Technology Policy in Malaysia

Greg Felker with Jomo K.S.

Malaysia's striking economic performance during the decade before 1998 attracted great interest in policy and academic circles around the world. Sustained high growth rates involved profound structural change. Malaysia was transformed in two generations from its immediate post-colonial status as a primary product exporter into an industrially-oriented economy and society and leading global manufactured exporter.[1] Real GDP grew by an average 5.2 per cent per year during 1980-90, and accelerated to a remarkable 8.7 per cent per year during 1990-95. Manufacturing output rose even more swiftly, averaging 8.9 per cent and 13.2 per cent per year during the same two periods. Malaysia's merchandise exports grew by 11.5 per cent annually during 1980-90 and by 17.8 per cent from 1990-95. Manufactured goods made up only 19 per cent of exports in 1980, yet by 1995, they accounted for 77.4 per cent of a vastly larger total.[2]

Even before the East Asian economic crisis erupted in 1997, however, notes of concern were often sounded amidst the chorus of acclaim for Malaysia's industrial achievements. Malaysia's economic "miracle" presented a curious mixture of manifest dynamism and chronic structural weaknesses, giving rise to conflicting views as to whether rapid industrialisation was based on durable strengths or transient factors. On the one hand, continued inflows of foreign direct investment (FDI) and the partial diversification of manufactured exports seemed to dispel fears that rising wages would erode the country's competitiveness and cause foreign firms to divert their investments to lower-cost countries.

At the same time, locally-owned firms' minimal participation in export industries, limited inter-industry linkages, and lagging productivity growth remained conspicuous problems. One leading Malaysian economist avowed a widely shared optimism that "There is always room at the top for a country that aims high and is prepared to work hard at it. It appears that Malaysia has the courage and the means to do just that" (Ariff 1991: 194). Other observers argued that the country's remarkable economic performance resulted from external factors like FDI and hence that "There is an inherent fragility in the current Malaysian industrial 'take-off'" (Bowie 1994: 191).

East Asia's financial crisis in the late 1990s made this debate more urgent than ever before, as Malaysia struggled to adjust to preserve its industrial gains in the face of the regional economic collapse. Does the slump reveal the Malaysian industrial miracle to have been little more than a mirage based on foreign capital injections and "irrational exuberance"? Or were real industrial and technological capabilities built up during the boom years, strengths that will revive the economy's upward trajectory once the turmoil subsides?

The crisis in Malaysia and other Asian economies was first and foremost a matter of currency and financial markets. A complex set of international and domestic factors, including a 'virtual peg' of regional currencies against the strengthening US dollar, encouraged a binge of short-term foreign borrowing in the mid-1990s, much of which financed speculative investments in real estate and corporate equities. When the Southeast Asian pegs fell to attacks by currency traders in the first half of July 1997, rapid withdrawal of foreign and local capital snowballed into a general meltdown of investor confidence, which in turn produced a self-reinforcing decline in currency and equity values. Collapsing asset values imperilled entire financial systems and caused an acute liquidity crisis affecting virtually all sectors and firms.

While the crisis thus stemmed primarily from problems and dynamics internal to financial markets and non-manufacturing sectors, the real economy's structural dynamism was also at issue. The current account deficits financed by short-term borrowing stemmed primarily from over-investment in non-tradable sectors, but a slow-down in manufactured export growth, which began in 1996, had also contributed. The competitiveness of Malaysian manufacturing was less important in explaining the financial crisis, however, than in determining the prospects for recovery.

According to conventional analysis, currency devaluation would enhance the cost competitiveness of industries in Malaysia and stimulate exports, offering a silver lining among the dark clouds of financial havoc. The actual picture has been far more complex. Malaysia's manufacturing industries, including exporters whose competitiveness is not in doubt, face a severe liquidity squeeze. Currency depreciation itself has been a mixed blessing for export industries, since non-resource based manufacturing relies heavily on imported inputs and technology, the costs of which have suddenly skyrocketed.

Slow growth in key markets and devaluations in other exporting countries make vigorous export growth anything but automatic for Malaysia. At most, devaluation would do little more than temporarily extend industrial and export competitiveness based on relatively lower production, especially labour costs. While the crisis does not constitute evidence that Malaysia's industrial boom is exhausted, therefore, neither does it postpone the need to grapple with the challenges of fostering dynamic industrial change. The question thus remains — what are the underlying strengths and prospects of Malaysia's industrial sector?

The ongoing debate about the nature of Malaysia's industrialisation stem from an awareness that years of double-digit manufacturing growth had, by the early 1990s, brought the country to a new stage of development. The economy confronted a pivotal transition from labour-intensive manufacturing to an industrial structure based on higher value-added, technology-intensive production. It is increasingly understood that technological change and the factors that shape it are the key issues in long-run industrial success.

As an economy moves beyond growth based on low labour costs and other factor-endowment advantages, industrial technology development becomes ever more critical to sustaining development momentum (World Bank 1993: 87-90; Dosi, *et al*. eds. 1988). Contrary to orthodox theory, technological development involves far more than an automatic response to changing factor prices. Observers and policy makers in

Southeast Asia, and in Malaysia particularly, recognise that the region's 'near-NICs' must spur the process of technological development if they are to recover and maintain their economic dynamism (Anuwar 1992; Ng, *et al*. eds. 1986; Osman-Rani, *et al*. 1986).

At its core, then, critical evaluation of Malaysian industrialisation involves an examination of its experience and prospects in industrial technology development. Has rapid growth in output and exports been accompanied by the development of capabilities to acquire, adapt, and improve important technologies? Or has the deepening reliance on the production decisions of multinational corporations signified an externally driven, or even 'technology-less' form of industrialisation (Yoshihara 1988)?

Government intervention is often needed to remedy failures in markets for finance, skills and information. These market failures are particularly acute in technology development, providing a rationale for government to provide special incentives for investments that build technological capabilities. Any such interventions require good policy design and careful implementation, which in turn depend on adequate administrative capabilities and information.

If the government lacks these capabilities, policies to encourage technological capability-building must be correspondingly modest in scope to minimise the likelihood of government policy failure. Lall (1996: 39) notes that the infant industry argument has been often been discredited by policies which invoke its logic while ignoring its requirements. He emphasises that such examples of government failure do not invalidate the case for judicious, selective interventions to address problems, which impede technological capability development. Instead, he draws the following policy implications:

- industries selected for promotion must be realistically capable of achieving world efficiency levels in the foreseeable future
- since resources are generally limited, efforts should be focused on a few industries at any one time, while performance should be strictly monitored and improved
- as protection reduces the incentive to invest in technology capability development, countervailing measures are necessary, e.g. strong requirements to export early tends to enhance technical efficiency.
- as firms are often linked to other firms in the national economy, protection itself cannot ensure competitiveness unless related problems are adequately addressed, i.e. protection has to be coupled with complementary measures to develop capabilities.

If economic arguments about industrial and technology policies are inseparable from the question of the government's policy capacities, this in turn points to debates about the political foundations of successful 'late' industrialisation. What sort of institutional and political arrangements enable governments to intervene in a disciplined fashion and avoid policy failure? This question is crucial whatever mix of markets and state intervention prevails, since even a market-based strategy requires effective and neutral administration capable of resisting egregious rent-seeking and reconciling broader distribution pressures with the demands of market competitiveness. One popular but contentious argument draws on the East Asian NIC examples to suggest that only a politically-insulated 'strong' state can implement strategic industrial policies without having them fall prey to rent-seeking pressures (Johnson 1987; Haggard 1990; Wade 1990; Onis 1991).

Malaysia's dramatic transformation makes it a critical case in these ongoing controversies. It has featured assertive state efforts to guide industrialisation, but strategic policies' actual contribution to development is strongly disputed (Lall 1995). Throughout the 1970s, government industrial policies sought to diversify the economy, diminish its reliance on primary commodities, and encourage manufacturing. The government became even more interventionist in the early 1980s, and launched a comprehensive strategy that set specific sectoral priorities to accelerate and deepen industrial growth. Strategic industrial policies initially focused on a state-led second round of import-substitution. The state's ambitious thrust into heavy industries resulted in several costly failures and contributed to fiscal and macro-economic crises in the early 1980s.

In the wake of the 1985-86 recession, the political leadership changed course and began an ongoing effort to streamline and rationalise industrial policies. Most importantly, the government embraced private sector-led industrialisation and turned once again towards export-oriented growth. Yet it also persisted in attempts to influence structural change through indicative strategic guidance (Lall 1995). As the economy swung from recession to hyper-growth with full employment, the industrial policy framework focused on issues of export competitiveness, productivity growth, and technological development. The success or failure of Malaysia's efforts to promote technology-based industrialisation holds unique significance for the political economy of late industrialisation — it is precisely this transition, in which an economy moves beyond traditional, factor-endowment sources of comparative advantage, which throws contending hypotheses about the roles of state and market in industrialisation into sharpest relief.

The export-led growth boom and the new approach to industrial began in the mid-1980s. Though the economic crisis has made the ultimate goal -- transition to technology-based industrialisation -- even more uncertain, the time is nonetheless ripe for an assessment of the character of Malaysia's industrial technology development and the role of technology policy and institutions. The next section identifies the developmental goals and challenges which have inspired Malaysia's ambitious technology policies. The third section discusses recent theoretical perspectives on technological change in developing countries and highlights their policy implications. The fourth section details the evolution of Malaysian technology policy and institutions, identifying key trends in government and corporate technology strategies.

National Innovation Systems and the Case of Malaysia

Firms create industrial technological development through their investment and production decisions, but they do not do so in isolation. Policies and institutions powerfully shape the incentives for firms to invest in technology, and also provide vital complementary resources, information, skills, and specialised technical services. In their efforts to develop technological capabilities, firms draw heavily upon such external technological resources through both market and non-market linkages. Furthermore, private investments in technological development confront various types of market failure.

Many aspects of technological learning are highly interdependent or involve pervasive externalities. For example, one firm’s investments in developing its workers’ technical skills might easily benefit its competitors if trained staff switch companies. Another well-known example is the interdependence of technical progress in capital goods (or other supplier industries) and in downstream machine-based industries. As a result, there are significant areas in which some degree of co-operation among firms and public institutions may result in more rapid technological development. Conversely, a lack of institutions or policies for co-ordination may inhibit the rapid accumulation of technological capabilities, because individual firms will under-invest in them.

Awareness that an economy’s technology development performance depends, to some significant degree, on investments and capabilities developed at a broader level than the individual enterprise has stimulated growing interest in ‘national innovation systems’ (see Nelson [ed.] 1993, Lundvall [ed.] 1992). Dahlman (1994: 541) defines a national innovation system as “…the network of agents and set of policies and institutions that affect the introduction of technology that is new to the economy… [including] policies toward foreign direct investment, arm’s-length technology transfer, intellectual property rights, and importation of capital goods.

The innovation system also comprises the network of public and private institutions and agents supporting or undertaking scientific and technological activities, including research and development, technology diffusion, and creation of technical human capital.” This definition suggests that general macro-economic, trade, industrial, and labour-market policies, and not only explicit technology policies, powerfully influence firms’ incentives and abilities to seek improved technology. Technology development is nonetheless a distinct process that, while integral to broader industrialisation, has its own specific determinants and dynamics.

