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Working Paper No. 12

Malaysian Electronics: At the Crossroads

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

economy environment employment

SME TECHNICAL WORKING PAPERS SERIES

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Malaysian Electronics:
At the Crossroads

MALAYSIAN ELECTRONICS: AT THE CROSSROADS

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The SME Technical Working Papers Series is a series of occasional papers arising from the work of the Small and Medium Enterprises Branch of the Programme Development and Technical Cooperation Division (PTC/SME) of UNIDO. It is intended as an informal means of communicating important insights and findings from the technical cooperation and research activities of the Branch to a wider public of interested development practitioners, policy-makers and academics. The Branch would welcome comments and suggestions on the issues raised in these papers, which may be addressed to:

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ACRONYMS

AFTA	ASEAN Free Trade Area
ASIC	Application specific integrated circuits
AMT	Advanced manufacturing technologies
CAD	Computer aided design
CAE	Computer aided engineering
CAM	Computer aided manufacturing
CRDF	Commercialization of R&D Fund
DRAM	Dynamic random access memory
ECM	Electronics contract manufacturing
EPU	Economic Planning Unit
ERSO	Electronics Research and Service Organization
FA	Factory Automation Equipment
FCPGA	Flip chip pin grid array
FIZ	Free industrial zone
HPWS	High performance work system
HRD	Human resource development
HRDC	Human Resource Development Council
HRDF	Human Resource Development Fund
ICST	Institute of Computer Sciences and Technology
ICT	Information and communication technology
IMP	First Industrial Master Plan
IMP2	Second Industrial Master Plan
IPC	International Procurement Centre
IRPA	Intensification of Research in Priority Areas
IT	Information technology
JIT	Just in time
KHTP	Kulim Hi-Tech Park
LMW	Licensed manufacturing warehouse
MIDA	Malaysian Industrial Development Authority
MIMOS	Malaysian Institute of Microelectronics Systems
MITI	Ministry of International Trade and Industry
MNC	Multinational corporation
MSC	Multimedia Super Corridor
ODM	Orginal design manufacturer
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
OLGA	Organic LAN grid array
PC	Personal computer
PCB	Printed circuit boards
PDC	Penang Development Corporation
PGA	Pig-grid array
PLCC	Plastic lead chip carrier
PS	Pioneer Status
PSDC	Penang Skill Development Centre
QFB	Quad flat back
R&D	Research and development
RA	Reinvestment allowance
SEDC	State Economic Development Corporation
SHRDC	Johor Skills Development Centre
SIJORI	Singapore-Johor-Riau Growth Triangle
SMED	Single minute exchange of dies
SME	Small and medium-scale enterprise
TQM	Total quality management
TTU	Technology Transfer Unit
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
UPS	Uninterrupted power supply systems
VDP	Vendor Development Programme
WTO	World Trade Organization

Foreword

The electronics industry has played a lead role in Malaysia's development in the past three decades. It has helped the country to make the transition from a natural resource based economy to an economy based on modern industry.

The electronics industry, however, has reached a point where major changes are needed. Low-wage competition from other countries is threatening the still predominantly labour-intensive industry. If Malaysia is to remain competitive in global markets and to continue on its growth path, the character of the electronics industry must change. From being dominated by assembly operations for large multinational firms, with a heavy dependence on imported components, it must transform itself into a knowledge-intensive industry with strong roots in domestic enterprise networks.

The authors analyze global trends, the development of the Malaysian electronics industry, and the efforts of policy makers to meet the challenges of the future in the context of the Second Industrial Master Plan 1996-2005. They also identify areas where action is needed to ensure the successful transition to a knowledge-intensive electronics industry. The analysis is not just of interest to decision makers in Malaysia, but to all developing countries and transition economies with a good industrial and human resource base that are facing similar competitive pressures.

The text is based on the final report of UNIDO project DG/MAL/96/001*Transition in Malaysian Electronics*, prepared for the Government of Malaysia and financed by the United Nations Development Programme. The Economic Planning Unit, Prime Minister's Department, was counterpart of this project.

Summary

As a result of technology transitions, new opportunities arise for product development, firm and industry creation. Technology trends are a powerful factor in determining government policies and firm strategies, relations between the public and private sector and the emergence of enterprise networks. The most dynamic among networks in the electronics industry are open networks with easy firm entry, stimulating experimentation and the spread of business opportunities. The new business model is one of focus and partner: focus on core capabilities and partnering for complementary capability. Government policy plays a major role in the creation of such networks.

There are three key elements in the promotion of innovation: technology management (relations among production, product development, technology choice and applied R&D in the enterprise sector), enterprise networking and clustering, and education. To put it slightly differently: each step up the technological ladder involves three interrelated domains: production, business organization and skill formation, forming the 'productivity triad'.

Within a few decades, a number of East Asian countries have become major players in the global market for electronics. The roots of success of these countries are all similar: the development of strong technology management capabilities in the private sector, linked to the development of production capabilities and human resources.

The electronics industry has been a powerful engine for economic growth in Malaysia for three decades, turning the country from an agricultural exporter into an industrial exporter. Malaysia's specialization in electronics is higher than in most OECD countries, which gives the country a strong foundation for a future in the most innovative sectors of manufacturing and related services. By 2000, the value of exports was US$ 50 billion, and the industry employed over 300,000 people at the end of the last century. Components are the major product category, although there is a shift to finished goods. Assembly and final testing dominate component production. Foreign multinationals have always been the major engine of growth of the sector. They work with a large number of local suppliers, many of which however are also foreign-owned. So far, the role of domestic innovation has been very modest.

The electronics industry is mainly located in three regions: Penang and the North of the country, the central region and Johor. The former two have the strongest manufacturing base, but enterprise networks are largely limited to Penang and the North. Johor has so far mainly served as a base for firms relocating from Singapore. All three lack an adequate innovation and human resource base, the regional authorities in Penang making the most serious efforts to remedy these problems.

Under the Second Industrial Master Plan (IMP2, 1996-2005), which has the long-term

objective of turning Malaysia into an advanced industrial nation by 2020, the following strategic directions for the electronics industry have been identified:

- Developing the value chain;
- Deepening the supply chain;
- Moving to a higher technology plane; and
- Developing world-class Malaysian-owned companies.

A special division for the electronics industry has been set up in the Malaysian Industrial Development Authority, financial support is available for R&D and advanced SMEs in the industry, and the Multimedia Super Corridor has been launched as a strategic project to attract major electronics and multimedia firms by providing highly sophisticated infrastructure in the area around the capital Kuala Lumpur. Technology-driven clusters have been explicitly singled out by IMP2 as key elements in making the transition, and the Corridor can be seen as an attempt to create a spatially compact cluster with close linkages and complementarities among highly advanced electronics firms.

At the beginning of the 21st century, Malaysia has a number of strengths:

- There are strong electronics manufacturing capabilities;
- The country is well integrated in the global electronics production system;
- R&D capability is emerging around the multinational companies;
- SMEs are beginning to move up the electronics value chain;
- IMP2 provides a good policy basis for future development and parts of the institutional support system (among others in Penang) are strong.

But there are also weaknesses:

- The industry is losing its competitive edge in labour-intensive operations;
- There are as yet few integrated production systems or high value added links in the industry's value chain;
- The domestic industry is still fairly weak in terms such as technological innovation, industrial diversity and general dynamism;
- As a whole, the support infrastructure is still weak;
- The human resource base for an advanced, Malaysian-owned electronics industry remains inadequate.

