union workers, avoiding costly duplication.[35]

Thailand's institutional capacities are distinctly weaker. First, Thailand lacks any kind of politically powerful and cohesive agency focused on technological upgrading. The country's macroeconomic agencies, historically the most powerful and cohesive government bodies, assumed that macroeconomic stability was sufficient for growth (as indeed it was for many years). Second, policy implementation is weakened by splits between the macroeconomic agencies and sectoral ministries as well as fragmentation among the latter. And finally, since the 1990s, the country's competitive party system, driven by rural-based politicians with little support for industrial promotion, have politicized the sectoral ministries and further undermined support for industrial upgrading.

These conditions have severely hindered the development of effective R&D and training institutions and policies. As part of the Sixth Plan (1986-1991), the government created the partially-autonomous Science and Technology Development Board to strengthen applied research in the public sector, diffuse public-sector R&D expertise to local firms, and offer direct support to private-sector research initiatives. Nevertheless, these objectives were undermined when the Ministry of Science, Technology and the Environment (MOSTE) created three technology institutes to pursue the same objectives as the STDB. Fragmentation is even more severe in technical training. At least seven ministries have a major role in education and training leading to duplication, waste, and intense bureaucratic infighting (Ritchie, 1999).[36]

Bureaucratic rivalries have also hampered initiatives to develop public institutions devoted to technology acquisition and diffusion. For example, the Fifth Development Plan (1982-1986) called for the creation of a Public Technology Transfer Corporation. Nevertheless, the effort was blocked by inter-ministerial rivalry. Likewise, the Thailand Institute of Scientific and Technological Research (TISTR), patterned after Korea's Advanced Institute for Science and Technology, foundered under a combination of bureaucratic controls and political interference

[35] In addition, the SDF does not directly administer any funds. All fund disbursement is handled through a financial department in the PSB, which coordinates with the Ministry of Finance. Thus, those that distribute the funds do not determine where they go, and those that determine where they go do not distribute them (Author Interview).

[36] For example, both the Minstry of Education and Interior provide primary education, the Ministries of Education, Labor, Industry, Interior, and Agriculture all provide vocational education, and the Ministries of Education and University Affairs both provide tertiary education.

(Doner and Brimble, 1996). Finally, all of these initiatives have suffered from a lack of systematic private-sector input.

At first glance, *Malaysian* institutions appear significantly more centralized and cohesive than in Thailand. In fact, however, once outside the inner sanctum of the Prime Minister's executive offices and agencies, the bureaucracy is highly fragmented, disconnected, and duplicative with few linkages to the private sector (Ritchie, forthcoming). Rather than the line ministries, it is executive-level bodies, such as the Economic Planning Unit, Office of Technology Policy, and Malaysian Business Council that coordinate economic, investment, and technology policy. Line ministry implementation at the sectoral level has been hampered by a lack of qualified personnel and by institutional fragmentation. MIDA, for example, lacks responsibility for fostering subcontracting linkages and the Prime Minister's Office exercises significant discretion over some of the country's most important industrial initiatives. This discretion is in turn justified by the need for distributive policies to favor ethnic Malays (Bumiputera) over ethnic Chinese.[37] Ethnic politics have had two deleterious effects. One is to direct most upgrading efforts, such as SME promotion, towards promoting the entry of new Bumiputera firms, rather than towards broad technological support for existing manufacturers (Felker 2000: 20). The second is to generate mistrust on the part of ethnic Chinese manufacturers who fear that participation in government assistance programs will lead only to more exposure to tax and regulatory authorities (Ibid. 22). The overall result is to weaken public-private linkages.

The exception to this fragmentation is Penang, where the PDC has been relatively unified, consulting effectively with and linking both multinationals and local firms. The fact that local firms in Penang are just as ethnic Chinese as elsewhere in Malaysia suggests the impact of broader political factors on institutional capacities.

V. Explaining Institutional Capacity: External Threats, Domestic Coalitions

Explaining these policy and institutional differences, at least prior to the 1997 crisis, requires understanding the incentives of politicians in building institutions and devising industry-specific policies. Our explanation emphasizes two related factors: external pressures and coalitional bases.[38]

External pressures, including security challenges from other countries and economic shocks of various sorts, typically have an important influence on the course of national development. Most generally, they expand the ability of political leaders to build new institutions and launch policy initiatives. More specifically, external shocks can influence the attention national leaders give to manufacturing, and export-oriented manufacturing as a way of garnering foreign exchange in particular.