Studies of successful late industrialisation, particularly in Japan, South Korea, Taiwan and Singapore, draw attention to the role of innovation systems in supporting technological catch-up in leading industries (Freeman 1987, Dahlman 1989, Samuels 1994). Governments in both the advanced industrial countries and the developing world have recently sought to create or reform innovation systems to boost industrial growth and national competitiveness. Indeed, as global economic integration undermines their ability to use trade, macroeconomic and state enterprise policies to promote national industrialisation, governments have become increasingly interested in directly influencing micro-economic dynamics such as productivity growth and technical change. Nelson (1993: 3) observes “There is clearly a new spirit of what might be called ‘techno-nationalism’ in the air…” while also cautioning that “…the belief that these [technological] capabilities are in a sense national, and can be built by national action…” may in fact be misleading. This, then, is the critical issue. Where do national innovation systems come from? To what extent do they reflect strategic development priorities set by political actors, or rather emerge 'naturally' as demand for technology support increases among firms in the market place?

Malaysia is especially important in answering these questions, because few countries have pursued technology development as consistently and self-consciously over the past several years. The national philosophy, the Rukunegara, commits Malaysia "to building a progressive society which shall be oriented to modern science and technology." Explicit policies and institutions to promote technology development arose in the mid-1980s as a natural corollary to the programme of accelerated industrialisation and, in large part, as a response to the weaknesses threatening its achievement. In seeking to emulate the development models of first-generation newly industrialised countries (NICs) like South Korea, Malaysian officials noted that explicit technology policies were important in the transition from labour-intensive assembly to a deeper and higher value-added industrial structure.

The cardinal industrial strategy document of the 1980s, the Industrial Master Plan (1985-95), therefore spotlighted technology development as a key weakness and object of policy intervention. Prime Minister Mahathir's 1991 'Vision 2020' manifesto, entitled 'The Way Forward' amplified the priority on technology development by declaring it one among nine strategic challenges facing the nation. It claimed, "There is inadequate development of indigenous technology. There is too little value-added, too much simple assembly and production…" and asserted the goal of creating "an economy that is technologically proficient, fully able to adapt, innovate and invent, that is increasingly technology-intensive, moving in the direction of higher and higher levels of technology."

As the economy grew ever more dependent upon foreign manufacturing investment and exports in the 1990s, technology came to be viewed as crucial to continued prosperity in the increasingly competitive and technology-driven international economy. The need to promote technology development became a central feature of the growing discourse on national 'competitiveness'. For example, policy makers widely discuss the annual World Competitiveness Report issued by a Swiss consulting firm, which ranks countries according to their technology development levels and several other factors.

Malaysia shares these developmental motives with other so-called 'second-tier' NICs, such as Thailand, Indonesia, and (latterly) the Philippines. Yet, it is distinctive in the scope and ambition of its effort to deploy strategic technology policies to engineer the transformation of its industrial structure. At a rhetorical level, the Prime Minister and top government officials constantly emphasise the challenges and goals of national technology development in policy and public fora.

Beginning with the Fifth Malaysia Plan (1986-90), each five-year development plan includes a chapter that identifies technology development goals and allocations. Public R&D and technology budgets have grown sharply, while new technology planning systems seek to guide investments and effort into priority areas. Along with increased funding, officials have mounted a two decade-long effort to expand and reform the nation's system of technology support institutions, including public R&D

laboratories and university consultancy units. To encourage private sector technology development, the government has offered new incentives for R&D and high-technology investments, even while gradually curtailing other discretionary investment incentives.

Other policy efforts established specialised technology finance mechanisms and built new science parks to attract high-tech industries. Technology transfer and development have become central issues in negotiations with the foreign investors who have led the economy's recent industrial surge. Taken together, these initiatives add up to a fairly comprehensive programme to build a national technology development system and harness it to strategic industrialisation goals through increased investment, coherent central planning, and intensified consultation with the private sector.

Despite its high policy priority, however, Malaysia's attempt to orchestrate a technological transformation in industry remains a difficult and uncertain enterprise. First, while national institutions and policies may affect technology development, the extent to which public policies can intentionally accelerate and guide technological development in line with explicit strategies is far from clear, as suggested above. Nelson and Rosenberg's (1993: 4) overview of several comparative studies of national innovation systems cautions, "There is no presumption that the [national innovation] system was… consciously designed, or even that the set of institutions involved works together smoothly and coherently." Accepting the premise that national policies and institutions significantly affect the course of industrial technology development, one is left with the formidable challenge of defining what constitutes good technology strategy, policy and practice.

Several other obstacles give pause to easy predictions of success. Malaysia began its technology development programme with a deficit of pre-existing public and private institutions for industrial technology, and measurable technology development within the private sector was negligible until very recently. While its export structure is concentrated in relatively sophisticated products such as component and consumer electronics, for example, the industrial structure in the 1980s was remarkably 'shallow', with poor inter-industry linkages and an underdeveloped capital goods sector. Specialised technology infrastructure for industry was lacking, with few engineering consultancy firms, sources of finance for innovation, advanced skills training institutes, and commercial or public providers of industrial technical services and R&D. In short, Malaysia presented a curious picture of burgeoning high-technology exports with little local innovation activity.

Other obstacles are legacies of Malaysia's history as a resource-rich exporter of primary products or of previous industrial policies. An elusive though fundamental issue is the absence of an 'innovation culture' or tradition within local industry, in turn reflecting local private business groups' historic orientation of towards commodities, commerce and other tertiary sectors. Throughout Southeast Asia, leading private business groups originated in trade and banking, but large-scale diversification into industry took place in the 1970s in countries such as Thailand and Indonesia.

In Malaysia, attempts to promote industrialisation came relatively late, and the business groups that emerged under state patronage during the 1970s under the New Economic Policy (NEP) were largely outside manufacturing (Lim 1981, Heng 1992). Even after the government shifted its stance in the late 1980s to promote manufacturing development under private-sector auspices, the dearth of locally-owned enterprises with distinct, long-run industrial orientations has frustrated efforts to jump-start indigenous technological development. Annual surveys by the Federation of Malaysian Manufacturers (FMM) indicate that, outside of the foreign investment sector, business awareness of and interest in R&D and other technology issues is generally poor.

A related concern is Malaysia's industrial structure, which was long characterised by a 'missing middle' of dynamic and technologically progressive medium- to large-scale indigenous enterprises. Small-scale, family-run ethnic-Chinese businesses dominated local manufacturing production until quite recently, and the majority of these employ obsolete production techniques and non-professional management systems (Ismail 1990). The gap in scale and technology between these firms and the leading MNCs has hampered efforts to build linkages between foreign-dominated export industries and the local economy.

A third issue is the historically dominant role played by multinational corporations (MNCs) in Malaysia's leading manufacturing industries. The deepening MNC presence has effected profound structural change in the Malaysian economy. Policy makers and observers are nonetheless concerned that passive reliance on foreign direct investment (FDI) results in a truncated form of technology transfer, whereby deeper design and research capabilities are not developed and the primary impetus for growth continues to lie in external factors (i.e. MNCs' international decision-making) rather than in locally-driven productivity growth.[4]

Finally, the transition to technology-based industrialisation is threatened by the acute scarcity of technically skilled human resources. This weakness crucially distinguishes Malaysian development from the East Asian NICs, where massive investments in human capital anticipated rapid industrial growth. Nowhere is the paradoxical mixture of high-technology exports with weak local technology inputs more evident. Malaysia's manufactured exports have evolved rapidly towards products which usually require higher skill levels, yet some recent scholarship has indicated a *decline* in the skill content of manufacturing (World Bank 1995) and exports (Lee 1996).

This paradox is largely explained by high-technology MNCs' capacity to subdivide and distribute the production process internationally to match host countries' differing skill levels and capabilities. A crucial question is the extent to which foreign firms in Malaysia have 'adapted down' to skills deficits by focusing on less skill-intensive production activities or by implementing skill-substituting automation, or instead, 'adapted up' by absorbing the costs and limiting or ignoring the externalities (e.g. job-hopping) of genuine skills upgrading through in-house training. Many recent studies have indicated that MNCs have invested large and growing amounts in workforce training in conjunction with automation and other technological improvements (Rasiah 1995; Lall, *et al*. 1994).

A bleaker interpretation is that, more than enlarging the pool of skilled labour through their training activities, large MNCs have upgraded their own human capital by crowding out other firms in the skilled-labour market, offering superior salaries and benefits. In this view, MNC responses to skills deficits might exacerbate the general market failures confronting private investments in human capital. The result might be growing technological dualism dividing large MNCs, for whom investments in skills development yield positive returns despite some spill-overs, from other smaller foreign and local firms struggling to maintain low-cost, low-skill production strategies. Thus far, the skills deficit has not appeared to prevent FDI-led industrial upgrading. Yet, even favourable analyses question whether such progress will be sustained in the absence of swift efforts to dramatically increase human capital stocks through expanded training and education infrastructure.

These cautions imply that local public and private institutions might be inadequate to overcome difficult challenges facing Malaysia's ambitious technology development programme. Other questions about the prospects for success start from the opposite premise, namely that national level technology strategies and institutions have themselves become obsolete. The flow of technology in capital equipment, foreign investment, and human skills is increasingly transnational, and Malaysian industry relies particularly heavily on international linkages for technological information and resources.

As FDI creates intra-industry and intra-firm divisions of labour across national borders, the goal of guiding industry to develop specific self-contained technological competencies within national borders appears unrealistic to many observers (Simon [ed.] 1995a). At the same time, national institutions and policies appear overly broad in light of recent work on flexible-specialisation and regional development in industry, in which inter-firm networks, often in particular geographic clusters, figure as the most important type of institution nurturing technological learning (Storper and Scott [eds] 1992, Ohmae 1995). Firms' needs for skills and technical support vary widely not only across industries, but also by individual networks of co-operating firms which develop distinctive technology 'codes', or standards and protocols for skills, design, and inter-firm communication.

In the context of these twin trends towards global integration and sectoral, regional, and network differentiation, therefore, many argue that the scope for national policies has become more strictly limited to broad investments in basic education and infrastructure development. The Malaysian government's efforts to target specific technologies are unlikely to influence industry's accumulation of capabilities, and worse, might divert scarce human and financial resources towards non-productive investments. From this standpoint, the best which central governments can do is to accommodate global trends and support local initiatives through decentralising decision making and resources to regions, cities, and non-state actors. The recent popularity of regional trans-border 'growth triangles' in Southeast Asia is an example of such an approach.