In short, the technology trajectory now presents Malaysia with opportunities and threats. The threat is that lower-wage rivals in Asia will create similar production capabilities.

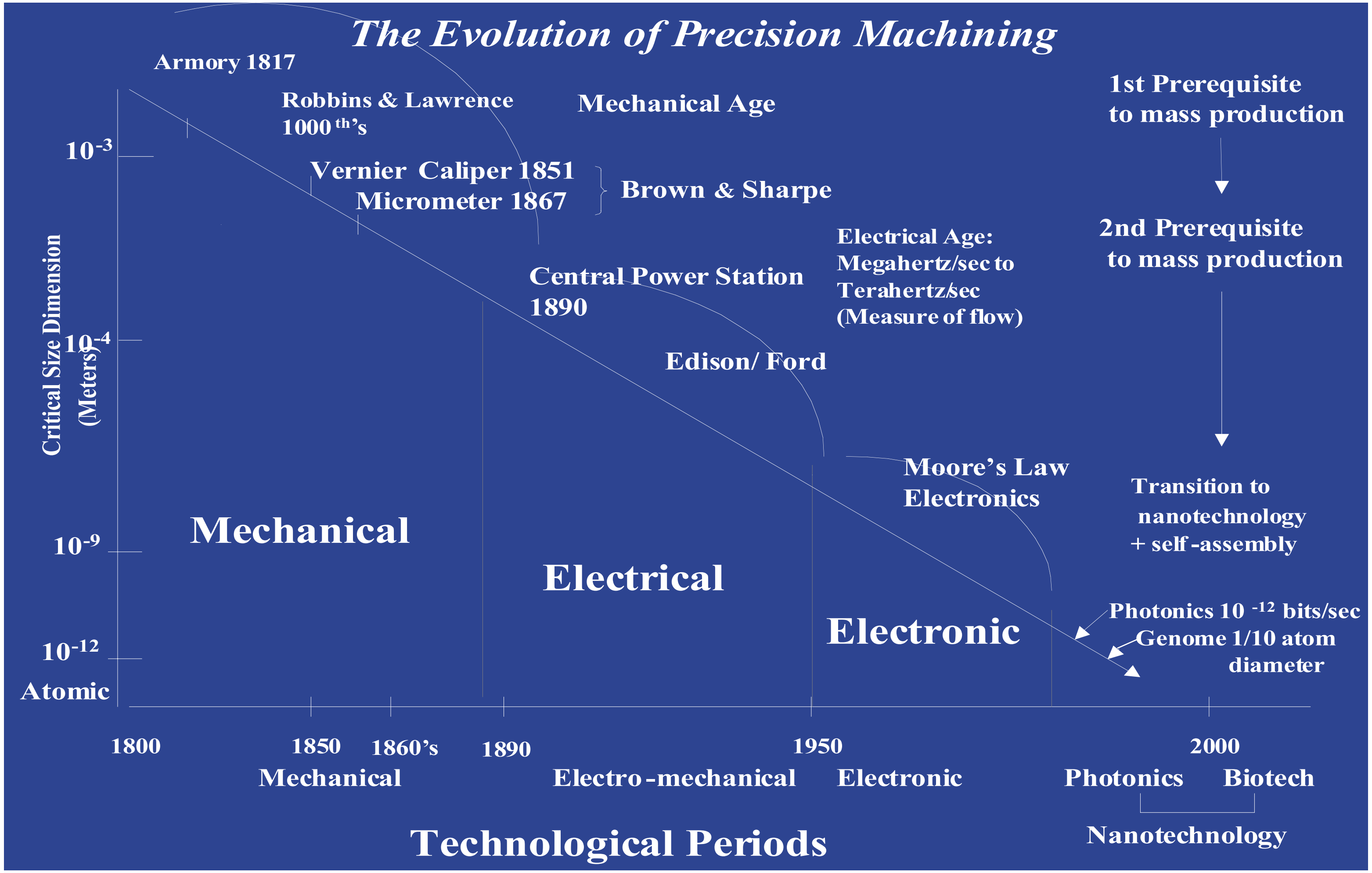
The opportunities are in higher value added activities in the knowledge-intensive segments of electronics. The challenge is to increase the number of domestic firms capable of exploiting those opportunities.

Building on Malaysia's strengths and overcoming its weaknesses to achieve sustained development towards higher value added, technologically innovative activities in the electronics sector will require that the country's policy makers and entrepreneurs address a number of inter-related challenges:

- Creating dynamic firms.
- Building production capabilities.
- Building networking capabilities.
- Technology management.
- Technology transition.
- Skill formation.
- Integration of governance efforts.

Because of the multiplicity of interdependencies and feedback effects, it is the task of government – first and foremost at the national level, but also at the regional level - to develop policies, agencies, and institutions that ensure mutual adjustment of activities, so that the development processes advance all three domains of the productivity triad.

Figure 1 The evolution of precision machining



Source: Best (2001,133)

1. THE SETTING

1.1 The logic of technology trajectories

While it is highly uncertain *which* new technology will establish itself on the market, technological trajectories have a logical progression. Figure 1 illustrates both the change and continuity dimensions of technological change and the major transitions ushered in by the introduction and integration of new technological domains into production systems.

Figure 1. The evolution of precision machining

(please see previous page)

One feature is constant: a sustained reduction in critical size dimensions cuts across technology transitions. As technologists and scientists' drive down the size dimensions of critical devices, new opportunities for technological change, product development, firm and industry creation emerge.

The technology trajectory towards ever smaller critical size can be a powerful factor in determining policies in even in the most technologically advanced companies and regions. The logic of the trajectory can be used to great effect by partnerships between firms and governmental research programmes. It provides a basis for the emergence of networked groups of firms acting as collective entrepreneurs in shaping technological and industrial change. This can be witnessed every day in every industry.

1.2 The dynamics of production networks

National systems of technology management at the firm level and government technology policy must also account for simultaneous changes in the dynamics of global production networks. The success of high-tech regions or 'regional innovation systems' such as Silicon Valley and Boston's Route 128 in the United States has led to the replacement of the vertically integrated enterprise with networked groups of firms. The new business model is one of focus and partner: focus on core capabilities and partnering for complementary capability. Arms-length, market relations between subcontractors and Big Business enterprises are being replaced by inter-firm 'value chains' and 'value networks'. The metaphor of chains to capture the links amongst enterprises is in turn increasingly giving way to the metaphor of networks of specialist enterprises. The chain metaphor suggests stability along a single 'production' line; the network metaphor suggests rays fanning out from nodes.

The network model of industrial organization is a major change as the coordination function across economic activities is no longer the preserve of either a managerial hierarchy within a single dominant enterprise or the ‘invisible hand’ of the free market. The term network is generic in that it captures an array of related but distinctive forms of inter-firm relations and coordination. The mode of inter-firm coordination of course also has an impact on the internal organization of the business enterprise itself. The relationship between the mode of inter-firm coordination and internal organization of the business enterprise was easily ignored in the era of vertically integrated business enterprises. Technologies were stable and competition was based on costs and production efficiency. Today technological change is integrated into the organizational capabilities of the leading enterprises and competition has shifted to new product development.