Singapore's national institutions emerged in the 1960s as the country faced a diverse set of external challenges: security threats from Indonesia, the loss of a domestic market and access to

[37] It is interesting that the PM feels it necessary to retain control over these initiatives to "ensure that the interests of the Bumi's are safeguarded" when that was the main rationale and mandate behind the creation of the Majlis Amanah Rakyat Agency, which is part of the Ministry of Entrepreneurial Development.

[38] This is drawn almost directly from MDH (2000: Chapter 9). If retained, it needs to be modified.

natural resources after its 1965 expulsion from Malaysia, and the departure of British military protection in the late-1960s. In response, the People's Action Party developed a national security strategy that had a strong economic component. The weakness of the country's manufacturing base (most indigenous firms were in trade and finance) led the government toward an emphasis on foreign investment-led growth.

Penang is of course part of Malaysia and therefore was not faced with Singapore's security challenges. But in other respects, Penang resembled Singapore. It not only lacked natural resources but also lost a key revenue-generating resource when its port facilities were made redundant as the bulk of Malaysia's entrepôt trade activities were transferred to a newly built, modern port in Klang, just outside of Kuala Lumpur. Penang's political leaders reacted to these challenges by consciously emulating Singapore's development strategy and institutions, albeit under constraints associated with Malaysia's federal structure.
Thailand illustrates another institutional variant based on a slightly different combination of threats. Like Singapore but unlike Penang, Thailand has faced significant external security threats—first from colonialism in the late 19th and early 20th centuries and subsequently from the wars in Indochina. Unlike both Singapore and Penang, however, Thailand was able to gain ample foreign exchange through large exports of natural resources, especially rice. National independence and political legitimacy therefore required a central bank and Finance Ministry sufficiently cohesive and expert to provide the macroeconomic bases for sustained natural resource exports. A bureaucracy focused on manufactured export promotion, however, was not critical.

But the simple existence of threats does not necessarily mean that institutions will emerge to address them. Political elites' ability to create institutions is also a function of their coalitional bases. Singapore's ruling People's Action Party came to power at least in part in opposition to indigenous business interests. Challenged on the left, the PAP needed to expand its support from within the working class. The result has been a regime that, despite its reliance on multinationals, is best described as an authoritarian social democracy. On the one hand, the People's Action Party-led government has historically had significant leeway to develop institutions that make use of foreign capital, even to the detriment of local firms. On the other hand, the People's Action Party's emphasis on increasing value added and on local skills development reflects the importance of satisfying an important working class constituency.

Decline in electoral support for the PAP in the early-to-mid 1980s reflected working class frustration over increasing income inequalities and the resentment of a middle class deprived of political rights and corporate participation in the country's economy. The government responded with programs such as the LIUP designed to strengthen indigenous firms, albeit through linkages to foreign producers. This subtle turn to domestic business contributed to policies that in turn had the effect of promoting a local supplier base, one of Singapore's key location-specific assets.

Coalitional factors were equally important for Penang's ability to respond to its external challenges by promoting both the expansion of foreign based multinationals and the growth of an associated group of local suppliers. Penang is the only Malaysian state with an ethnic Chinese majority. As a result, the state's political leadership is more inclined to pursue a development strategy that promotes the interests of local Chinese firms than are governments in the rest of

Malay-dominated Malaysia. Second, because of its utility as an alliance partner to the ruling coalition, Penang's political elite has been given the policy autonomy to pursue its own development strategy, including promoting industry-specific institutions and policies for advancing the electronics sector. The result is an effort to integrate MNC upgrading with indigenization.

Thailand again differs, both with regard to coalitional bases and the cohesion of the state elite more generally. Historically, the key supporters of Thailand's political leadership were found in the urban-based banking and industrial sectors. Both of these sectors developed in large part through revenues generated from agricultural exports. Until quite recently, none of these three sectors pressed for the kind of industry-specific institutions and collective goods evident in Singapore or Penang. This is obvious for agriculture and banking, less so for industrialists. Many local manufacturers expanded simply through cheap labor; indeed, labor-intensive manufactured goods such as textiles constituted the key to Thailand's boom in the 1980s and early 1990s. Another group of more skill- and capital-intensive local firms—presumably those with the potential to supply the disk drive firms—expanded through access to a protected domestic market in areas such as automobiles and consumer electronics. Thai governments have provided tariffs in part for revenue purposes but also due to the political strength of these producers. Meanwhile the government provides incentives for foreign-based multinationals to operate freely in Thailand but not to increase value added. All of this has resulted in powerful constituencies that do not need and/or are suspicious of industry-specific support. They have therefore accommodated themselves to the bureaucracy's fragmentation. And they have reinforced the bureaucracy's lack of interest in and capacity for institutions, goods and services necessary for competitive upgrading. The result is a highly fragmented industrial structure in which multinationals operate in isolation not only from one another, but also local suppliers. Unlike Penang, and more recently Singapore, indigenization has occurred at the expense of upgrading.[39]