Finally, quite apart from the economic challenges to national technology strategies is the question of the administrative and political conditions necessary for effective implementation. A large literature addresses the political factors behind the successful use of strategic trade and industrial policies in the East Asian NIEs, asking why and how policy-generated rents (or subsidies) were deployed to reward infant-industry learning rather than the wasteful rent-seeking evident in many political economies (Amsden 1989). As noted above, one argument emphasises the importance of a politically autonomous 'strong state', which insulates economic policy making from distributional demands, permits technically proficient bureaucrats to allocate rents towards developmental objectives, and holds private business accountable to performance measures (see Haggard 1990, Amsden 1992, Wade 1990).[5]

Critiques of statism, some of them drawing from Southeast Asian cases, stress the progressive role of private business classes, state/business policy networks or growth coalitions, and non-state institutions such as business associations and sub-contracting networks (MacIntyre, 1994, Doner 1992, McVey 1992, Hamilton [ed.] 1991). The puzzle of what political arrangements support effective industrial policy is no less pertinent to technology policies, inasmuch as enhanced technological capabilities are essential to the maturation of infant industries and the achievement of dynamic comparative advantage. Indeed, the strongly industry- and firm-specific character of technological change makes the administrative challenges to government policy — measuring performance and ensuring accountability — particularly difficult and critical.

Malaysia presents a somewhat contradictory mixture of the political factors supporting effective industrial policy. While the Malaysian state does not approach the degree of dominance historically evident in Korea or Taiwan, many observers argue that it enjoys the highest levels of political autonomy and bureaucratic capacity in Southeast Asia, Singapore excluded (Crouch 1984, MacIntyre 1994). On the other hand, inter-ethnic redistribution has contended with national economic development for official priority, and political relations between the state and private business were not always cordial during the implementation of the New Economic Policy (NEP) from the 1970s (Jesudason 1989, Lubeck 1992).

Beginning in the 1980s, Mahathir's reforms facilitated a rapprochement between political and business elites, with the government intensifying formal consultations with private sector representative associations (World Bank 1993: 186-187). Clientelist linkages between government and business have changed, but persist in the new liberalised environment, and closer formal policy consultation under the rubric of Malaysia, Inc. has yet to spawn the indigenous industrial entrepreneurship which might spearhead a nationalist thrust into high-technology industrialisation. At the same time, the Malaysian state seems to have preserved some autonomy from business groups if not broader distributional pressures, and remains somewhat capable of pursuing coherent and disciplined policy initiatives.

In sum, the ambitious scope of the country's technology policy effort, together with the challenges it confronts, make Malaysia a compelling case for the study of national technology development programmes in late industrialisation. Analysis of its experience in industrial technology development and the role of its technology policies and institutions promises to shed light on several critical issues in the political economy of development. First, what are the distinctly national sources of ‘competitiveness’, or more specifically, industrial dynamism understood in terms of technological capability building, productivity growth, and structural change? How do institutional mechanisms for industrial technology development emerge as industrialisation progresses towards more advanced stages?

Second, what is the role of the state and private sector actors in creating the conditions for such industrial dynamism? Can national innovation systems be self-consciously engineered to propel growth? Are optimal technology policies limited to functional investments in human capital and physical infrastructure, or are selective and strategic interventions in technology development integral to successful late industrialisation? Are the political and administrative prerequisites for effective intervention related to state autonomy, to well-organised private business sectors, or both? Finally, to what extent have attempts to govern national development been rendered obsolete by the transnational character of industrialisation, in which MNCs integrate and manage production and innovation across national borders?

Models of Innovation and Technological Development

Evolutionary Models in Late Industrialisation

An inquiry into national innovation systems might best begin with a conceptual understanding of the innovation process itself. Departing from Kenneth Arrow’s seminal (1962) article on ‘learning by doing’, a growing literature in the economics of innovation has depicted technological change as a complex evolutionary process at odds with the linear, science-driven model that dominated post-war thinking about science policy (Nelson and Winter 1982, Mowery and Rosenberg 1989: 7-9). In the old model, innovation progresses in linear fashion from exogenous laboratory research breakthroughs through development, prototype, and production to commercialisation in the market. By contrast, evolutionary models include three key features.

First, they understand the innovation process as interactive or partly endogenous.[6] Industrial innovation reflects neither purely ‘market-pull’ nor ‘science-’ or ‘research-push’ forces, but rather arises as innovators blend information about market and production conditions with the changing stock of scientific and technological knowledge to make product or process improvements. This means that, while formal R&D is frequently critical, much of the activity and cost of innovation occur in less formal engineering, testing, quality control, and process control activities aimed at improving performance or solving production problems. In short, technological development encompasses far more than formal R&D, which itself often begins as an outgrowth of these production-based learning activities.

Second, evolutionary models depict innovation as inherently and fundamentally uncertain, making technological change both strategic and cumulative. Decisions to invest in innovation (e.g. R&D projects, or purchasing a technology license) confront many possible outcomes in terms of their impact on productivity, each with vague or even unknowable probabilities. They comprise strategic rather than narrowly rational optimisation problems.[7] The direction of technological change will therefore be influenced by firms’ strategies as well as by the strategic biases created by surrounding institutions and histories, e.g. patent regimes, technical traditions, etc. Moreover, multiple possible outcomes at a single stage of development will, over time, yield diverging paths or 'trajectories' of technical change, along which firms and industries advance in cumulative fashion (Dosi 1982). New products and processes usually emerge out of attempts to improve upon old ones in specific ways. In this way, the possibilities for technological advance at a given stage build upon, and are limited by, the choices made and capabilities developed earlier.

Third, evolutionary models conceive of technology in broad terms as a set of linked capabilities based on different types of knowledge. These include formal knowledge embodied in blueprints, manuals, machinery, or products on the one hand, and "tacit", non-codified, experiential knowledge on the other.[8] Since technology is partly tacit, the full set of capabilities necessary for its optimal use often cannot be obtained through market transactions or imitation. Rather, the purchaser or recipient must make active efforts to assimilate and apply acquired technology in its own specific production routines. Such investments to imitate or master acquired technologies can be as costly as those required to generate entirely new innovations.[9] Moreover, improving technology over time, i.e. achieving dynamic efficiency, involves a deeper level of technological knowledge and requires capabilities distinct from those required for static efficiency (Bell and Pavitt 1993).

Although evolutionary models were developed to explain innovation at the global technological frontier (the key concern of advanced industrial countries), the non-linear, path-dependent, and tacit characteristics of technological change make innovation similar in some important ways to technological catch-up, the task facing most developing country firms. Like innovators at the frontier, developing country firms must make deliberate, costly, and risky-cum-strategic investments in learning in order to assimilate acquired technologies (Fransman and King, *et al*. 1984). Choosing the right technologies requires firms to identify weaknesses in production and opportunities for improvement. Mastering them entails integrating newly acquired formal technical knowledge with previously accumulated capabilities and production routines, often through trial and error.

The claim that developing countries enjoy an inherent 'latecomer's advantage' in the availability of a global stock of easily-transferred technologies tends to overlook the risks and costs of technology acquisition, which stem from the imperfect tradability of the full range of relevant capabilities (Amsden 1992). Similarly, the popular notion of technological 'leapfrogging', by which developing country firms might skip entire vintages of technology and adopt state-of-the art techniques, overlooks the necessity of path-dependent learning, or the cumulative deepening of technological capabilities, to sustain productivity growth (Soete 1985, Hobday 1995). As Amsden (1991) argues, the opportunity to acquire and apply pre-existing technology is the distinguishing characteristic of late-industrialisation. However, technological acquisition and catch-up is far from automatic or costless, and firms, industries, and countries display tremendous variation in technological progress.

Evolutionary models thus inform the growing body of empirical work on technological change in developing country settings. This literature depicts technology development as an evolutionary process of accumulating specific capabilities to use and improve technology. Dahlman, *et al.* (1985) proposed a framework that distinguished technological capabilities related to operating *production* efficiently -- those required for *investment* to create new production capacity, and those to engage in *innovation* of products and processes.[10] Reflecting the path-dependent nature of innovation, developing country firms typically (though not always) accumulate these capabilities in sequence, gradually deepening in-house capacities from production management towards more innovative design and adaptive functions.[11] Technologically dynamic firms make conscious efforts to monitor their performance and assess their technological strengths and weaknesses, search for and evaluate external sources of technological support, and use external technology sources to complement and augment internal capabilities. As firms acquire deeper capabilities, they become better able to improve productivity over time and to enhance the value added in production (Bell and Pavitt 1993).[12]

Some authors broaden the firm-level model of capability accumulation to describe the technological development of whole industries and economies. Hobday (1995) placed the accumulation of technological capabilities at the heart of the modal corporate growth strategies that propelled industrial success in the four first-generation Asian NICs. As they deepened technological capabilities, NIC firms moved from simple sub-contract assembly roles to become original-equipment manufacturers (OEM), own-design manufacturers (ODM), and in some cases own-brand manufacturers (OBM) with full international marketing capabilities (Hobday 1995: 186-195). Linsu Kim (1980), drawing on Korea's experience, proposed a model of national technological development in which newly industrialising countries progress through stages analogous to those of individual firms: *implementation* of imported technologies in production; *assimilation* of technology through efforts to diffuse and adapt it; and *improvement* of technology using local scientific and engineering capabilities.[13]

The concept of evolutionary stages should imply neither spontaneous and automatic progress, nor strict linearity. Both the mix of technological capabilities and the sequence in which they are developed can differ significantly across industries and countries, as well as individual firms. As fundamental uncertainty would suggest, important trade-offs are endemic to the technology development process (Ernst and O'Connor 1989: 34-36). For example, a central strategic decision for developing country governments and firms is what balance to strike between pursuing deeper local design capabilities on the one hand, and keeping up with global technological change through licensing or purchasing the latest foreign technologies.[14] The strategic choices made in response to this and similar dilemmas generate divergent and path-dependent technological development trajectories (Simon [ed.] 1995b, Dosi 1982, Hobday 1995: 195-197). Notwithstanding these variations, however, the core features of evolutionary technology development define a general model with several critical implications for the role of national innovation systems in late industrialisation.

Implications of the Evolutionary Innovation Approach for Technology Policy

What are the implications of evolutionary theories for late industrialisers? The most fundamental one is that, due to uncertainty and imperfect tradability, market failures are likely to confront individual firms' investments in technological learning. The need for cumulative, production-based learning suggests that public investments in technology cannot themselves determine the course of industrial technology development. Market failures, however, create a strong rationale for nuanced policy or institutional support for firms' efforts to acquire and deepen technological capabilities. Non-government institutions, including sub-contracting networks, business associations, venture capital sources, and specialised commercial providers of technical services, may also help to overcome market failures in technological accumulation.

If such private institutions and linkages fail to emerge spontaneously, however, policy action may be warranted to promote them. Beyond static market failures, evolutionary innovation models indicate that dynamic learning economies are pervasive in late industrialisation, thereby providing a powerful rationale for selective infant-industry policies (Pack and Westphal 1986). Governments may justify protecting local industry and subsidising investments in technological learning because of the essential role of production experience in deepening technological capabilities.