The role of multinational corporations (MNCs) is being transformed in the process. In the past, MNCs focused on the penetration of protected markets by tariff-hopping investments and the exploitation of international factor cost differentials for low-skilled labour and resource-intensive activities within an unchanging production system. But with the development of world-class manufacturing capabilities in Japan, followed by the four Asian Tigers, global production networks (GPNs) have emerged. They have facilitated the transition to the focus-and-partner business model in the world’s leading technological regions. The central offices of the GPNs, located primarily in America, Europe and Japan, came to coordinate independently owned enterprises, many of which were located within the four Asian Tigers and a second tier located in Malaysia, Thailand, the Philippines, and China.

Japanese firms, for example, now rely heavily on production outside Japan, the whole of Asia being viewed as a production base. This has led to a decline in electronics SMEs in the home country, but the production networks that have emerged in the region continue to rely heavily on the Japanese *keiretsu* model of inter-firm coordination between transnationals and SMEs (many of which have relocated to other Asian countries). These networks increase flexibility in production, but the keiretsu model has negative side effect: it does not decentralize and diffuse design activities that tend to concentrate innovation in the lead firm.

Such ‘closed’ networks can be contrasted to ‘open networks’ which are characteristic of the enterprise networks that have emerged in the American electronics industry. Subcontractors of large US firms are becoming systems integrators who can provide a range of engineering and product development services. US firms are increasingly demanding that key subcontractors have plants in all major markets. Open networks are more conducive to rapid development of new (product) concepts than closed networks because new firm entry is easier, with a positive impact on experimentation. They also spread business opportunities, and can therefore foster local capability development.

Government plays a major role in the creation of such dynamic networks, in various respects:

- Government policy is a major determinant of the supply of skilled labour and technological know-how in a country.
- Import and export regulations, investment policies and rules governing the employment of foreigners provide a framework for the flow of capital and know-

how across borders.

- Decentralization and regional development policies can mobilize entrepreneurial potential throughout the country; the latter is of particular importance in the creation of business networks in which geographical proximity plays a major role. High quality national and regional development agencies are critical to the effective execution of policies and regulations.

- By entering into partnerships with the private sector, finally, governments in many countries have ensured that framework conditions correspond to specific domestic needs, and that measures to promote an innovation-driven development strategy are smoothly executed.

1.3 Malaysia's electronics industry at the crossroads

The electronics industry has been a powerful engine for economic growth in Malaysia for three decades, as Chapter 4 will show. It was the major factor in turning the country from an agricultural exporter into an industrial exporter. Malaysia's specialization in electronics is higher than in most OECD countries, which gives the country a strong foundation for a future in the most innovative sectors of manufacturing and related services.

The technology trajectory now presents Malaysia with opportunities and threats. To grasp the opportunities, the country has to overcome some formidable obstacles. Malaysia's electronics industry is still mainly active in the lower value added segments. The country is a global production platform for mass production and rapid start-up of externally designed product lines. Local firms are mainly producers of components or assemblers of imported components. Foreign MNCs dominate the industry. Malaysia lacks the indigenous technological management capabilities to engage in the higher value added activities associated with new product design and development; the networking capabilities required in this context are also insufficiently developed. Yet this is where the country's future would lie.

The danger of the present situation for Malaysia is that lower-wage rivals in East and Southeast Asia are creating similar production capabilities. Raising development levels and per capita income in Malaysia will therefore depend on moving into higher value added activities.

The Malaysian Government is aware of all this. The Second Industrial Master Plan 1996-2005 (IMP2) envisages a transition '... to more automated operations involving high technology and knowledge-driven processes' (MITI 1996, 63) – in other words, a transition from a labour-intensive to a knowledge-intensive electronics industry. Networks are clearly perceived as key elements of this transition: 'The IMP2... focuses on the cluster-based industrial development approach [to] improve on the existing industrial foundation of the manufacturing sector. It will further strengthen industrial linkages both in terms of depth and breadth at all levels of the value chain' (EPU 1996, 30).

While IMP2 expects that MNCs will continue to be the main source of new technologies, major efforts are being made to create a base for an innovative Malaysian electronics industry. The main elements in the Government's strategy are:

- Developing the value chain by encouraging MNCS to shift more sophisticated operations to Malaysia;
- Deepening the supply chain through the development of capabilities in domestic firms;
- Moving to a higher technology plane through the acquisition and development of technological capabilities;
- Developing the information technology (IT) and multimedia industry;
- Developing world-class Malaysian-owned companies in this context.

The following chapters will discuss some major developments in the electronics industry as well as developments in the industry in East and Southeast Asia, to provide a context for the following chapters: the state of the industry in Malaysia and in specific regions in the country, and the identification of areas of action which will help ensure that the progress made under IMP2 will indeed result in a transition to an innovative, high value added domestic electronics industry.

2. PROMOTING INNOVATION: THREE BASIC ELEMENTS

2.1 Technology management

Technology management concerns the relations among production, new product development, technology choice and applied R&D within and across firms. The challenge of technology management is to develop the organizational capacity to continuously combine and recombine technologies in order to retain a competitive edge in an era of rapid change.

The transition of firms to more advanced production capabilities increases not only the versatility of those firms, but also of the regions in which they operate, allowing them to compete more successfully across a wider range of industrial activities. The development of production capabilities and their characteristics is shown in Table 1, which also indicates the level of sophistication required in technology management.

Table 1. Development of production capabilities

Level	*Characteristics*
1	*Pre-flow, pre-interchangeability*: Craft production by itself offers no basis for production flow. Each drawer of a craftman's cupboard, for example, is custom fit.
TM 1	
2	*Interchangeability*: Fosters precision engineering, but in the absence of process engineering inventory turns and working capital productivity are low.
TM 2	
3	*Single product flow*: Plants with economies of speed for a single product or range of products with dedicated lines. Workers are not multi-skilled; tend one or several homogeneous machines. Training does not include continuous improvement, rapid changeover, or blueprint reading skills. TNE electronics production in Indonesia.
TM 3	
4	*Single product flow with continuous improvement*: Involves problem-solving work, self-directed work teams. Common training programmes involve Plan-Do-Check-Act, the seven problem-solving tools, 5S (a system to ensure general order and cleanliness) or TQM at shop floor level.
5	*Single product flow with process innovation*: Maintenance and process control technicians have skills to identify, fix and redesign machinery and production lines. Bottleneck analysis determines priorities. This may involve reconfiguring product design parameters at main office. Singapore in the mid-1980s, MNCs in Malaysia in early 1990s.
6	*Multi-product flow*: The Toyota system. Kanban, JIT, and SMED are introduced in large plants. High throughput and flexibility are combined. Cellular production with self-directed work teams.
TM 4	
7	*Multi-product flow and product development*: Japan and Taiwan both excel at concurrent engineering and design for manufacturability. Skills include reverse engineering, prototype development and pilot runs.
8	*New product design and technology fusion*: Japan's Toshiba and Canon are leaders in linking development to operations at the plant level and linking research in generic technologies to product development. Core technologies are developed, often via fusion in generic technology labs. Technology management involves worldwide sourcing of the existing technology base in pursuit of novel applications.

TM 5	
9	*Systems integration and disruptive innovation*: 3M, HP and Motorola use cross-disciplinary teams to identify new technology drivers for product development. Disruptive or breakthrough innovations are pursued but within an organizational context of process integration. Hardware and software integration drives product concept development.
10	*Open systems and design modularization*: Focus and network strategies are supported by standard inter-face rules and diffusion of design capability. Fosters technology-deepening R&D and techno-diversification. (PC industry in Silicon Valley)
Note: TM = technology management level	

Source: Adapted from Best (2001, 55).