VI. The Crisis and National Responses

The disk drive industry experienced a severe cyclical downturn in 1997-1998. This fall occurred prior to and independently of the region's broader economic crisis. But, given the region's heavy reliance on electronics exports, the fall in exports of "computers and parts" (led by hard drives) exacerbated the crisis.[40] The national impact varied. For Singapore, this combination of disk drive problems and regional crisis exposed the country's high reliance on key electronics sectors (Wong 2000: 11). For Thailand, the persistent current account deficit contributing to the crisis was a further wake-up call regarding the country's lack of supporting industry and resulting high import content in

[39] An illustrative case: A Singaporean baseplate producer, MMI, grew in part through development of extrusion techniques. Support from Conner, subsequently part of Seagate, was key to MMI's growth. Presumably this relationship was "fostered" either directly or indirectly by Singapore state officials and incentives (Poh-kam?). There are similar cases in Penang. We can find no such cases in Thailand.

[40] The impact of the crisis on disk drive firms depended on whether they had denominated their transactions in local currencies vs. the U.S. dollar. Those that denominated transactions in the Thai baht suffered significant financial losses as a result of the baht's devaluation (Author interview, Read-Rite engineer, March 2001).

exports.[41] For Malaysia, as we shall see, the crisis does not seem to have been a wake-up call. Rather, Malaysia saw the crisis as something completely exogenous: as an externally induced calamity that had little to do with any structural weakness of their own (with the possible exception of the banking sector).

How then did each of the three countries respond to these threats? Perhaps not surprisingly, given its continued concern with reducing its external vulnerability, the crisis seems to have had the most obvious and far reaching impact on *Singapore*. But while the primary influence has been to accelerate existing direction and strategy, elements of a more nationalist approach to technological development have also emerged, albeit not in the traditional, mercantile sense.

In the mid 1990s, the Singapore government began to talk of transitioning from an intensive industrial economy to a knowledge-based economy. To do so, Singapore would have to create a world-class science and technology base (National Science Technology Plan (NSTP), 1996:6). The original NSTP envisioned that it would take between 10 and 15 years to reach these objectives. An official at the ministry of trade and industry indicated that the crisis had compacted the original 10-15 year estimates into 5-7 years.[42] As an indicator of this acceleration, since 1997 there has been an explosion of government initiatives designed to foster the development of science and technology, both with regards to training and R&D (see table 1 at end of paper).

Much of this effort continues to be focused on acquiring technology and expertise directly from multinationals. Nevertheless, although MNCs continue to play the primary role in Singapore's ongoing technological development strategy, new elements of technology development with a distinctly nationalist orientation are emerging, albeit not in a traditional technonationalist sense. By the mid-1990s it was clear that two problems existed with the MNC-led technology strategy. First, most of the SMEs that MNCs had helped to create were rooted in low- to mid-level technologies.[43] Firms with higher-level technologies, such as those supplying precision-engineered parts to the disk drive industry, were involved much more in process as opposed to design development. But second and perhaps more troubling, although it was clear that the MNCs were upgrading the level of technology within their organizations, even to the point of high-level product R&D, the number of spin-offs was low. Thus, the economy was technologically top-heavy: many large MNCs and few small, "technopreneurial" firms. To respond to this gap, the government has expanded its strategy to include the creation of new, and in many cases publicly funded, technology ventures.

There are at least two reasons for this additional policy direction, one more closely approximating the technonationalist model and the other not. First, this thrust is not technonationalist in that rather than seeking to replace foreign-based multinationals, it simply seeks to fill an economic gap not met by existing strategies. As a director at the NSTB put it, "we need to support the MNCs with a vibrant source of new, niche technologies that can enhance the

[41] Lauridsen (1999: 18), who also notes that concerns about supporting industries expressed in the mid-1980s faded away in the wake of the 1987-94 boom.
[42] Author interview, July-September 2000.
[43] Clearly this was not the case for all firms. Firms such as Creative Technologies led their respective industries in technological development.

capacities and technologies of foreign MNCs. In this way, new MNCs will be attracted to Singapore and existing MNCs will be encouraged to upgrade their facilities." If spin-offs from the MNCs had been filling this gap, there would have been no reason for government to get involved. But second, the crisis placed in stark relief the vulnerability of Singapore having all its proverbial eggs in one basket. In a very real sense, the government saw this effort as an opportunity not only to support and enhance the MNC sector, but also to create indigenous firms with the capacity to develop on the technological frontier. Thus, the ideal technological relationship between MNC and SME would be bi-directional with the public research institutes playing a critical linking role between the two.