Of course, the general criticism of industrial policy holds — protection from imports may provide time for infant industries to move up the learning curve, but simultaneously removes a powerful incentive for them to do so. Alternative sources of pressure for performance improvement are required, whether from domestic or export market competition or from the state's administrative 'discipline'. In this context, the political economy pitfalls of selective industrial policies — the difficulty in 'picking winners', the likelihood of rent-seeking — apply in equal or greater force to the subtle task of encouraging technical change in industry. The evolutionary approach further argues that production experience alone is inadequate without deliberate efforts to deepen capabilities; thus, any infant industry strategy must go beyond sheltering national industries to include specific investments in skills, infrastructure, and technological absorption.

While pointing to the need for policy or institutional remedies for market failures, evolutionary models also stress the critical importance of firms' own production-based efforts in technological learning. This implies that national technology policies must seek to bolster industry's internal technological investments and capabilities, as much or more than to provide sources of external technology support.[15] An emphasis on industry-centred measures reflects evolutionary models' scepticism about 'research-push' factors in innovation, but it does not follow that there is little need for assertive or strategic intervention.

Given the diffuse nature of the externalities involved in technology development, not to mention constraints such as traditional management attitudes, developing country firms are often unaware of the technological dimensions of and solutions to their competitive problems. Thus, the demand for technology support is often latent and vaguely defined. National innovation systems must therefore seek to stimulate technology *demand* as much as to *supply* the industrial sector with greater quantities of R&D, skills, information, etc.[16] Measures that prompt industry to identify technological weaknesses and opportunities might be as important to activating technology demand as subsidies to overcome the market-failure constraints. In this context, standards-setting and certification of skills, product technologies, and process/quality management systems can mobilise firms' awareness of and demand for technological development.[17]

For similar reasons, the scope of technology policy must expand from formal R&D to other capability-building investments, such as information gathering, quality improvement, skills development, production engineering, and mastery of imported technologies. Especially in earlier stages of industrialisation and in supporting smaller firms, policies should seek to stimulate technological effort in improving production and labour processes on the shop-floor, rather than in devising entirely new products or processes. Firms engaged in more basic levels of capability-building are unlikely to utilise external sources or incentives for formal R&D. However, they might well need information services, training support, and help with selecting, mastering, and optimising imported technology. Other important targets for policy should be the diffusion of improved production technologies and best-practice management techniques; provision of technological information and standards-writing; assistance with technology selection; providing specialised technical training; and consulting for technical problem-solving and trouble-shooting.[18]

Understanding innovation as driven by the interaction between 'knowledge push' and 'market demand' factors also puts the function of marketing in a new and more important light. Firms' incentives to invest in developing technological capabilities are heightened by the need to compete for demanding customers, be they downstream producers or final consumers.[19] Competing in export markets creates tremendous pressure to constantly upgrade quality, and this provides a major incentive for technological development. Beyond incentive pressures, the marketing function may provide new technological resources.

Firms' interactions with customers often convey vital information about which routes of technological change are likely to be profitable and what types of improved technologies are already available. Developing country firms are often at a major disadvantage because they operate at a remove from quality-sensitive markets and rely on foreign assemblers or trading companies for exports, and this may filter much of the 'extra' information out of export transactions. It is now understood that exporting and direct linkages with major Western retailers allowed East Asian NIC firms to capture important technological externalities. In short, whereas infant-industry arguments apply to protection of firms' production-based learning, they do not imply extended quasi-autarkic withdrawal from global markets.[20]

This analysis points to an important distinction between promoting local industrial *production* to develop technological capabilities and relying on *indigenous sources of innovation or technology*. A core lesson of comparative analyses of late-industrialisation in countries like Brazil, Korea, India, and others is that foreign or imported technology usually complements, rather than substitutes for, efforts to build local technological capabilities (Evans 1992; Lall 1987, 1992, 1993b; Dore 1984).[21] An important question, however, is whether the relationship between foreign and indigenous technologies changes as local industry accumulates capabilities. A general hypothesis is that developing countries will gradually substitute locally developed innovations for foreign technologies as industrial capabilities deepen.

One result of this transition is a shift in the primary *mode* of technology acquisition from fully internalised or 'packaged' forms, such as FDI, to more externalised or 'unbundled' modes, such as technology licensing or technology-specific strategic alliances. Evidence of such a shift can be drawn from Korea and Taiwan, who welcomed foreign investors while starting up export-oriented industries (e.g. electronics), but gradually restricted FDI in favour of expanded arm's-length licensing (Mardon 1990, Dahlman and Sananikone 1990).[22] Similar arguments for greater selectivity towards FDI in Malaysia have been frequently advanced (Abdullah 1995).

In contrast to this sequence, however, Malaysia has been at the forefront of a global trend to liberalise foreign investment and technology transfer regulations over the past decade. In part, the trend reflects a growing recognition that strict and non-selective regulation of technology acquisition *per se* cannot redress uneven bargaining power in international technology transactions, and often simply discourages the volume or quality of technology inflow.[23] Second, and more importantly, the core technologies necessary for international competitiveness have become increasingly proprietary as rapid innovation, compressed product cycles, and the diffusion of electronics-based processes and components have affected many industries, including segments of 'mature' industries such as textiles and foundries (Dahlman 1989, Ernst and O'Connor 1989).

Developing countries are frequently unable to use licensing or other 'un-packaged' modes in their efforts to catch-up technologically, and attracting FDI has virtually become a universally assumed prerequisite for technology acquisition in most high-growth industries. The question remains open as to whether this sea-change in FDI policies bodes well for long-run technological development in host economies. If foreign technology can no longer be 'unbundled' to provide local industry alternative means to acquire technology, MNCs would control the pace of technology development in FDI-reliant economies such as Malaysia. On the other hand, in the new era of global production networks, shaping local industrial structure to complement FDI might be the *sine qua non* of continued technology access, and thus, a way of opening new opportunities for positive-sum bargaining over technology transfer.[24]

Finally, while evolutionary models caution against a linear research-push approach to fostering technology development, they do not imply a rejection of 'supply-side' investments in national technological resources. The most important of these is the creation of technical human capital, though public investments and promotion of R&D may also be important in various specific ways, as both types of investments address serious market failures. Broad functional investments in human capital formation, including the provision of high quality basic education, strong vocational training programmes, and university training of scientists and engineers, are almost universally accepted as an appropriate government role.

As industrialisation moves beyond basic capability levels, however, industry's demand for technical skills become more specialised, and investments in human capital formation are likely to involve more discretionary judgements. Again, a variety of institutions can emerge to meet the medium-term demand for specialised technical skills, ranging from firms' in-house training units to private and public-sector training centres. Fostering the emergence of such institutes, and encouraging co-operative training relationships between industry, universities, and other sources of technical training are a critical counterpart to broad investments in education.

The need to locally accumulate pre-commercial or basic knowledge calls for similar types of specialised investments in scientific and technological research, often in university and public-sector research. While public sector R&D may rarely lead directly to original industrial innovations, it nonetheless can contribute to industrial technology development by building institutional and human reservoirs of relevant scientific and technological knowledge. The links between such intellectual capital resources and industrial development are often hard to measure, but the emergence of 'Silicon Valley' type agglomerations of technologically dynamic manufacturing industries around major universities illustrates the importance of knowledge externalities.

Given that many developing countries have invested scarce resources in public R&D with little effect on industrial growth, the need for selectivity and relevance to industrial needs are central issues.[25] Yet, scientific and other basic research is by nature exploratory and pre-commercial, its contribution to industrial development is indirect and anticipatory, and is realised over long time-frames through flows of human-embodied knowledge. Thus, ensuring the relevance of the public research agenda is often less a matter of enhancing the commercialisation of public R&D than of fostering diverse channels of information-sharing and personnel exchange between industry, academia, and government researchers. This might be accomplished by having public and university labs perform non-R&D services for industry, or by using industry consultations to guide public research funding decisions.[26]

The Evolution of Technology Policy in Malaysia

Industrial technology development has been a central national development goal for over two decades. Malaysia's technology policy has evolved rapidly, however, in response to changing economic and political circumstances. Three phases in the evolution of technology policy making are evident: from independence to the early 1980s, from the mid-1980s to the early 1990s, and from 1992-93 to the present.

Historically, Malaysia's science and technology infrastructure reflected its economic structure, dominated as it was by rubber exports. The British colonial inheritance included world-class research institutions in rubber cultivation and processing, which the post-Independence government extended in maintaining the country's global pre-eminence in rubber. As older rubber plantations became less productive in the late 1960s, Malaysia embarked upon the commercial cultivation of oil palm for export. New education and research facilities contributed to rapid increase in agricultural yields, processing efficiency, and product development. Support for small-holder agriculture, in which the politically-dominant Malay population was concentrated, was a high policy priority during the early independence decades, and the Malaysian Agricultural Research and Development Institute (MARDI) institute played important research and technical assistance roles. Local universities also conducted research and training useful to agricultural and other resource-based industries.

Within the framework of industrial policy, technological development was accorded a relatively low priority. The manufacturing sector's chief mode of acquiring technology was through joint ventures and direct foreign investment by multinational corporations (MNCs), first in the import-substituting sector and during the 1970s in export-processing operations within subsidised Free Trade Zones (FTZs). One of the chief criticisms of the early import-substitution industrialisation (ISI) programme was that the government’s investment incentives and tariff protection for domestic industry created an unintended bias towards capital-intensive production techniques, resulting in low employment generation (Jomo and Edwards 1993: 24). A shift in strategy to more labour-intensive export-oriented industrialisation was codified in the 1968 Investment Incentives Act, the 1971 Free Trade Zones Act, and related labour law reforms, which sought to attract export-oriented foreign investment. The government’s desire to accelerate employment creation was sharpened by the election debacle and subsequent ethnic riots of 1969, and under the ensuing New Economic Policy (NEP), social restructuring through employment generation became a paramount motivation for manufacturing sector development.

The revamped incentives and facilities complemented foreign MNCs’ interests in locating their labour-intensive assembly operations in off-shore locations for re-export to home or third countries. While investment projects promoted or registered under the 1968 Investment Incentives Act and the 1975 Industrial Coordination Act (ICA) were required to register technology transfer agreements with a Technology Transfer Unit in the Ministry of Trade and Industry, in practice, the regulations were quite passive, concerned more with policing restrictive contract terms than with screening and measuring the technological content of promoted projects (Anuwar 1992: 89). Studies of the electronics industry development during 1970s and early 1980s indicate extremely limited technological development within MNCs’ Malaysian operations, and noted few spill-overs to the local economy.

The national-level S&T policy machinery established in the 1970s served primarily to nurture R&D capabilities in the public sector and universities. The National Council for Scientific Research and Development (MPKSN) was established in 1975 to provide policy advice and to co-ordinate allocation of public S&T resources. The creation of the Ministry of Science, Technology, and Environment (MOSTE) followed in 1976. In their first decade of operation, these agencies had a low profile within the bureaucracy. MOSTE, as a minor ministry with a limited budget, lacked the political and financial resources to influence the broader range of trade and industry policies affecting the country’s technological development.

Moreover, the leading research institutes remained under the control of other line-ministries, with the Ministry of Trade and Industry having purview over industrial sector policies and the then newly formed Standards and Industrial Research Institute (SIRIM). The National Science Council, though inter-ministerial in composition and chaired by the Chief Secretary to the Government, was also unable to impose a co-ordinated agenda on the various ministries, and concerned itself primarily with supporting basic research activities in the university and public sectors. Private sector interest and input into the Council's decision-making was negligible.