The main successive development levels are interchangeability, flow, multi-product flow and systems integration.

Interchangeability

Designing a production system around the principle of interchangeability is the first step in developing technology management capabilities. Specialist machines have to be designed and built to apply the principle. The ‘accumulation of capital’ means building networking relationships between users and makers of machines - a pure market relationship between machine maker and user does not build indigenous technology management capabilities. It can at best result in ‘turnkey plants’. Application of the principles means the emergence of product engineering as a set of standard procedures, an organizational capability, and an occupational category to specify, identify, design, make, set-up, modify, improve and efficiently operate the machines in question.

Converting the principle of interchangeability into enterprise (and regional) production capability lays the foundation for major advances in growth potential. It requires reorganizing industrial enterprises from top to bottom for consistency with interchangeability. Manufacturing methods and organization, engineering practices and skill development programmes must all be developed and made consistent with one another.

Historically, the rudiments of process engineering were developed with the application of the principle of interchangeability as methods were established to lay out, inter-face, standardize, measure, operate, and trouble-shoot machining activities along a production line. The elements of a production management system become subject to searches for improvement. Technology management is no longer a one-off affair in which a machine with superior performance capacity is introduced; instead, it becomes an organizational capability of industrial enterprises.

Skill formation is integral to the process of applying and diffusing the principle and helps to create a basis for further development. While the makers and users of the specialist machines are independent firms, co-location can fuel a regional innovation process which in turn will be anchored in a work force of skilled workers and practical engineers.

Flow and multi-product flow

The principle of flow underlies a myriad of terms used today to describe the revolution in manufacturing led by the Japanese, such as just-in-time (JIT), ‘lean production’, 'reengineering', advanced manufacturing, time-based competition, process integration and 'synchronised production'. But Henry Ford already applied it to achieve an unprecedented increase in throughput efficiency, productivity and wages. The breakthrough in production performance demanded that attention focused on *technology management* and measures of throughput efficiency, not on *labour management*. The concurrent development of Ford's production line and machines powered by electric motors both were the result of simultaneously redesigning the production system and the elements in it to capture the full advantage of technical change in electric power delivery.

The system had its limits: innovation was not institutionalized, but seen as a one-off activity focused on the development of a new plant. Permanent integration of technology integration and production would have required a more radical revolution in work organization and skill formation.

Multi-product flow is an extension of the principle of flow but dependent upon prior or simultaneous changes in work organization associated with cellular manufacturing methods, including the associated practices of JIT, quick changeover machines, *kanban* (visual co-ordination of production activities), self-directed work teams, and *kaizen* (Japanese for continuous improvement methods). Application of the principle of multi-product flow established comprehensive performance standards involving cost, quality and time.

The new production system required multi-skilled workers capable of operating and setting up a range of machines, departments organized by process and not similarity of machine or activity, and work organised into teams inclusive of the various skills and range of activities required to carry out the process from beginning to end. Flexible production means workers educated in blueprint reading, in the range of problem solving tools that constitute quality management and in the communication skills required to work in teams.

Conducting experiments and discovering new knowledge is no longer the preserve of engineers but spread to work teams. The business challenge becomes to build the discovery process into every ongoing activity. In practice this meant the establishment of *kaizen*, a foundation for incremental, collective innovation and the pursuit of product-led competition. Extending cycle time competition from production to 'time to market' of new product designs meant integrating design into the manufacturing process. Workers become part of the technology adaptation process.

The plan-do-check-act methodology, team-centred work organization and inclusion principle of 'total quality management' are a set of skills and practices that constitute the organizational counterpart to multi-product flow. Skills, organization, and material conversion technique are three aspects of the same, flexible production system and their synchronization is essential for achieving the comprehensive performance standards of cheaper, better, and faster.

Systems integration

Systems integration involves (re)designing products along with their production systems. The emergence of new information and communication (ICT) technologies has promoted the use of this approach, which offers a response to the challenge of managing manufacturing processes along a technology trajectory where productivity is increasing faster and faster – 50 per cent every 18 months. In fact, the microprocessor is to the knowledge-driven economy what the machine tool industry was to the diffusion of the principle of interchangeability and unit-drive electricity was to the diffusion of the principle of flow, which ushered in the age of mass production.

The competitive advantage derives from the modularization and decentralisation of design in conjunction with shared inter-face design rules and, simultaneously, the replacement of the business model of vertical integration with one of horizontal integration across networked groups of companies – of which more is shown in Section 2.2. Systems integration builds the organizational capability to incorporate the rapidly changing technology of components into complex products. Design modularization is a methodology that integrates two sets of design rules: those at the level of individual technologies or sub-systems and those that integrate sub-systems into a single system. The process of integrating sub-systems is not an additive one: interactions among sub-systems have dynamic feedback effects.

Systems integration often entails the fusion of two or more technologies anchored in different scientific disciplines and associated language communities, and which operate according to different design protocols; hence the organizational imperative of teamwork across scientific backgrounds. The clearest example of systems integration is the integration of hardware and software, which, with advances in information technology, has made it possible to continuously rethink product concepts across most industries.

An advantage of design modularization is the potential to mobilise resources from outside the company for component design to meet the challenge of rapid technological change - this is not possible under Ford’s business model. The open-system networking model both fosters and is fostered by systems integration at the enterprise level. This is because barriers from bureaucratic inertia are lowered and companies can integrate, disconnect, and re-integrate with other companies as technologies change.

Networking, systems integration, diversity and information technology have contributed to the rise of new clusters of IT-based industries. The best know examples are Silicon Valley and Route 128 in the USA, but in Malaysia there is also an example: Intel, which depends upon, and reinforces, a network of affiliated companies constituting multiple design nodes. Intel not only partners with a vast array of specialist producers and research institutions; it also draws upon a large industrial high-tech region with an extraordinary capacity to conduct experiments, carry out innovations, and conduct research.

It cannot be emphasized enough that IT is not a factor that makes systems integration easier: it is right at the heart of it. The integration of information technology and hardware allows firms to make the transition to the open-systems models of innovation and business organization. ICT is of course used in firms based on traditional business models; but it does relatively little to enhance their competitiveness.

Technology management and regional development

A technology management strategy based on a clear understanding of the different stages, a realistic assessment of the domestic potential in the light of the various stages (the industrial potential may well require a differentiated approach for different industries) and efforts required to realize that potential are central elements in economic policy-making and business strategies. Each of the high-growth East Asian countries has a distinctive technology management strategy. Some of the aspects are discussed in Chapter 3.

At the regional level, as at the national, a critical mass of firms that makes the transition to a higher level of production capabilities can trigger a region-wide transition. Figure 2 illustrates how the industrial structure of a region can change in the process.

Figure 2. Technology management and sectoral transition
(Please see next page)

Each advance in capabilities increases the potential to make a shift to the top left-hand corner of the diamond. This shift does not necessarily mean that the less sophisticated industries are doomed. Regional competitive advantage combines generic production and technology management capabilities with technological know-how and skills that are regionally specific. Consequently, low-tech industrial districts can persist in high wage regions because of a combination of unique and generic capabilities, on the one hand, and a critical mass of firms that can periodically trigger a new a cluster dynamic. Whether a region or a cluster succeeds in doing this is highly dependent on the quality of their governance system.