Malaysia's response, on the other hand, focuses less on industrial efficiency and more on ethnic redistribution and what might be termed financial nationalism. The government has responded to the crisis by committing itself to a more selective industrial policy driven primarily by private-sector patterns of specialization rather than state plans. In addition, it has also formally announced a revamping of the educational and training system to meet the requirements of a rapidly evolving industrial structure (Felker, 1999:24). Nevertheless, more than a year after this announcement was made, there had been little agreement on the substance of the reforms, let alone any concrete action. Part of the difficulty in carrying out educational reform may be due to the government's continued commitment to intervene in the economy to promote Bumiputera interests. But equally problematic, the bureaucracy responsible for education and training is highly fragmented and politicized making agreement and cooperation on education and training policy very difficult.

Unlike Thailand or Singapore, Malaysia responded to the crisis by implementing capital controls, the short-term result of which was to suppress FDI. The prime minister's office convened a National Economic Action Council, which met every morning to assess the effects of the crisis. Capital being siphoned to Singapore, primarily by ethnic Chinese business owners, was given one month to return or it would not be allowed to return at all. Although initially viewed with skepticism, many in the international community are grudgingly admitting that these controversial initiatives have been effective: the Malaysian economy grew 5.6 percent in 1999 and many analysts expect it to grow at better than 7 percent in 2000.

Many in government, including Mahatir, see this evidence as vindicating Malaysia's strategy of fostering foreign investment while actively working to ensure distributional equity. From the government's perspective, Malaysia is on track to reach vision 2020. [44] As has been the case historically, the government continues to call on businesses to "forgo some short-term profits in exchange for longer-term ethical [read ethnic] goals."[45] The primary focus of the government is not on increasing underlying training and education or R&D capacity, but rather on "trying to balance the development of the indigenous people with the non-indigenous Chinese and Indians."[46]

[44] Mahatir Mohammad. "Malaysia on track for 2020 Vision." 10 January 1999.

[45] Speech given by Mahatir on 29 August 2000 at the 21st Century Conference to Commemorate the Establishment of the Un Ismail Ali Chair in Monetary and Financial Economics.

[46] Mahatir Mohammad. "Many Challenges Lie Ahead." 5 June 2000.

This is reflected in a comparison between the Skills Development Fund in Singapore and the Human Resource Development Fund in Malaysia and their respective responses to the crisis. First, the SDF *increased* its training and education effort in the face of the crisis while in Malaysia the tendency was to decrease the amount of training (See Table 2 at end of paper). At the same time both countries tried to lessen the burden of the levy on business. Singapore dropped the wage level requirement from S$1500 to S$1000 during the crisis (although they have since raised it again). This ensured that all firms with low-cost labor would continue to bear the costs of the program evenly; it simply reduced the amount each would pay. Malaysia, on the other hand, exempted 28 industries from paying their levy for 11 months while another 10 were given 6 additional months reprieve. The remaining industries continued to pay the levy through the downturn (the Malaysian report does not detail which industries were exempted, although it is widely believed that politics played a significant role).[47]

The *Thai* response to the crisis was perhaps the most impressive with regard to policy and institutional initiatives, if not in terms of achievements. The outbreak of the crisis spawned extensive discussion and research on Thailand's declining competitiveness. These concerns were especially serious in light of increasing pressures for liberalization under new WTO agreements and imminent regional trade agreements (AFTA). The World Bank sponsored major research on weaknesses in the manufacturing sector[48] as foreign experts lambasted Thai producers for their high costs and low quality, and local industry association officials claimed that Thai firms could cut costs as much as 50 percent by identifying inefficiencies in manufacturing (Yuthana 1998).