Mahathir's appointment as Prime Minister in 1981 heralded decisive shifts in economic policy that resulted in a greater emphasis on technology development. Initially taking the form of a second-round of import-substitution through state investments in heavy industries, his new industrial programme attempted to reconcile ethnic redistribution goals of the New Economic Policy (NEP) with a much more concerted effort to deepen the industrial structure and accelerate technological development (Bowie 1988).

In early 1986, the government issued the Industrial Master Plan, 1986-1995 (IMP) as an indicative guide to a programme of sectoral interventions. The IMP included a separate volume on technology development issues that identified a weak indigenous technological base as a major threat to future growth. The report recommended aggressive strategic investment and regulation to build up local capabilities, noting that "Although a beginning has been made in the establishment of some modern industries like electronics, this has not been accompanied by corresponding build up of technological competence…. This is partly for the reason that these industries are largely foreign owned, partly or wholly [*sic*], and depend almost exclusively on external sources for technology" (MIDA/UNIDO 1986 III 6: 5).

From the mid-1980s, the structure and content of S&T policy-making was transformed in an attempt to mobilise technology development through central co-ordination and strategic targeting to support the ambitious industrialisation programme. In line with the heightened priority accorded S&T policy, a Science Advisor was appointed to the Prime Minister's office in 1984 as a locus of policy co-ordination and a source of new initiatives from above the ministerial bureaucracies. Under his supervision, a national science and technology policy document was issued in 1985, followed by a separate S&T chapter in the Fifth Malaysia Plan (1986-1990) and subsequent plans.

Among several significant policy measures launched in the late 1980s was the extension of tax incentives for research and development (R&D), the creation of new technology institutions for specific industrial sectors, the establishment of centralised policy planning and funding, and intensified consultations with industry representatives. The Science Advisor was also instrumental in creating the Intensification of Research in Priority Areas (IRPA) programme in 1986, which gathered all public R&D funding under a single allocation and review process. The IRPA programme sought to provide a strategic policy instrument with which to harness public research investments to industrial development goals. Central planners hoped to use the IRPA allocation process to rapidly boost the overall national R&D investment, set strategic technology priorities, and alter the incentives facing public institutions to encourage greater interaction with the industrial sector.

The emergence of a distinct technology policy framework culminated in the 1990 Action Plan for Industrial Technology Development (APITD), a document which built upon the 1986 IMP and became the primary reference for further policy action. The Action Plan diagnosed five basic structural weaknesses in Malaysian technology development, among them inadequate institutional infrastructure and low private sector investments in technology, and offered forty-two recommendations to create a comprehensive and integrated national innovation system.

Following its release, the existing S&T policy architecture was revamped. The major industrial technology institutes were transferred to the Ministry of Science, Technology, and Environment (MOSTE) in an effort to elevate its co-ordinating role. The National Science Council was reformed to include more private-sector representatives and charged with exercising closer oversight of IRPA-funded projects. New peak-level policy making bodies were created outside the formal bureaucratic structure to more closely link government officials and private business leaders. These include a technology committee of the Malaysian Business Council and a special consultative body called the Malaysian Industry-Government Group for High-Technology (MIGHT). Finally, the Cabinet formed a new Committee on Science and Technology, chaired by the Prime Minister, to authorise new technology legislation and programmes.

The reforms of the late 1980s and early 1990s produced enormous growth in public planning and investments in S&T. Budget allocations rose from RM540.5 million (approximately US$216 million) under the Fifth Malaysia Plan 1986-90 to RM1,160 million in the Sixth Plan 1991-95, with the share of capital investments in S&T infrastructure (as opposed to current expenditure on R&D) rising from 23 per cent to 48 per cent of the total. These expenditures mainly fuelled a rapid expansion of research capacities in public technology institutes.

At the same time, the Science Advisor and the National Science Council sought to implement strategic targeting of technology development, in line with the Action Plan's identification of five critical areas — automated manufacturing technology, advanced materials, biotechnology, electronics, and information technology (later joined by other designated fields, including energy, environmental, and aerospace technology). The Council established technical working groups with public and private representatives to develop policy recommendations in each target area. The policy makers simultaneously sought to use the IRPA R&D funding allocation process to engineer reforms within the country's system of public research institutions (PRIs). The National Science Council instructed each PRI to screen and justify research proposals in terms of their relevance to development needs, and declared a preference for projects identifying a specific industrial or commercial clientele.

This vigorous drive to build the national innovation system soon encountered a basic paradox. The principle aim of reform was to integrate S&T and industrial policy to create a Japanese-style, 'demand-driven' technology infrastructure focused on applied research and guided by specific sectoral needs, this in contrast to an 'American-style' science-push system emphasising basic R&D and driven by academic curiosity or bureaucratic priorities. Yet ,to implement systemic reform, technology policy became increasingly centralised and top-down in nature.[27] The incongruity stemmed from the basic trends shaping economic policy making more broadly, as the Mahathir administration concentrated authority under the chief executive and sought to trim the bureaucracy's direct involvement in the economy, to address poor public-sector management (which it blamed for the failure of the heavy-industries programme), rent-seeking and waste, and to discipline the public sector to serve private foreign and local investors. In the realm of S&T policy, this meant using centralised funding and oversight to guide public universities and research institutions towards industrially relevant work and to target strategic technologies to support industrial development goals.

The 1990 Action Plan stressed the need for new measures to stimulate technology demand within the private sector as well as the reform of public R&D and human resource systems. However, consistent with the political priority on public-sector reform, the overwhelming focus of technology policy initiatives was on the supply side, and new technology programmes or subsidies for the private sector were minimal. Though hampered by ongoing administrative difficulties and a lack of technically qualified bureaucratic personnel, supply-side reforms eventually did make significant progress in changing the ethos and operation of the public R&D infrastructure. Yet, the policy machinery as a whole remained poorly equipped to evaluate, at a detailed sectoral level, the actual capabilities and external assistance needs of the private sector, much less to encourage the pace or direction of private sector technology development.

At the same time, the sweeping economic liberalisation implemented in the wake of the mid-1980s recession altered the character of Malaysia's industrial policies in ways that were increasingly at odds with an ambitious, centrally co-ordinated technology development strategy. Among several other measures, the government eased restrictions on foreign investment to permit 100 per cent foreign equity ownership in a broader range of export-oriented industries and extended new duty and tax privileges to attract what soon become a flood of foreign direct investment (FDI) from Japan, Taiwan, and South Korea. The embrace of MNC-led industrialisation paid swift dividends in the form of accelerated growth, but the foreign-dominated export industries had little need or interest in accessing the public sector's R&D institutions, no matter how demand-oriented they might be. While the Industrial Master Plan's sectoral growth targets were more than fulfilled, qualitative issues involving inter-industry linkages, productivity growth, and indigenous technological development remained problematic, but were a lower priority, at least temporarily.

At the start of the 1990s, however, the government became aware that the foreign-owned manufacturing sector was more technologically dynamic than had previously been believed. The electronic components sub-sector, concentrated in Penang and Kuala Lumpur, responded to intensified global competition in the late 1980s with rapid automation and process technology upgrading. Genuine technological learning within Malaysian-based subsidiaries — notably the accumulation of process engineering capacities and technical and workforce skills – both encouraged and enabled such progress (Lim & Pang 1991). Some reports suggested that MNCs' Malaysian subsidiaries had begun to approach the global frontier in several aspects of manufacturing process technology. Congruent with intra-firm upgrading, some studies identified rapidly growing linkages between electronics MNCs and local vendors of components and more technologically sophisticated machine tools (Rasiah 1994: 285-291).

Meanwhile, an influx of new Japanese and East Asian consumer electronics producers brought about a long hoped-for diversification of the electronics sector, partly mitigating the manufacturing sector's narrow reliance on semiconductor assembly and export. In addition to diversification, the IMP had targeted consumer electronics with the rationale that the sub-sector offered much greater potential than semiconductors for the growth of technologically dynamic linkages with local suppliers of parts and components. The appreciation of the yen and other East Asian currencies gave Japanese and Taiwanese investors an added incentive to increase local content swiftly. In sum, a conjuncture of forces in the late 1980s made MNCs relatively more disposed to technological development and linkage formation within the Malaysian economy.

In response to this perceived opportunity, as well as to the initial disappointments of supply-side technology reform, a new emphasis began to characterise industrial and technology policies after 1993, which has since become the dominant theme in policy reforms. The new approach seems to take its cue from the growing literature on the relationship between industrial structure and international competitiveness, in particular a focus on sub-contracting networks (Wong 1991) and broader 'industrial clusters' (Porter 1990). In contrast to the attempt to guide technological change through strategic supply-side investments, new policy initiatives focus on creating appropriate intra- and inter-firm networks to capture technological externalities emanating from the demands of MNCs as customers for components and inputs. Stable networks and close interaction between technology users (in Malaysia, MNC or other foreign buyers) and producers (local sub-contractors) are central to the development of competitive industrial clusters, as recent work on subcontracting networks in Japan and the East Asian NICs highlights. More broadly, Malaysia's new industrial policy strategy echoes similar successful attempts by Singapore to capitalise on MNCs' globalisation strategies by inducing foreign companies to upgrade their locally-based subsidiaries to undertake higher-technology and more locally-integrated production.

In an explicit effort to emulate Japanese *keiretsu* structures, the government has launched formal vendor development programmes to address the problem of weak industry linkages by encouraging large foreign and local assembly firms to assist designated local suppliers. First, officials have made vendor development a point of negotiation with established and new foreign investors, while also enlisting state-linked corporations and selected domestic private manufacturers in the effort. At the same time, the government has given its programmes to assist small and medium-scale industries (SMIs) more prominence. During the NEP era, SMI assistance programmes proliferated as a means to assist new *Bumiputera* (mainly ethnic Malay) entrepreneurs to establish small start-up businesses, though these programmes all too often devolved into patronage and mismanagement. Recent reforms have augmented SMI-assistance programmes' social ethnic promotional mission with an emphasis on upgrading existing enterprises' basic technological capabilities and on encouraging improved quality control and management practices. SIRIM, for example, has aggressively promoted the diffusion of the international ISO 9000 quality control system certification system. The new vendor development initiatives have encountered initial difficulties, but it is still too early to evaluate their actual impact.

In the meantime, foreign companies have significantly increased local procurement and sourcing, and new geographic and sectoral clustering appears to be taking place, as in Penang, where many disk-drive producers and their suppliers have relocated from Singapore. Most of this activity has involved linkages between MNC assemblers and other foreign supplier firms who have followed them to their Malaysian production sites. A small but growing number of local firms have also begun to serve as sub-contract assemblers to the major electronics MNCs. Several MNCs have also established formal R&D centres in their Malaysian complexes for their own reasons (e.g. cosmetic production modifications or other design functions), but also in line with government exhortations. Finally, both the federal and some state governments have sought to provide new high-technology infrastructure for local and foreign companies in the form of several technology parks.