2.2 Enterprise networking and regional clusters

Individual firm development – the basis for firm networks

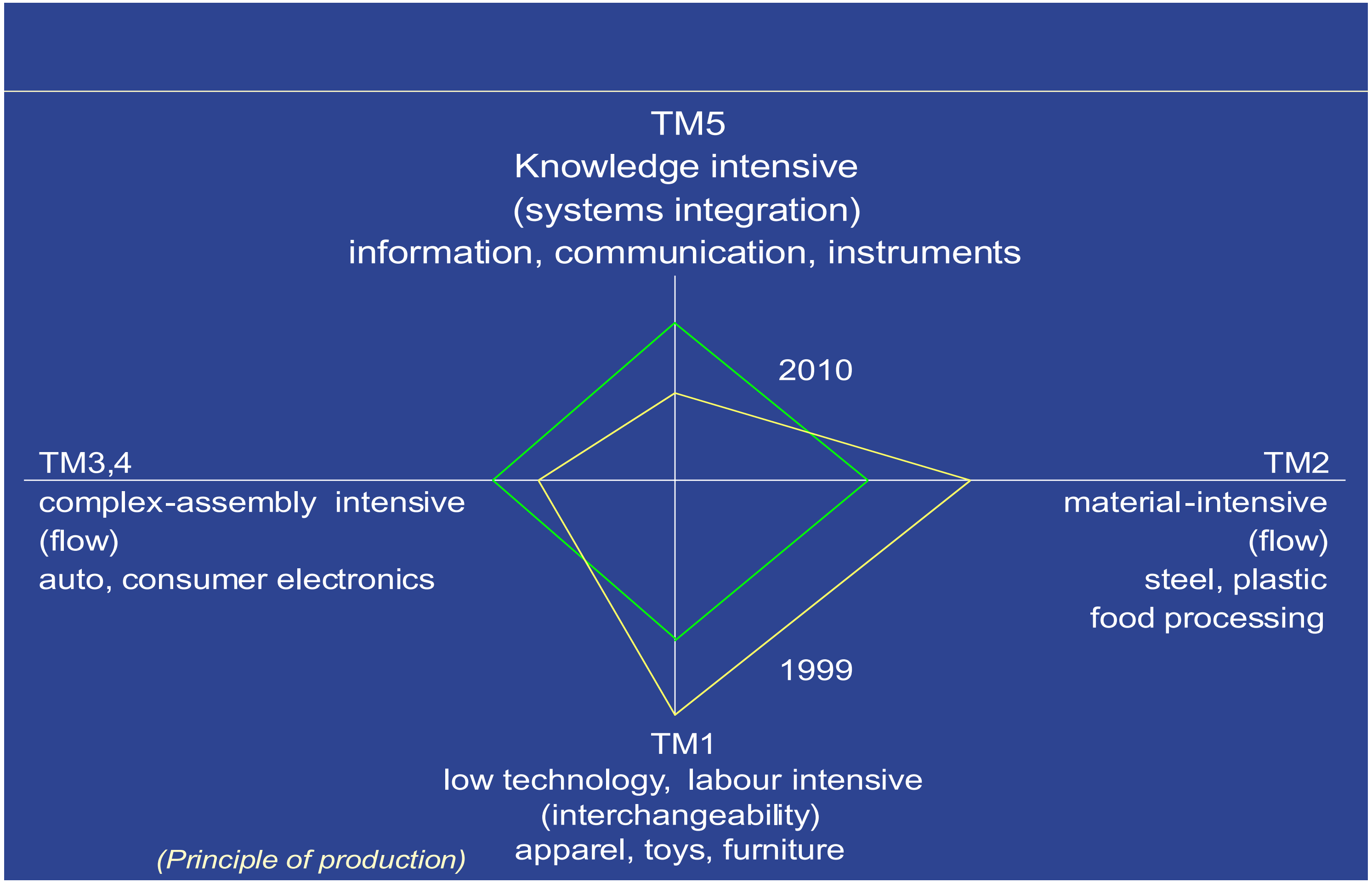
Chapter 1 made it clear that enterprise networking is a key factor in the global electronics industry. What are its mechanisms and characteristics?

The starting point is the firm in the market economy, driven by a technology/market dynamic: technology and markets impact on each other. Firms strive to create unique capabilities to ensure that the products they offer are what the customer wants. What the customer wants is reflected in products, but products also redefine the character of markets, competitive pressure acting as a catalyst in this two-way process. The new market opportunities motivate changes in productive capabilities, setting in motion a new technology and market dynamic.

The originating firm can generate three types of new productive opportunities to other firms that can, in turn, initiate secondary internal dynamics in yet other firms:

- First, because of the inherent uncertainty about future technological pathways, the firm must place its R&D and new product development bets on specific opportunities and forsake the development of others.
- Second, the firm may not have sufficient capabilities to pursue the new opportunities – or it may not find them attractive enough.

Figure 2 Technology Management and Sectoral Transition



Source: Best (2001, 57)

- Third, if the firm is part of a networked group of firms each specializing on a complementary capability, a technical change at one link in the chain will create new opportunities for specialists in each of the complementary capabilities. In this way advances in design and technology spread across production networks. In some cases the effect may be to set off a secondary internal dynamic and consequent pressures for change across the network.

In the first two cases, productive opportunities that have been created but not pursued are potential productive opportunities for new enterprises, spin-offs, or existing enterprises with capabilities in similar activities. These can trigger a process of industrial 'speciation' – the emergence of new products, etc, within an industry. Classic examples are the transistor, the telephone, the laser, and the personal computer. The companies that sponsored the original research developed none of the key technological innovations, even though all became the basis for the emergence of a vast range of new enterprises better positioned to seize the opportunities. In most cases, the new companies were not saddled with existing capabilities in competing technologies and therefore were not forced to make a decision between supporting core technologies and associated skills and new technologies and the new skills.

The exploitation of niche opportunities by small and new firms limits the tendency to industrial concentration. In this way the growth dynamic is propagated to the larger industrial system. Low entry barriers are essential to ensure that this process takes place. One key factor is the way in which inter-firm relations are organized. Open-system networking, as discussed in Chapter 1, stimulates new firm creation because it offers greater flexibility for new product development and innovation than does vertical integration. It can also foster the relations necessary for effective co-location of specialist but complementary activities (in the form of new firms) more easily: specialist firms can readily 'plug into' existing product chains, creating localized industrial clusters. Open-systems-networking does not lock an enterprise into any specific relationship as is the case in closed systems; nor do they face the obstacles to change in vertically integrated firms: bureaucracies, individual career paths or established technologies. The Internet is a great facilitator of open systems networking.

Spatial proximity as a catalyst for networks

The fact that open systems attract new businesses, and that proximity to other firms can be a key factor in location decisions, means that (sub-national) regions can simultaneously benefit from and stimulate technological innovation, provided that a number of conditions are met. The right combination of *local* factors – the region's 'socio-economic capital' - allows regions to compete in those *global* market areas where they have built up strong clusters of industrial activity.

Regional production systems have assumed a vital role in the shift from standardized mass production to continuous innovation, flexible specialization and relatively small-scale, know-how intensive production. As networking capabilities of a region become more robust, the region takes on the semblance of a collective entrepreneur. While high-tech districts, such as found in the USA, are unique in terms of specific technologies and research intensity, they exhibit regional innovation characteristics in an exaggerated form that are common to the virtuous circle of regional growth:

- First, the high-tech, open-system industrial district is also a collective experimental laboratory. Clusters of firms are, in effect, engaged in continuous experimentation as the networks form, disband, and reform.