Simultaneously, officials in the Ministry of Industry initiated an extensive set of public-private discussions with representatives of almost all sectors of the economy. In terms of process, this was a real effort to promote bottom-up exchanges and reach consensus on both problems and solutions. These discussions highlighted Thai producers' general lack of attention to productivity issues and resulted in a comprehensive Industrial Restructuring Plan. The Plan explicitly recognized the need to move out of low wage, mass production activities through measures such as skills upgrading and SME support. To these ends, it proposed specific productivity-enhancing measures for 13 of Thailand's most important industries (including electrical appliances and electronics). Some of these efforts, especially in the area of training, drew on Singapore's programs. More broadly, the Plan explicitly proposed "inducing FDI in strategic industries with technologies for the future" ("Thailand's Industrial Restructuring Plan"). And in terms of process, the plan called for more systematic public-private consultation.

The crisis also prompted significant efforts at institution building. This included measures to strengthen the BOI's capacity for technology promotion and the creation of eight public-private institutes designed to address productivity issues in key sectors such as textiles, autos, food and electronics. It also led to calls for greater bureaucratic centralization, cohesion and insulation from political influences. In fact, in May 2000 the Civil Service Commission proposed the creation of a Ministry of International Trade and Industry ("Revamp spawns..."). Although

[47] SDF annual report 1998/1999. HRDF annual report 1998.

[48] See the papers prepared for the conference on Thailand's Dynamic Economic Recovery and Competitiveness (Bangkok, May 20-21).

immediately opposed by the Foreign Affairs Ministry as an out-of-date, Japanese-style institution (Woranuj 2000), the MITI proposal is significant because it highlights government awareness of the need to combine responsibilities for manufacturing (presently under the Ministry of Industry) and export promotion (under the Ministry of Commerce).

The results of these efforts thus far are uncertain at best. Although Thai manufactured exports grew in a number of sectors, the core problems of low productivity and a weak supplier base persists. Indeed, a senior Ministry of Industry official stated outright that, owing to "red tape and lack of cooperation from the private sector," the industrial restructuring program "was a failure in terms of boosting efficiency and cooperation" ("New lease on life..."). Whether or not this is the case in all sectors, it seems clear enough in electronics and disk drives: Government agencies have not given much support to initiatives for a disk drive training program along the lines of Singapore's course.[49]

VII. Conclusions / Implications

Several points emerge from the preceding account.

Sources of policy and institutional change:

An analysis of national responses to a crisis requires greater attention to the factors influencing policy and institutional change. In our effort to explain cross-national differences in preferences and institutional capacities, we emphasized structural factors: external vulnerability and coalitional bases. But these may not be all that powerful for explaining the shorter-term impact of external shocks even if, as we have argued, there are strong pressures for convergence. After all, there is a long tradition of scholarship demonstrating divergent national responses to similar external pressures. To draw a parallel with the endogenous growth literature, economic institutions have a lot of tacitness; many "need to be developed locally, relying on hands-on experience, local knowledge, and local experimentation" (Rodrik 1999: 16).

Several approaches might be useful in this regard. One, a "national systems" literature, asks whether new institutions are complementary with existing arrangements; perhaps even more important, it notes that institutional systems, as well as capacities for adaptation and quick evolution within these systems, vary across countries. A second assesses the impact of ideas and norms on policy and institutional reforms. This approach is particularly relevant in an era of increasing globalization. How much of a country's technological strategy is influenced by the dissemination of norms and ideas through increasing economic liberalization? And a third emphasizes the impact of "veto players"—the number and cohesion of actors with decision-making authority. The veto player literature brings us to the broader political topic—namely, the impact of various types of electoral rules and various types of democratization. This seems especially important in light of the contrast between Singapore's cohesive response to the crisis and Thailand's game but comparatively ineffectual efforts.

[49] Author interviews.

Regional options?

We argued at the outset of this paper that successful engagement with globalized production networks requires convergence toward technology upgrading through strong local institutions. However, where value chains contain labor-intense activities, and where such components are best located proximate to higher value added activities, opportunities remain for low-wage countries without the capacity for upgrading. This does, however, assume a regional convergence to the Southeast Asian standard of free trade and investment regimes.

Techno-models:

Our review of Southeast Asian policies and institutions provides evidence that globalist/nationalist categories for technological trajectories are of limited use when viewed in isolation. The strategy of "MNC-induced technological learning" implies a combination of more nationalist objectives (greater autonomy seeking) with relatively globalist means (reliance on foreign firms for technological spillovers). Globalist means may in turn be mixed up with strong nationalist means in the form of strong support for indigenous producers. And if Singapore's recent moves into the promotion of "technopreneurship" are an indication, more successful developing countries may move toward increasing nationalist means. Indeed, Singapore's recent initiatives are beginning to resemble Taiwan's strategy of promoting local firms through its own public research institutes rather than through multinational auspices. But such a strategy may be more useful in a more stable industry such as autos or even CD-ROMS than in an industry with highly rapid technological change such as disk drives.[50]

[50] This is the conclusion from an examination of Taiwan's ambitious but ultimately unsuccessful effort at local disk drive production (MDH 2000: Chapter 10).