Reform of the public technology infrastructure has continued in the 1990s, particularly in the areas of the legal status and management practices of research institutions (RIs). Again, reforms have reflected broader political trends shaping the state's role in the economy. In the past decade, an increasing number of governance institutions and functions have been 'de-bureaucratised' — i.e. removed from the formal civil service structure through a process of corporatisation and privatisation, while policy initiative and co-ordination has been lodged in policy networks directly linking political and business elites (Leigh 1992). The government established the Malaysian Technology Development Corporation (MTDC) as a joint public-private technology venture capital company in 1992 to facilitate the commercialisation of public research findings. The peak-level public-private MIGHT forum, mentioned above, is another example of the state elite's effort to mobilise private sector technology investments through direct, extra-bureaucratic policy networks. MIGHT organises sector- and technology-specific interest groups to study technology trends and identify business opportunities.

Meanwhile, the system of public research institutions has been moved towards a contract research system, and individual institutes have been prepared for corporatisation as independent government-held companies. Universities have similarly been pressured to develop industry linkages through designated contract research and consultancy units. In the industrial policy realm, the government has also sought to achieve technology development goals through quasi-private instruments. The leading privatised utilities and government-related companies have been directed to participate in vendor-development programmes and to establish their own technical training institutes. A successful industry-run skills training centre in Penang has been adopted as a model for replication in other states, and new technical training institutes have been set up on a bilateral basis with German, Japanese, and French government agencies.

The focus on industrial clustering as a path to technological upgrading was fully articulated in 1996 in the *Seventh Malaysia Plan, 1996-2000* and the *Second Industrial Master Plan, 1996-2005* as the key principle guiding industrial policy. The strategy envisions a more selective industrial policy driven by private-sector patterns of specialisation rather than state plans. At the same time, state officials appear committed to continued intervention in the economy to achieve several objectives, including promoting *Bumiputera* enterprise and other favoured corporate interests, and revamping the educational and training system to meet the requirements of a rapidly evolving industrial structure. In sum, though industrial and technology policies have gradually shifted from expansive aspirations to strategically direct structural change to a model more focused on private-sector dynamics and institutions, the Malaysian state retains its activist stance in fostering technological upgrading. It continues to emphasise strategic intervention, if increasingly in a supportive and facilitating role.

In 1996, Malaysian Prime Minister Mahathir announced his latest and most ambitious industrial technology policy initiative thus far — the establishment of a Multimedia Super Corridor (MSC). The MSC has been defined to be a special development zone located in a swathe of land fifteen by fifty kilometres south of the federal capital of Kuala Lumpur. The area will include the new federal administrative centre at Putrajaya, the new Kuala Lumpur International Airport (KLIA) at Sepang and a new 'hi-tech' city called Cyberjaya. The MSC initiative seeks to attract investments in multimedia software development, primarily from the leading transnational companies that currently dominate the industry. To win MSC status, IT companies must indicate plans to undertake new development activities. In turn, the Malaysian Government has promised to generously invest, to the tune of more than a billion ringgit annually, in the physical infrastructure as well as other support desired by IT companies. Other special incentives for MSC investors include generous tax breaks and exemptions from various laws such as those restricting the number of foreign personnel a company can hire to no more than five. In addition, the government plans to spur new development activities by offering lucrative procurement contracts for seven "flagship" IT applications, including telemedicine, smart schools, electronic government operations, smart cards, international manufacturing co-ordination, electronic marketing, and R&D.

Since launching the project, the Malaysian government has gone out of its way to impress potential investors with its commitment to creating the physical and legal conditions they desire. For example, to the surprise of many, Malaysia apparently reversed its previous opposition to the US-sponsored Information Technology Agreement (ITA) under the auspices of the World Trade Organisation, presumably to reassure the mainly US-based companies it hopes to attract to the MSC. Similarly, in 1997, the government promulgated new laws elaborating IT-related intellectual property rights, and has begun to enforce existing intellectual property rights laws with a newfound zeal.

Although the envisaged government investments in the MSC should have a crowding in rather than crowding out effect, many concerns have been raised with regard to the scheme. An open question is whether any government can adequately plan for future developments in this extremely fluid and unpredictable industry. Without tremendously detailed information at its disposal, along with the ability to quickly shift planning and policies in light of rapidly changing market trends, the relevant authorities will find it impossible to target public investments to effectively play a supportive role, let alone a leading one. For the same reasons, it will be extremely difficult to monitor the activities of firms receiving MSC incentives and contracts to ensure the growth of genuine innovation activity and skills transfer.

Without such careful analysis, however, there is a real danger that heavy public investments in IT will result in little more than public subsidies of multinational and favoured local businesses, while distracting or deterring the growth of non-MSC firms who might discover unanticipated high-growth niches. While the government has made progress in reforming public technology institutions and policies, it is precisely the sparseness of such capacity for continuous, detailed, sector-specific assessment of market and industry trends that are the greatest constraint on effective policy implementation. Ultimately, of course, the MSC initiative will have to be judged on its own merits, more specifically by whether the net benefits outweigh its costs — taking externalities into consideration as well — when evaluated from a long-term dynamic perspective.

Closing Remarks

Malaysia's transition to technology-based industrialisation remains in flux, and diverging interpretations of its nature and prospects are inevitable. The evolution of Malaysia's technology policies demonstrates an ability to adjust policy-making (at least its principles and goals, if not fully its implementation and practice) in response to new economic circumstances and conceptual understandings of the sources of technological development and industrial competitiveness. What is less clear is whether the efforts to elaborate and reform technology policies and institutions, and thus build a national innovation system have had significant impact on the course of industrialisation thus far, and whether they are likely to do so in the future. Those sceptical of statist political economy claims are likely to view the technology policy framework as having been largely inconsequential, and like most nations, Malaysia offers much evidence of policy failure or ineffectiveness. On the other hand, measuring the effects of state interventions against their own ambitious strategic goals may obscure the importance of infrastructure, indirect, or even unintended policy impacts. Adaptive and supportive policies (e.g. physical infrastructure, investment incentives) are likely, at the very least, to have facilitated the technical upgrading observed within industry thus far. Whether conceived as leading or following market-driven changes, the need for supporting policies and institutions presumably will grow as technology levels rise in the economy.

The studies in Jomo and Felker (1999) revealed the complexity and dynamics of the industrial technology development policy process associated with Malaysia's rapid industrialisation. Weighing both structural features and emerging trends, the studies differed in their assessment of the strength and effectiveness of Malaysia's national innovation system. In considering the state's deliberate attempts to construct an integrated institutional system, they revealed problems of design and implementation, though few of the authors maintained that appropriate technology policies are irrelevant and unimportant to the success of technological upgrading. Indeed, most asserted the need for a more focused, supportive and effective public role.

In problematising the institutional and strategic dimensions of industrial technology development, all the studies sought to move beyond facile understandings of technology development as a simple function of market-driven processes. It should be noted that, whereas technological change is central to long-run economic growth, the relationship between the two is complex and indirect. The 1990s' debate about the contribution of productivity growth to East Asian economic success underscores this point (Krugman 1995). If current trends indeed represent a successful transition to self-sustaining, technologically progressive industrialisation, it will likely be exclusively reflective of state leadership, or the 'natural' maturation of local firms, or even benign MNC-led globalisation. Rather, it would be an expression of the creation of new types of industrial governance appropriate to an era of globally integrated production — a particular intersection of strategies and governance roles played by the state, domestic businesses, MNC subsidiaries, and MNC parent companies. For example, Singapore's successful MNC-led model involved a high degree of strategic intervention through a range of non-trade policy instruments, combined with specific changes in MNCs' strategies and network structures.

Further, the positive examples of technological development within Malaysian industry (Jomo, Felker and Rasiah [eds] 1999) remain much smaller in scale than earlier patterns in the first-generation NICs, the only developing countries to succeed in ascending into the ranks of industrialised economies during the post-war era. From this standpoint, the effort to build a national innovation system remains a critical task, notwithstanding the constraints on state policies posed by globalisation. Malaysia has been exceptionally fortunate in enjoying the beneficial influences, such as technology diffusion, which the international economy has afforded during the last decade. The policy and institutional framework has been notably successful in the permissive sense of attracting and not discouraging foreign investment and technology. Yet, with international competition, those firms, industries, and national economies that do not move ahead may indeed fall behind. The still urgent mission of Malaysia's national innovation system is to convert the economy's global fortunes into a strengthened local impetus for industrial progress and technological change.

Notes

1. The share of manufacturing in GDP has risen to 30 per cent in 1995, while the primary sector has declined to 24 per cent.
2. Figures are from the World Bank's *World Development Report 1997*, Table 11, p. 234 and Table 15, p. 242, except for the 1995 manufactures share in exports, which is taken from MITI (1995/96: 38). Export growth figure is for export volume rather than value.
4. Indeed, the East Asian success stories (particularly Japan, South Korea, less so Taiwan) featured a progressive expansion of the role of local industry over foreign capital in spearheading industrialisation, even in high-technology industries. The two city-states of Hong Kong and Singapore provide counter-examples, whose relevance to the Malaysian case should be an important point of debate. In the case of Hong Kong, local industrialists (including leading figures from Shanghai's textiles industry fleeing the revolutionary PRC) were well-established prior to the take-off of foreign direct investment. Local industry subsequently played a major role in industrialisation despite the absence of FDI controls. In Singapore, by contrast, development policies have explicitly sought to maximise foreign investment in manufacturing, and MNCs remain dominant in most industrial branches. While Singapore might arguably provide a positive argument for the viability of Malaysia's FDI-led development strategy, one of the stated goals of Malaysian industrial and technology policies is to mitigate the risks of FDI-reliance by strengthening capabilities within local industry.
5. A highly controversial issue is the linkage between authoritarianism and effective industrial policy making. Haggard (1990) and others have argued that authoritarian regimes are neither necessary nor sufficient for effective intervention, but that there is an 'elective affinity' between certain authoritarian corporatist political structures and developmentally rational economic policies (Wade 1990: 24-29). Many authoritarian regimes are actually penetrated by powerful political constituencies, and are therefore incapable of 'disciplining' rent-seeking coalitions or shielding economic policy from distributional demands. However, pluralist democratic are, by design, subject to the pull of competing social claims, and so find it difficult both to extract and transfer surplus to capitalist elites and to hold subsidy recipients accountable to performance goals. Malaysian politics are formally democratic, though the political hegemony of the ruling coalition suggests the system is at most 'quasi-democratic' (Case 1993). Leong (1991) argues that Malaysia represents a case of a democratic regime successfully insulating economic policy making from distributional pressures. Bowie (1994) identifies an inter-penetration of business and political elites associated with a rising authoritarian trend.
6. Detailed innovation studies show that information generated in the use of technology, whether in production (process technologies) or final marketing and consumption (of products), is frequently decisive in stimulating technological change. Histories of specific technologies reveal a similar macro-level pattern, wherein technological innovation, or discovery of a certain technology's functional properties, has often preceded scientific understanding of its causes and stimulated basic research to uncover them. In this way, technological changes in industry have often driven scientific research agendas (Rosenberg 1982). Freeman (1987) and others have shown, nonetheless, that science has become progressively more critical to innovation in a number of industries over the twentieth-century, a trend evidenced in the growth of industrial R&D facilities and the linkages between industry and universities. At the same time, changing production and market conditions, such as consumer preferences or factor costs, alone do not provide information fully sufficient to determine a unique optimal path of technological change (Mowery & Rosenberg 1989). Explanations of technical and institutional change as optimising responses to changing market conditions, or 'market-pull' models, are found in Schmookler (1966), Binswanger and Ruttan [eds] (1978), *passim*.
7. Lundvall (1992: 47) goes even farther to claim that, "Not only does innovation imply

uncertainty and thus bounded and differentiated rationality… it points towards a break with a [*sic*] instrumental and strategic rationality."