- Second, an open-system district expands the number of experiments conducted simultaneously. A vertically integrated company may carry out several experiments at each stage in the production chain, but a district can exploit dozens simultaneously. In this way a district counters the barriers to introducing new ideas in firms that already have well-developed capabilities, and can avoid becoming locked into industrial specialisms which one day will inevitably lose their competitive edge.

- Third, an open-system district fosters the decentralization and diffusion of design capabilities. This diffusion of design capability increases collective innovation capacity. It can also strengthen the district model of industrial organization, even enhance conversion from a closed to an open system.

The challenge is to balance experimentation with well-focused joint efforts to exploit market opportunities. Achieving this means dealing with issues and time spans, which will often be beyond the range of individual actors. Therefore cooperation is needed among economic actors and between these and other key actors, such as local government and science/education institutions. The quality of their interaction is a development factor by itself. Geographically limited areas help to reduce the interaction costs.

2.3 Education

The development and diffusion of a new technology depends on improving engineering and related know-how and skills. While some of the skill development will be internal to the firm, most of the know-how will be provided through a country's education system. The rapid growth in technical skill levels that has accompanied the high growth rates in some of the East Asian high-growth economies is shown in Table 2.

Table 2. First university degrees awarded in key science areas, 1975 and 1995

Country	*Natural science and engineering*		*Mathematics and computer sciences*	
	1975	1995	1975	1995
Singapore	702	2965	NA	NA
Republic of Korea	10266	47277	Nil	12351
Taiwan	6700	15170	1200	2818

Source: National Science Board, *Science and Engineering Indicators—1998*. U.S. Government Printing Office, Washington DC, Appendix Table 2-2.

Singapore, South Korea, and Taiwan all followed Japan in investing heavily in engineering, natural science, mathematics and computer science education to make technology-driven growth happen. A virtuous cycle emerged that funded the advances in education by rapidly growing national income.

An expansion in graduates by 1,000 requires an increase of 4,000 students in a four-year electrical engineering degree programme which, in turn, requires an expansion in faculty positions of roughly 270 (given a 15 to 1 student to faculty ratio) in electrical engineering plus a corresponding investment in facilities. Investment in skill formation is costly.

The challenge of providing a good engineering education is increased by technological change. At times of technology paradigm or domain shift, such as from the age of mechanical to electrical technologies, curricula must change. Firms seeking to advance their technological capabilities in opto-electronics, for example, seek graduates educated in photonics as well as electronics. Simply increasing the number of graduates is not the answer; their professional qualifications must be adapted.

Only Governments have both the funds and legitimacy for the large-scale investments and educational restructuring programmes that are needed. But matching supply and demand requires joint efforts of the relevant Government authorities (Ministry of Education, Ministry of Science, etc.), the scientific community and the business community.

An important feature of growth is that skill formation processes are instituted at both the high and mid-technological levels. Often, the critical factor is mid-level skills. This has been the case in the transition from electronic, circuit-switched networks to ones based on optical, packet-switched technology. In the case of optical networking equipment, it is estimated that a single graduate engineer can support five to six associate engineers. Combined with a *kaizen* or high performance work system (HPWS) capability in operations, these combined skills can compress the times for new product introduction and production processes.

A broad introduction to business (both theoretical and practical) is also needed at universities if applied science is to become a major force in development - and a source of income to support research. At the same time, an adequate supply of know-how for making business plans in support institutions must also be ensured, to bring down the often prohibitive cost of external business plan development for small enterprises.

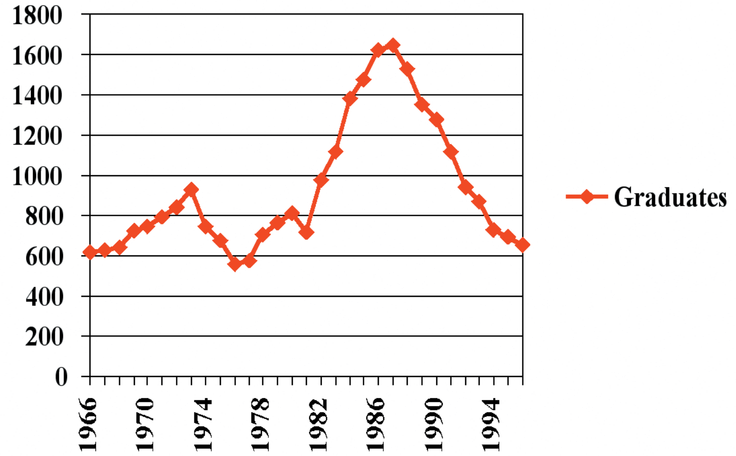
At the regional level, the quality of the educational system is of course a decisive development factor as well. Its overall quality and the scope for action (and funding) by regional authorities will depend on national policy. But the regions themselves can and do have an impact on the availability of the know-how and skills needed for a dynamic economy. The USA provides some good examples of university-enterprise cooperation. Silicon Valley and Stanford University, in the words of Leslie and Kargon (1996, 470):

> '…had grown up together, gradually adjusting to each other and to their common competitive environment. Each helped the other discover and exploit new niches in science and technology…In the proliferation of new technical fields and new companies that characterized the early evolutionary stages of these industries, the right kind of university could make a real difference in fostering horizontal integration and collective learning throughout the region.'

The remarkable feature of the 'Massachusetts Miracle' years (1978 to 1986/7) was the responsiveness of the education system to the skill needs of the rapidly growing firms.

The result was a steep increase in both engineering graduates and the technical skill base of the region. Entrepreneurs, educational institutions, and government funding partnered to provide the skill base for the growth and development of America's first regional concentration of high tech. Figure 3 shows the supply response to business needs. There is a noticeable decline after the late 1980s. This is a reminder that education must not become too focused on a narrow range of skills for which there is a present demand, but should be based on a long-term strategy, which stimulates flexibility and creativity in the workforce.

Figure 3. Bachelor degrees in electrical engineering in Massachusetts, 1966-1996



Source: M. Best, "Technology Integration and the Resurgence of Route 128," UMass Lowell, 1999

In the USA, there is a long tradition of cooperation between business and universities, which also expresses itself in low legal barriers to the commercialization of science and enterprising attitudes at universities. Many developed market economies have established science incubators where students and university staff can start up small enterprises to commercialize their scientific knowledge.

In most developing countries this close link between academia and the commercial application of science results is not yet found (one of the exceptions is discussed in Chapter 3.3), and building up working relations between business, regional governments and local universities is a long, complex process. Elements of a coherent regional innovation strategy would:

- Involve all key public and private sector stakeholders.
- Identify key regional strengths on which to concentrate efforts.
- Develop a long-term vision, with stages for its realization.
- Create an institutional support infrastructure to help realize the strategy.
- Explore new funding mechanisms, using public and private resources.
- Coordinate with national strategies and priorities, and press for a review of national regulations that still form an obstacle to cooperation between science and business.

- Explore the possibilities of cooperating across borders with similar regions in the context of organizations such as the Asian Free Trade Association (AFTA).