Table 1: New Government Initiatives since 1997

Initiative/Program	Objective	Lead Agency	Details
Education and Training			
People Developer Standard	Corporate Training Systems	PSB	S$50,000 per firm to set up holistic training programs
Skills Redevelopment Fund	Training of retrenched and older workers	NTUC	Pays for both training and compensates employers for training time away from work
Manpower Development Assistance Scheme	Develop training facilities inside firms	MoM	Reimburses costs up to a specified amount to create in-house training
Initiatives in New Technology	Train high-level technical talent	EDB	Reimbursed up to 70 percent for training outside of Singapore or to bring in outside expertise to train Singaporeans
Manpower 21	Engage government, labor, and the private sector to meet human resource needs in the next century	MoM	Government is evaluating several new peak cooperative organizations to facility training and education
(no official name)	Recruit highly trained foreign labor	NSTB	Subsidized housing, salary reimbursement, extended visas, etc. for foreign workers
Technopreneurship 21	Develop tertiary institutions into generators of both manpower and business opportunities	NSTB	Undisclosed amount of funds
Manpower upgrading for Science and Technology	Develop R&D and Technopreneurship capacity in local firms through training and post-graduate studies.	NTSB	1. Training attachment / internship to local and overseas companies and local and overseas trainers to the companies. Help with financial, legal, and info. services. 2. Grants for advanced degrees at local and overseas universities
Critical Infocomm Technology	Create specialized IT talent	IDA	S$2 million to train 1000 IT professionals. Reimburse up to

Resource Program			50 percent of costs.
Research and Development			
NTSB Venture Funding	Provide seed funds for new technologies	NSTB	Funds for university incubators, public research institutes, and private firms
University Technology Incubators	Provide opportunities for students to develop new technologies while learning "culture" of high-tech productization	MoE	Provide space and infrastructure to encourage technology development
Pioneer Tax Incentives (or extensions)	Encourage private firms to invest in formal R&D centers	EDB	Renew or provide tax incentives to firms doing product and design R&D
Technopreneurship Fund	Attract venture capital activities	NSTB	US$1billion fund to invest in new technologies
INTECH	Upgrade the technology in local firms	EDB	Reimburse costs for transferring technology (both process and product) to Singapore

Table 2: HRDF and SDF Comparison

	HRDF		SDF	
	1997	1998	1997	1998
Training Places Committed	533,227	409,242	502,686	530,755
Grants Committed	RM159.49 million	RM138.79 million	S$86.52 million	S$88.41 million
Applications Received	Not reported	Not reported	52,990	53,368

Sources: SDF Annual Report, 98/99; HRDF Annual Report, 1998.

References

Burki, Shahik Javed and Guillermo E. Perry. 1998. Institutions Matter: Beyond the Washington Consensus. Washington, DC: World Bank Latin American and Caribbean Studies.

Chalongphop Sussangkarn. 1997. "Thailand: Looking Ahead to 2020 in Light of Global and Regional Changes." TDRI Quarterly Review 12:2: 3-13

Clauge, Christopher. 1997. "The New Institutional Economics and Economic Development," in Clague, ed., Institutions and Economic Development (Baltimore: Johns Hopkins University Press, 1997), pp. 1-13.

Coloco, Francis X. 1998. "Thailand's International Competitiveness: A Framework for Increased Productivity." Paper presented at the Conference on Thailand's Dynamic Economic Recovery and Competitiveness, Bangkok, May 20-21, 1998, pp.12-14.

Crispin, Shawn. 2000. "Out of the Driver's Seat." Far Eastern Economic Review. (August 17): 46.

Dahlman, Carl and Peter Brimble. 1990. *Technology Strategy and Policy for International Competitiveness: A Case Study of Thailand*. Industry and Energy Department Working Paper, Industry Series Paper No. 24, World Bank, Washington, D.C., April 1990.