8. Technology, in its codified form, has public-goods characteristics that make it significantly non-proprietary, subject to diffusion, and dependent upon intellectual property rights or other institutional means to control its appropriation. However, the tacit elements of technology, acquired through accumulated experience and embedded in the organisational routines of individuals, firms, and institutions, make technology imperfectly tradable.
9. Assimilating technology usually entails adjusting or improving products or processes to better fit the conditions particular to a firm or country, and so involves learning-by-using, often in pilot production, prototyping, or reverse engineering products. However, it may also involve formal R&D designed to develop a deeper understanding of a technology's properties. Indeed, perhaps the greater part of industrial R&D is undertaken by firms in order to gain a deeper understanding of externally acquired technologies, rather than generating new breakthroughs (Cohen & Levinthal 1990).
10. Production capabilities include: production management, production engineering, control systems for raw materials, production scheduling, quality-control, and trouble-shooting, repair and maintenance, and basic marketing. Investment capabilities include: search and selection of technology, project management, project engineering, procurement and contracts, skills training and acquisition. Innovation capabilities range from minor adaptations to major transformations of production tools, processes, or final products.
11. Lall (1992) proposes a slightly more complex matrix framework of capabilities, in which three macro-categories of technological capability (investment, production, and linkage-management) may be developed to varying depth (basic: routine and experience-based, intermediate: adaptive and duplicative, or search-based, and advanced: innovative, risky, and research-based). Many other typologies of technological capabilities have emerged with particular variations on the ones proposed by Dahlman, Westphal, *et al*.
12. It is important to note that seeking the fastest route to self-reliance in deeper capabilities is not necessarily an optimal strategy, particularly if rapidly evolving product cycles threaten existing technologies with obsolescence. For example, deepening from production to innovative capabilities in electro-mechanical machine tools might provide a less sound basis for long-run growth than moving horizontally to manufacture computer-numerically controlled (CNC) machines under license, even at the cost of delaying the development of in-house design capabilities. *Ceteris paribus*, however, capability deepening better equips firms to adapt to changing technology and market conditions.
13. While firm-level investments are the primary mechanism of progress, he argues, government policies are essential in stimulating and supporting the transition to more advanced stages. Public investments in technology creation anticipate the development of industrial capabilities, such that the balance of initiative, for example as measured in R&D expenditures, gradually shifts from the public to the private sectors as development proceeds.
14. Another important strategic trade-off faced by rapidly developing economies lies between promoting large-scale industry to capture scale economies in production and innovation, and encouraging small- and medium-scale enterprise to preserve domestic competition and achieve greater flexibility (Mody 1989).
15. To elaborate, technology policy must encourage and make use of any institutions that can access and integrate information on production-driven capabilities and needs with an awareness of available technological solutions. Quite often, this means enhancing firms' incentives and capabilities to invest in technological accumulation by providing direct subsidies. Another important possibility is to promote the technology-related

activities of business and non-governmental organisations, such as sub-contracting networks, formal industry associations, etc. whenever they prove effective in bringing together detailed production-based technology demands with 'supply-side' information on various technologies and expertise.

16. Reform efforts in Malaysia and elsewhere have thus far concentrated on making the public institutions that create these assets more responsive to the needs of industry. As mentioned above, however, firms are quite often unclear or even complacent about their need to invest in technological improvement. Even when motivated, firms are frequently financially constrained, and so do not manifest effective demand for external technology support programmes and services.

17. Programmes like the ISO9000 that certify quality control systems can be important tools for prompting industry to undertake greater self-assessment of production capabilities, identify needs, and seek resources for improvement. By linking firms' immediate desire for credibility in the market to quality-improvement protocols, this programme both activates demand for technical improvement and points firms towards resources to achieve it.

18. A general difficulty in subsidising non-R&D investments is measuring their impact and the actual progress towards improved capabilities. Whereas formal R&D projects are somewhat easier to identify and monitor, many other production-related improvements are fairly routine, making promotional programmes subject to waste or abuse. Nonetheless, difficulties in measurement do not diminish their importance, and efforts to improve the administration of policies focusing on training, quality improvement, etc. are likely to yield a high pay-off.

19. Porter (1990) emphasises the role of quality-sensitive home markets and intense domestic market competition in fostering globally competitive industries.

20. A contradiction is apparent, since infant-industry promotion usually involves restricting foreign investment, and allowing local firms to undertake technological learning while producing for a protected domestic market. While infant industries are in the initial learning stages, therefore, they must have alternative means of keeping up with international market and technology trends. Meanwhile, opportunities for exports should be pursued at the earliest possible point in an industry's development. It this mix of selective import-protection for targeted industries and export-promotion which characterises accounts of successful infant-industry policies in Korea and Taiwan (Pack & Westphal 1986, Wade 1993).

21. As Lall (1993b: 102) observes, the relationship between technology import and indigenous capabilities is more complex than the substitute/complement dichotomy allows. In the absence of indigenous efforts to learn, a passive reliance on imported technology can become habitual and lead to production inefficiencies and recurrent direct costs. Such concerns are often voiced in Malaysia, where payments on technology licenses are a significant component of structural deficits in the invisibles account of the balance of payments.

22. One important application of this analysis is the question of whether and when to promote a local capital goods industry. The machinery sector plays a central role in industrial technology development by embodying process technology innovation in equipment and diffusing it through sales to a range of industries (Fransman 1986). Imported capital goods are a vital source of improved manufacturing technology, but the absence of a local machine tool industry frustrates the type of user-producer interaction which drives process innovation in various engineering industries (Lundvall 1988). Promotion of local capital goods production might thus be desirable, but also risks damaging the competitiveness of downstream exporters if the technological learning process in machinery is prolonged and quality lags behind internationally available equipment. The importance of supporting industries more generally has been heightened by the rise of flexible production systems and increased out-sourcing in

many industries. The technical competence of a country's base of ancillary industries and components suppliers is vital to attracting high-quality manufacturing FDI and capturing the potential technological spill-overs it offers. In turn, participation in multinational corporations' supplier networks helps local industry acquire new technological capabilities. As noted above, however, technologically self-reinforcing linkages may not form spontaneously, and independent efforts to boost suppliers firms' technical capabilities and to induce linkage relationships are likely to be critical (Meyanathan [ed.] 1994).

23. As Lall (1993: 92) observes, "many developing country governments have intervened extensively in the import of technology in order to lower its costs and improve the capabilities of local enterprises. The results have, however, generally been counterproductive. Rigid and cumbersome regulations on the content and terms of technology transfer have tended to reduce the quantity and quality of inflows, to the detriment of the buying country. The growth of local TCs [technological capabilities] has been hampered rather than helped by over-enthusiastic regulations. The desire to legislate and regulate have often ignored market realities, which reflected the costs and risks of innovation and the costs implicit in transferring technology to enterprises that lacked many of the capabilities needed to absorb it."

24. Singapore's FDI-based industrial strategy might well be the critical test-case for this argument. The Singaporean government has enjoyed considerable success in fostering a transition to high-technology industry by making targeted investments in its workforce skills and supplier base to provide MNCs with vital complementary assets to engineering-intensive production and design activities. Malaysia has implemented similar policies vis-à-vis foreign investors. The number of MNCs establishing formal design units has increased significantly, but the ultimate impact on local technological capabilities is an important question for study.

25. Creating excellent graduate research and education programmes is expensive, moreover public basic R&D often fails to contribute significantly to industrial development. The late emergence of basic research capacities and graduate degree programmes in science and engineering in Japan, South Korea, and other countries illustrates that technology development may progress for long periods without them. Yet, ready access to advanced scientific and technological knowledge does become increasingly important as local industry approaches deeper levels of technological capability, and creating high-quality research institutions requires significant lead time.

26. At the same time, over-specific efforts to guide research towards industry applications may interfere with the primary scientific and educational missions of universities and other research institutions. The high costs of basic research capabilities derive in part from the essential role of creative freedom in maintaining standards of excellence.

27. Interestingly, this contradiction echoed that seen in the similar efforts of the Latin American newly-industrialising countries (NICs) in the 1970s to construct technology support systems. See Bastos & Cooper (1995: 16-18) and other essays in Bastos & Cooper [eds] (1995).

References

Abdullah Mohamed Tahir. (1995). "Industrial policy and industrial development: Issues and policy directions". *Managing Industrial Transition in Malaysia.* Victor Kanapathy [ed.] Kuala Lumpur: ISIS.

Amsden, A.H. (1989). *Asia's Next Giant: South Korea and Late Industrialization*. New York: Oxford University Press.

Amsden, A.H. (1991). "The Diffusion of Development: The Late Industrializing Model and Greater East Asia". *American Economic Review*, May.

Amsden, A.H. (1992). "A Theory of Government Intervention in Late Industrialization". In *State and the Market in Development: Synergy or Rivalry?* [eds] L. Putterman and D. Rueschemeyer. Boulder, CO: Lynne Rienner.

Anuwar Ali (1992). *Malaysia's Industrialization: The Quest for Technology*. Singapore: Oxford University Press.

Ariff, Mohamed. (1991). *The Malaysian Economy: Pacific Connections*. Singapore: Oxford University Press.

Arrow, Kenneth. (1962). "The Implications of Learning by Doing". *Review of Economic Studies*, 29, June.

Bastos, M.I., and Charles Cooper (1995). "A Political Approach to Science and Technology Policy in Latin America". In *Politics of Technology in Latin America* [eds] M.I. Bastos, and Charles Cooper, London: Routledge: 1-27.

Bell, Martin, and K. Pavitt (1993). "Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries". *Industrial and Corporate Change* 2(2).

Binswanger, H. and V. W. Ruttan [eds] *Induced Innovation*. Baltimore: Johns Hopkins University Press, 1978.

Bowie, Alisdair. (1994). "Dynamics of Business-Government Relations in Industrializing Malaysia". In *Business-Government Relations in Industrializing East Asia* [ed.] A. MacIntyre. Sydney: Allen and Unwin.

Case, William. (1993). "Semi-Democracy in Malaysia: Withstanding the Pressures for Regime Change". *Pacific Affairs*, Vol. 66, No. 2. Pp. 183-205.

Cohen, W. and D. Levinthal. (1990). "Innovation and Learning: The Two Faces of R&D". *Economic Journal*. No. 99. September.