2.4 Conclusion: the productivity triad

Each transition to a higher step up the technological ladder involves processes in three mutually interactive domains: production, business organization, and skill formation. This is the *productivity triad*. The concept captures the systemic dimension of organizational change. At the level of the firm it means that to move to multi-product flow, a company must simultaneously replace batch with flow production principles, supervisor with team-centred work organization, and educate workers and managers in problem-solving practices and their new roles. Changes in any one of the three dimensions are not sufficient to drive the transition. But successful transition also requires the move to process integration along the supply chain. This will usually involve stronger networking amongst firms.

At the level of the region or country it means that to jump to higher productivity and per capita income, change has to be co-ordinated at the level of technology management, business organization, and the business support and educational systems. Achieving this requires the creation of another triad: business, (regional) government and the science community.

3. THE EXPERIENCE OF EAST ASIAN COUNTRIES

Within a few decades, East Asian countries have become major players in the global market for electronics. The East Asian economies have each developed the capability to adopt, adapt, and diffuse technologies, which originated in the technologically most advanced nations, laying the foundations for their own innovative industries. Both to the peculiarities of the industrial structure of the countries in question and government strategies contributed to their success. In the following pages, the experience of the East Asian countries is described briefly, after which the main lessons are summarized.

3.1 Japan

Large firms have been in the forefront of innovation and building technological management capabilities in Japan. They take the lead in upgrading capabilities and performance standards of suppliers, and were therefore natural partners for the Government and for specialized intermediary agencies in efforts to boost industrial performance. Financial institutions and corporate governance were all designed to provide a long-term basis for technological advances. The result was a dynamic domestic production system composed of lead manufacturers interacting intensively with a broad small and medium-scale enterprise (SME) base.

A small group of highly competitive firms was the focus of the Japanese Government's early efforts to develop the Japanese enterprises. These were eligible for support if they established cooperative research projects. The approach proved successful and became the model for subsidies to research and development. The actual amount of financial support was small, amounting to less than US$ 1 million during 1957-1961, the main instrument being direct technical support by public sector laboratories and universities. Inter-firm cooperation was promoted by the Japan Electronic Industry Development Association, set up with encouragement from the Ministry of International Trade and Industry (MITI) in 1958.

Although the electronics industry took off rapidly, the country suffered from a high degree of concentration of technological innovation and a lack of basic R&D, most innovation being of a 'downstream' type. MITI launched a technolopolis programme in 1980 to achieve world leadership in technological innovation, boost regional development and prevent the hollowing out of the manufacturing sector's domestic capabilities through offshore production. However, the programme, which is to be completed by the end of the present decade, only appears to be a partial success. Most of the production in the technopolises – of which only a handful are successful - is of an assembly character, based on designs drawn up in Tokyo or Osaka. Top quality staff (such as software designers) remains in short supply, and the integration of the research and productive sectors is still in need of improvement.

The SME sector is supported by 178 *kohsetsushi* centres (Shapira 1998). These centres are administered by the prefecture governments; part of the budget is provided by the central Government. The centres offer research, technology, testing, training and management services to enterprises with up to 300 workers. About half the staff time is spent on research. The centres cooperate with MITI's Japan Small Business Corporation, set up to implement a wide range of support programmes. As a consequence of the industrial enterprise structure, however, the SME sector remains relatively weak in terms of developing independent initiatives.

3.2 Taiwan

In Taiwan, which used the examples of Japan and the Republic of Korea for the transition from labour to energy intensive industries and complex consumer goods, the high cost of energy resulting from the 1973 oil crisis speeded up the development of non-energy, technology intensive sectors including machine building, semi-conductors, computers, telecommunications, and robotics.

Taiwan did not have the conglomerate corporate structure of Japan or the Republic of Korea to drive R&D and technology management, industry being dominated by SMEs. It was therefore decided to create public sector R&D capacities in strategic areas. Under the Industrial Technology Research Institute (ITRI), five research organizations were established, among them the Electronics Research and Service Organization (ERSO). The absorption of US technologies was the first step to the creation of a Taiwanese micro-electronics and software industry.

In 1986, ERSO was involved in the creation of the Taiwan Semiconductor Manufacturing Corporation (TSCM) and contributed about half of the start-up costs of a joint venture with Philips and several domestic firms. TSCM decided to concentrate on application-specific integrated circuits (ASICs) rather than to compete with, for example, Japan and Korea in memory chips.

By the late 1990s, Taiwanese firms had cornered about 70 per cent of the global market in IC foundry services, and 'Taiwan's IC [integrated circuit] industry [consisted] of many small firms specializing within a narrow range of the value chain, such as IC design, mask production, foundry service, packing and testing...organized by an industrial network system with a strong connection to Silicon Valley' (Chen and Chen 2001, 10). Inter-firm relationships are highly localized, the spatial organization of industry resembling that of Italy's industrial districts.

ERSO has been involved in over 20 information technology (IT) research projects since the early 1980s and is an active licenser of technologies. It has helped to diffuse technology to thousands of firms in many industries, helping the rapid development and international expansion of Taiwan's computer, software and telecommunications industry. It has also encouraged its engineers to leave and start up their own companies, for which a wide range of incentives is available.

3.3 The People's Republic of China: Beijing's 'Silicon Valley'

At Beijing, the Zone for the Development of New Technology Industries is characterized by a high concentration of research institutes – four universities as well as the Chinese Academy of Science are represented - and close interaction between research and industry. Some 2000 high-tech companies have been set up by university staff and students. The urban environment ensures proximity to metal working, machine making and precision engineering firms. The intention is to create 100 key laboratories in fields that the country considers to be of strategic importance for future development. If this is realized, localized development would be given a strong boost.

Beijing Founder Electronics, a product of this hothouse environment, is the leading Chinese software company and one of the leading personal computer (PC) manufacturers. In a number of fields, researchers and firms in the Zone have gone beyond the stage of absorbing foreign technologies, and made a number of breakthroughs in the field of IT, mostly by former students of the Institute of Computer Sciences and Technology (ICST). This includes a mapping and conversion programme for Chinese characters, which has again led to applications in precision engineering, lasers and electronics (Lu, 2000).

3.4 The Republic of Korea

The Republic of Korea encouraged the development of large corporations (*chaebols*) that took the lead in the development of indigenous technology capabilities. The SME sector is relatively weak.

In the mid-1960s, foreign MNCs in the electronics industry, attracted by the country's cheap labour, set up plants in Korea. In 1975, Samsung began to produce wafers after buying out a small local firm run by a former Motorola engineer; twenty years later, the firm was the world leader in dynamic random access memories (DRAMs), with exports of US$ 5 billion.

3.5 Singapore

The electronics industry in Singapore has made the transition from labour-intensive to automated, and from automated to integrated manufacturing as well as from vertically integrated MNCs to dynamic, horizontally integrated local clusters. It is the most important contributor to MVA. The strategy was not based on leapfrogging technologies but on step by step advances in production that facilitate the development of technology management capabilities.

The heavy influx of foreign investment MNCs allowed Singapore to build manufacturing and technology management capabilities that matched emerging market opportunities. Skills formation was synchronized with the progression of firms along the production capability spectrum. When the point was reached that local firms and subsidiaries could develop their own design capabilities, their role in the sector became truly entrepreneurial.

Singapore's educational system has been the major factor enabling local operating units to successively pull in higher valued added production activities from the home bases of the MNCs: '...since the 1960s, the educational system has been continually restructured... Forty per cent of the graduates from polytechnics and universities are trained in engineering and technical areas... Formal education is supplemented by training in specialized training institutes to produce qualified craftsmen and technicians' (Siow Yue Chia 1998, 2-3).