Deyo, Fredrick and Richard F. Doner. 2000/Forthcoming. "Introduction: The Political Economy of Flexible Production in East Asia." In Fredrick Deyo, Richard Doner and Eric Hershberg, eds., , The Challenge of Flexible Production in East Asia, Boulder, Col.: Rowman and Littleifield.

Doner, Richard F., with Peter Brimble. 1999. "Thailand's Hard Disk Drive Industry." Report 99-?. The Data Storage Industry Globalization Project, University of California, San Diego.

_____, and Eric Hershberg. 1999. "Flexible Production and Political Decentralization: Elective Affinities in the Pursuit of Competitiveness? " Studies in Comparative and International Development. 34 No. 1 (Winter).

_____, and Ben Schneider. 2000. "The New Institutional Economics, Business Associations and Development." Geneva: ILO, International Institute for Labour Studies, Discussion Paper 110/2000.

Dunning, John H. 1998. "Location and the multinational enterprise: A neglected factor?" Journal of International Business Studies. 29:1, 45-66.

Felker, Greg B. 1998. "Upwardly global? The state, business and MNCs in Malaysia and Thailand's technological transformation." Ph.D. diss., Princeton University.

___. 1999. "Malaysia's Innovation System: Actors, Interest and Governance." In Jomo K.S. and Greg Felker, eds., Technology, Competitiveness and the State. London: Routledge.

_____, and Charles Weiss, Jr. 1995. "An Analytic Framework for Measuring Technological Development." In Denis Fred Simon, ed., The Emerging Technological Trajectory of the Pacific Rim, pp. 384-400.

Gereffi, Gary. 2001. "Intel Inside: A Global Commodity Chains Perspective on Costa Rica's Industrial Upgrading Options." Memo prepared for SSRC-CODETI-FLASCO Roundtable on Industrial Upgrading, San Jose, Costa Rica (March).

Gore, Charles. 2000. "The Rise and Fall of the Washington Consensus as a Paradigm for Developing Countries." World Development. 28:5, pp. 789-804.

Gourevitch, Peter, Roger Bohn, and David McKendrick. 1997. "Who is Us? The nationality of production in the hard disk drive industry." Report 97-01. The Data Storage Industry Globalization Project, University of California, San Diego.

Haggard, Stephan. 1997. "Democratic Institutions, Economic Policy, and Development." In Clague, ed., Institutions and Economic Development, pp. 121-152.

Humphrey, John (1998). Assembler-supplier relations in the auto industry: Globalization and national development." Unpublished ms., Brighton: Institute of Development Studies, University of Sussex.

Hobday, Michael. 1994. "Technological Learning in Singapore: A Test case of leapfrogging." Journal of Development Studies. 30:4. Pp. 831-858.

Jackson, Karl D. 1999. "Introduction: The Roots of the Crisis." In Jackson, ed., Asian Contagion: The Causes and Consequences of a Financial Crisis. Boulder: Westview.

Kaplinsky, Raphael. 1999. "Spreading the Gains from Globalisation: What Can Be learned from Value Chain Analysis." Unpublished ms., Institute of Development Studies, University of Sussex.

Lall, Sanjaya. 1998. "Thailand's Manufacturing Sector: The Current Crisis and Export Competitiveness." paper presented at the conference on Thailand's Dynamic Economic Recovery and Competitiveness (Bangkok, May 20-21).

____. 1999. "Technology Policy and Competitiveness in Malaysia." In Jomo K.S. and Greg Felker, eds., Technology, Competitiveness and the State. London: Routledge.

Lauridsen, Laurids. 1999. "Financial crisis, structural problems and linkage policy in Thailand in the 1990s." Paper presented at the 7th International Conference on Thai Studies. Netherlands, July 4-8.

McKendrick, David, Richard F. Doner and Stephan Haggard. 2000/Forthcoming. From Silicon Valley to Singapore: The Competitive Advantage of Location in the Hard Disk Drive Industry. Stanford: Stanford University Press.

Meyer-Stamer, Jorg. 1998. "Clustering, systemic Competitiveness and Commodity Chains: How Firms, Business Associations and Government in Santa Catarina (Brazil) Respond to Globalization." Paper prepared for International Workshop on Global Production and Local Jobs. Geneva, International Institute for Labour Studies.

Mody, Ashoka. 1998. "Industiral policy after the East Asian crisis: From 'outward-orientation' to new internal capabilities?" Unpublished ms., World Bank (November 15).

"New Lease on Life for Manufacturing." 2000. Bangkok Post / Mid-year Economic Review (July).