Crouch, Harold. (1984). *Domestic Political Structures and Regional Economic Cooperation*. Singapore: Institute of Southeast Asian Studies (ISEAS).

Dahlman, C.J. (1989). *Impact of Technological Change on Industrial Prospects for the LDCs*. Washington, D.C.: World Bank.

Dahlman, C.J. (1994). "Technology Strategy in East Asian Developing Economies". *Journal of Asian Economies* 5(4): 541-72.

Dahlman, C.J., Bruce Ross-Larson, and L.E. Westphal (1985). *Managing Technological Development: Lessons From the Newly Industrializing Countries*. Washington, D.C.: The World Bank.

Dahlman, C.J., O. Sananikone. (1990). "Technology Strategy in the Economy of Taiwan: Exploiting Foreign Linkages and Investing in Local Capabilities". unpublished ms. Washington, DC: The World Bank, December.

Doner, R.F. (1992). "The Limits of State Strength: Towards an Institutionalist View of Economic Development". *World Politics* 44, April.

Dore, Ronald. (1984). "Technological Self-Reliance: Sturdy Ideal or Self-Serving Rhetoric". In *Technological Capability in the Third World* [eds] M. Fransman, and K. King, New York: St. Martin's Press: 65-80.

Dosi, G. (1982). "Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change". *Research Policy* 11.

Dosi, G., Christopher Freeman, Richard Nelson, G. Silverberg and L. Soete [eds](1988). *Technical Change and Economic Theory*. London: Pinter.

Enos, John, and W.H. Park (1987). *The Adaptation and Diffusion of Imported Technologies in the Case of Korea*. London: Croom Helm.

Ernst, Dieter, and David O'Connor (1989). *Technology and Global Competition*. Paris: OECD Development Centre.

Evans, Peter. (1992). "Greenhouses and Strategic Nationalism: A Comparative Analysis of Brazil's Informatics Policy". In *High Technology and Third World Industrialization: Brazilian Computer Policy in Comparative Perspective* [eds] P. Evans, C. Frischtak and P. Tigre, International and Area Studies — Research Series Number 85, University of California, Berkeley: 1-37.

Fransman, Martin. [ed.](1986). *Machinery and Economic Development*. London: Macmillan.

Fransman, Martin. and K. King, [eds](1984). *Technological Capability in the Third World*. New York: St. Martin's Press.

Freeman, Christopher. (1987). *Technology Policy and Economic Performance*. London: Pinter.

Haggard, Stephan. (1990). *Pathways From the Periphery*. Princeton: Princeton University Press.

Hamilton, Gary. [ed.](1991). *Business Networks and Economic Development in East and Southeast Asia*. Hong Kong: Centre of Asian Studies, University of Hong Kong.

Heng Pek Koon (1992). "The Chinese Business Elite of Malaysia". In *Southeast Asian Capitalists* [ed.] Ruth McVey, Ithaca, NY: Cornell Southeast Asia Program.

Hobday, Mike. (1995). *Innovation in East Asia: The Challenge to Japan*. Aldershot, UK: Edward Elgar.

Ismail Muhamed Salleh (1990). *Small and Medium Scale Industrialisation: Problems and Perspectives*. Kuala Lumpur: ISIS Malaysia.

Jesudason, J.V. (1989). *Ethnicity and the Economy: The State, Chinese Business, and Multinationals in Malaysia*. Singapore: Oxford University Press.

Johnson, Chalmers. (1987). "Political Institutions and Economic Performance: The Government-Business Relationship in Japan, South Korea, and Taiwan". In *The Political Economy of the New Asian Industrialism* [ed.] F. Deyo. Ithaca, NY: Cornell University Press.

Jomo K.S. and C.B. Edwards. (1993). "Malaysian Industrialisation in Historical Perspective". In *Industrialising Malaysia: policy, performance, prospects*. ed. Jomo K.S., London: Routledge.

Kim, L. (1980). "Stages of Development of Industrial Technology in a Development Country: A Model". *Research Policy* 9: 254-77.

Krugman, Paul (1994). "The Myth of Asia's Miracle". *Foreign Affairs* 73(6): 62-78.

Lall. Sanjaya. (1987). *Learning to Industrialize: The Acquisition of Technological Capability by India*. Basingstoke: MacMillan.

Lall, Sanjaya. (1992). "Technological Capabilities and Industrialization". *World Development* 20(2): 165-86, February.

Lall, Sanjaya. (1993a). "Policies for Building Technological Capabilities: Lessons From Asian Experience". *Asian Development Review* 11(2): 72-103.

Lall, Sanjaya. (1993b). "Promoting Technology Development: The Role of Technology Transfer and Indigenous Effort". *Third World Quarterly* 14(1): 95-108.

Lall, Sanjaya. (1995). "Malaysia: Industrial Success and the Role of Government". *Journal of International Development* 7(5).

Lall, Sanjaya. (1996). *Learning from the Asian Tigers*. Houndmills, Basingstoke and London: MacMillan Press Ltd.

Lall, Sanjaya. R. Boumphrey, and B.J. Hitchcock. (1994). "Malaysia's Export Performance and Its Sustainability" unpublished. Manila: Asian Development Bank.

Lee Kiong Hock (1996). "Labour Market Issues: Skills Training and Labour Productivity". Paper presented at the "National Convention on Seventh Malaysia Plan", Kuala Lumpur, 5-7 August.

Leigh, Michael. (1992). "Politics, Bureaucracy, and Business in Malaysia: Realigning the Eternal Triangle". In *The Dynamics of Economic Policy Reform in South-East Asia and the South-West Pacific* [eds] A.J. MacIntyre, and Kanishka Jayasuriya, Singapore: Oxford University Press: 115-23.

Leong C.H. (1991). “Late industrialization along with democratic politics in Malaysia”. Ph.D. dissertation. Harvard University.
Lim, L.Y.C., and E.F. Pang (1991). *Foreign Direct Investment and Industrialization in Malaysia, Singapore, Taiwan, and Thailand*. Paris: OECD Development Centre.
Lim Mah Hui (1981). *Ownership and Control of the One Hundred Largest Corporations in Malaysia*. Singapore: Oxford University Press.
Lubeck, Paul. (1992). “Malaysian Industrialization, Ethnic Divisions, and the NIC Model: The Limits to Replication”. In *States and Development in the Asian Pacific Rim* [eds] R.P. Appelbaum, and J.W. Henderson. Newbury Park, CA: Sage.
Lundvall, B. (1988). “Innovation As an Interactive Process — From User-Producer Interaction to the National System of Innovation. In *Technical Change and Economic Theory* [eds] G. Dosi, and Richard Nelson. London: Pinter.
Lundvall, B. [ed.](1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.
MacIntyre, A.J. [ed.](1994). *Business and Government in Industrializing Asia*. Ithaca, NY: Cornell University Press.
Mardon. R. (1990). “The State and Effective Control of Foreign Capital: The Case of South Korea”. *World Politics*. Vol. 43, pp. 111-138.
McVey, Ruth (1992). *The Materialization of the Southeast Asian Entrepreneur*. Ithaca, NY: Cornell Southeast Asia Program
Meyanathan, Sahathevan. [ed.] (1994). *Industrial Structures and the Development of Small and Medium Enterprise Linkages: Examples from Asia*. Washington, D.C.: The World Bank.
MIDA/UNIDO (1986). *Medium and Long Term Industrial Master Plan: Malaysia, 1986-1995*, Vol. III, Part 6, R&D and Technology Policies. Kuala Lumpur: Malaysian Industrial Development Authority.
Mody, A. (1989). *Institutions and Dynamic Comparative Advantage: Electronics Industry in South Korea and Taiwan*. Industry Series Paper No. 9. Washington, DC: The World Bank
Mowery, D.C., and N. Rosenberg (1989). *Technology and the Pursuit of Economic Growth*. Cambridge: Cambridge University Press.
Nelson, R.R. [ed.](1993). *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press.
Nelson, R.R., and N. Rosenberg (1993). “Technical Innovation and National Systems”. In *National Innovation Systems: A Comparative Analysis* [ed.] R.R. Nelson, New York: Oxford University Press: 3-21.
Nelson, R.R., and S.G. Winter (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.
Ng, C.Y., R. Hirono, and R.Y. Siy [eds](1986). *Effective Mechanisms for the Enhancement of Technology and Skills in ASEAN: An Overview*. Singapore: Institute of Southeast Asian Studies (ISEAS).
OECD (1992). *Technology and the Economy: The Key Relationships*. Paris: OECD.
Ohmae, Kenichi. (1995). *The End of the Nation State: The Rise of Regional Economies*. New York: The Free Press.
Onis, Ziya. (1991). “The Logic of the Developmental State”. *Comparative Politics* 24 (1): 109-126.
Osman-Rani, H., K.W. Toh and Anuwar Ali (1986). *Effective Mechanisms for the Enhancement of Technology and Skills in Malaysia*. Singapore: Institute of Southeast Asian Studies (ISEAS).
Pack, Howard, and Larry Westphal (1986). Industrial Strategy and Technological Change: Theory vs. Reality. *Journal of Development Economics* 22: 87-128.
Porter, Michael. (1990). *The Competitive Advantage of Nations.* New York: The Free Press.
Rasiah, Rajah (1994). “Flexible Production Systems and Local Machine-tool Subcontracting: Electronics Components Transnationals in Malaysia”. *Cambridge Journal of Economics* 18: 279-298.

Rasiah, Rajah (1995). *Foreign Capital and Industrialization in Malaysia*. New York: St. Martin's Press.

Rosenberg, Nathan (1982). *Inside the Black Box*. Cambridge: Cambridge University Press.

Samuels, Richard. (1994). *"Rich Nation, Strong Army": National Security and the Technological Transformation of Japan*. Ithaca: Cornell University Press.

Schmookler, J. (1966). *Invention and Economic Growth*. Cambridge, MA: Harvard University Press.

Simon, D.F. [ed.](1995a). *Corporate Strategies in the Pacific Rim: Global Versus Regional Trends.* New York: Routledge.

Simon, D.F. [ed.](1995b). *The Emerging Technological Trajectory of the Pacific Rim*. Armonk, NY: M.E. Sharpe.

Soete, L. (1985). "International Diffusion of Technology, Industrial Development and Technological Leapfrogging". *World Development* 13(3): 409-22.

Storper, M., and A.J. Scott [eds](1992). *Pathways to Industrialization and Regional Development*. London: Routledge.

Wade, Robert. (1990). *Governing the Market*. Princeton: Princeton University Press.

Wade, Robert. (1993). "Managing Trade: Taiwan and South Korea as Challenges to Economics and Political Science". *Comparative Politics*. 25(2): 147-167.

Wong Poh Kam (1991). *Technological Development Through Subcontracting Linkages*. Tokyo: Asian Productivity Organization.

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

World Bank (1995). *Enterprise Training, Technology, and Productivity*. Washington, DC: The World Bank.

Yoshihara, Kunio. (1988). *The Rise of Ersatz Capitalism in Southeast Asia*. Singapore: Oxford University Press.