Nipon Paopongsakorn and Belinda Fuller. 1997. "Thailand's development experience from the economic system perspective: Open politics and industrial activism." In Toru Yanagihara and Susumu Sombommatsu, eds., East Asian development experience: Economic system approach and its applicability. (Tokyo: I.D.E.).

Nipon Paopongsakorn and Pawadee Tonguthai. 1997. "Technological Capability Building and the Sustainability of Export Success in Thailand's Textile and Electronics Industries." In eds., Dieter Ernst, Tom Ganiatsos, and Lynne Mytelka, Technological capabilities and export success in Asia (London: Routledge), 309-59. .

Peters, Hans J. 1998. "Thailand's Trade and Infrastructure," paper presented to Conference on Thailand's Dynamic Econmic Recovery and Competitiveness (Bangkok: May 20-21).

Rasiah, Rajah. 2000/forthcoming. "Politics, Institutions and Flexibility: Microelectronics Transnationals and Machine Tool Linkages in Malaysia." In Fredrick Deyo, Richard Doner and Eric Hershberg, eds., , The Challenge of Flexible Production in East Asia, Boulder, Col.: Rowman and Littleifield.

"Revamp spawns new Ministries." 2000. Nation. (May 26).

Ritchie, Bryan K. 1999. "The Resource Curse, Ethnicity, and the Origins of Technical Education and Training." Paper delivered at the Annual Meeting of the American Political Science Association, Atlanta Marriott Marquis and Atlanta Hilton and Towers, September 2-5, 1999.

____. 2001. "Political Preferences and Increasing Returns: the Boon and Bane of Technological Development in Southeast Asia." IKMAS working paper series. Paper no.

____. Forthcoming/2001. "Innovation Systems, Collective Dilemmas, and the Formation of Technical Intellectual Capital in Malaysia, Singapore, and Thailand." Journal of Business and Society. Forthcoming.

Rodrik, Dani. 1999. "Institutions for High-Quality Growth: What They Are and How To Acquire Them." Paper presented at the IMF Conference on Second-Generation Reforms, Washington, DC, November 8-9.

Romer, Paul. 1990. "Endogenous Technological Change." Journal of Political Economy. 98:5, S71-S102.

Sevilla, Ramon C. and Kusol Soonthornthada. 2000. "SME Policy In Thailand: Vision and Challenges." Unpublished paper, Institute for Population and Social Research, Mahidon University, Thailand.

Waldner, David. 1999. State Building and Late Development. Ithaca: Cornell University press.

Winterton, Jonathan and Ian M. Taplin. 1997. "Making Sense of Strategies for Survival: Clothing in High Wage Economies." In Ian M. Taplin and Jonathan Winterton, eds., Rethinking Global Production: A Comparative Analysis of Restructuring in the Clothing Industry. Brookfield, Vt.: Ashgate Publishing, 189-198.

Westphal, Larry et al. 1990. "The Development of Technological Capability in Manufacturing: A Macroscopic Approach to Policy Research." In Robert E. Evenson and Gustav Ranis, eds., Science and Technology: Lessons for Development Policy (Boulder: Westview Press).

Wong Poh-Kam. "The Role of the State in Singapore's Industrial Development." Paper presented at the conference on The Role of the State in East Asian Industrial Development: Reflections in the Light of the Asian Crisis." University of California, Berkeley.

_____. 1997. "Creation of a Regional Hub for Flexible Production: The Case of the Hard Disk Drive Industry in Singapore." Industry and Innovation. 4:2 (December).

_____, and Chee-Yuen Ng. 2000. "Re-thinking the Development Paradigm: Lessons from Japan and the Four Asian NIEs." Paper presented at the conference on The Role of the State in East Asian Industrial Development: Reflections in the Light of the Asian Crisis." University of California, Berkeley.

_____, David McKenrick, Richard Doner, and Stephan Haggard. 2000/Forthcoming. "Singapore." In McKendrick, Doner and Haggard, From Silicon Valley to Singapore.

Woranuj Maneerungsee. 2000. "New ministry a blunder, say Kobsak – Japanese model soon will be out of date." Bangkok Post. August 9.

World Bank, 1993. The East Asian Miracle: Economic Growth and Public Policy. New York: Oxford University Press (for the World Bank).

_____. 2000. Thailand Economic Monitor. (June).

Yuthana Priwan. 1997. “Industry: Electronics Institute Planned: B20bn fund Would Back New Ventures.” Bangkok Post (August 4).

_____. 1998. “Production defects pushing up costs.” Bangkok Post (June 23).