The transformation has also affected Singapore's competitive advantage and business model: manufacturing-related services are becoming more and more important. These include engineering-intensive product redesign and process automation and complementary business services associated with regional coordination, procurement, development, and integration activities. The manufacturing/services dichotomy is broken down; the value chain makes place for the value network. The typical Singapore firm has become a complete business partner for its customer, packaging and integrating a number of activities.

The success of Singapore can partly be explained by the fact that its neighbour Malaysia offered abundant low-cost labour for branch plants of Singapore firms. But a Malaysian technology drive would not involve a zero sum game: technology-led growth can be beneficial to both countries if it involves the creation of stronger capabilities in both. Together, they have a great potential to develop a competitive advantage in flexible mass production in which one-piece flow is integrated with specialist design capability, so that each item produced is independently designed.

3.6 Hong Kong

Like Singapore, Hong Kong used MNCs as vehicles to develop indigenous production, organization, and technology management capabilities, and has specialized in procurement from neighbouring countries with large labour supplies. Like Singapore, Hong Kong enjoyed a rapid rate of capital accumulation by multinational companies that introduced cutting edge technologies. The absorption of these technologies required the development and diffusion of production qualifications across a wide range of firms. Crucial to the diffusion process, therefore, was the development of a broad class of product and process engineers and multi-skilled production workers.

3.7 The roots of success

The East Asian countries have shown high and sustained economic growth rates over decades. While the individual countries used different strategies and methods, each has acquired strong technology management capabilities. This is no simple task, and one that only handful developing countries have so far tackled successfully. The success stories suggest a distinctive set of prerequisites, which confirm some major findings of the previous chapter:

1. Technology cannot become a vehicle for growth by itself, it needs technology management capabilities.

2. Technologies are embedded in business organizations; therefore technology management and R&D must be centered in firms.

3. Technology management is intertwined with the development of production capabilities.

4. Skill formation must accompany technology advance.

The point of the interrelation between technology management and production capabilities is easily overlooked. The rapid introduction of technologies in the successful countries of East Asia is a consequence of the prior or simultaneous development of a specific set of production capabilities. Technology management must follow the principle of flow and associated practices that are required for flexible production systems. No amount of R&D or government incentives will have an effect on industrial growth if the business sector is not prepared for this.

The fast-moving pace of technological change, the need for a strong science base and the issue of scale pose a formidable challenge. All make the process of acquiring technology more difficult. Successful indigenous acquisition requires reverse engineering and R&D.

Of course it must be constantly kept in mind that success can breed failure, if an industry does not continuously adapt to new competitive challenges. Japan's success at developing the electronics industry through a set of intermediary agencies that targeted a core set of functions turned into a weakness once their goals had largely been achieved and the resurgent US industry had developed a new open enterprise networking system led by regions such as Silicon Valley, Route 128, and Austin, Texas.

The virtue of the cluster-based approach outlined in Malaysia's Second Industrial Master Plan (IMP2), discussed in Chapter 5, is that it relies on the country's historical attractiveness to foreign direct investment in combination with an open system business model. Put differently, one of its major aims is to link global production networks to local cluster dynamics.

4. THE ELECTRONICS INDUSTRY IN MALAYSIA

4.1 Overall growth patterns

Effectively, the start of electrical and electronics industry in Malaysia was the establishment of a Matsushita plant in 1965. The first component plant was set up by Clarion and Semiconductor established the first semiconductor testing and packaging plant in Penang in 1971. Within two-and-a-half decades, the industry employed 330,000 workers with a total output value of RM 85 billion in 1997 (roughly US$ 30 billion). The industry's exports account for over half the country's export revenue and about two-thirds of manufactured exports.

The first big wave of electronics firms was dominated by multinationals, many from Silicon Valley and Japan, seeking low wages for labour-intensive assembly branch plants. A second wave of Asian electronics firms arrived in Malaysia in the late 1980's. This was driven by the strong appreciation of the yen and the withdrawal of the generalised system of preferences from the newly industrializing countries (NICs) in Asia in 1988. The first wave of foreign investments in electronics was almost entirely devoted to components (over 80 per cent of value added until 1986), while the second wave expanded the consumer and industrial goods segments of the industry, based on component assembly. Malaysia is one of the largest importers and exporters of electronic components in the world. Table 3 (see next page) gives key figures for the development of the industry.

Statistics of the National Bank of Malaysia give an indication of recent developments in the electronics industry.

The index of electronics output dropped from 182 to 168 (1993 = 100) in 1997-1998 before recovering to 194 in 1999 and leaping to 272 in 2000. In 2001, the index dropped again to 229, recovering to 249 in 2002. Electronics exports, measured in Malaysian rupees (RM) surged from RM119 billion in 1997 to RM 162 billion in 1998, RM 195 billion in 1999, and RM 230 billion in 2000, but fell to RM 200 billion in 2001. However, given the devaluation of the RM from 2.47 to the US$ in July 1997 to 4.59 in December 1998, the US$ value of exports declined from approximately US$ 48 billion in 1997 to US$ 35 billion in 1998 before recovering to US$ 50 billion in 2000.

The spectacular growth of the industry was mainly due to the huge inflows of foreign direct investment that has generally shown an upward trend. The electronics industry accounted for 95 per cent of approved investments in 1995. Electronic components

Table 3. The development of the electrical and electronics industry

Year	Output		Employment		Exports		Imports	
	RM Billion	% Growth	No.	% Growth	RM Billion	% Growth	RM Billion	% Growth
1986	6.5	-	57,000	-	7.1	-	-	-
1987	8.9	36.9	89,000	56.1	9.2	29.6	-	-
1988	12.2	37.1	106,000	19.1	13.0	34.8	-	-
1989	15.9	30.3	123,000	16.0	17.9	38.7	-	-
1990	20.3	27.7	144,000	17.1	23.1	28.5	-	-
1991	26.1	28.6	171,000	18.8	30.4	31.6	24.7	38.8
1992	32.2	23.4	204,000	19.3	34.6	13.8	25.5	3.2
1993	42.1	30.7	231,000	13.2	46.7	35.0	32.9	29.0
1994	56.4	34.0	278,000	20.3	66.4	42.2	49.1	49.2
1995	71.0	25.9	313,000	12.6	85.0	28.0	63.8	29.9
1996	76.0	7.0	329,100	5.1	91.7	7.9	68.0	6.6
1997	85.6	12.6	343,300	4.2	107.3	17.0	75.7	11.3
1998	103.5	20.9	320,600	(6.6)	146.1	36.2	96.6	27.6
Average Annual Growth Rate 1991-1998	-	22.9	-	10.8	-	26.4	-	24.5

Source: MIDA

comprised about 75 per cent of the total investments in electronics during 1985-1996, followed by industrial electronics (16 per cent) and consumer electronics (9 per cent). Electronic components have consistently shown the largest capital investment and number of applications approved, followed by industrial electronics and consumer electronics. Table 4 illustrates this development.

Table 4. Number of electronics projects approved by electronics sub-sector

	Electronic Components				Consumer Electronics				Industrial Electronics				Total	
			Capital Investment				Capital Investment				Capital Investment			
Year	No	%	RM (mil)	%	No	%	RM (mil)	%	No	%	RM (mil)	%	No	RM (mil)
1985	17	46	104	80	9	24	4.6	4	11	30	21.6	17	37	130.2
1986	19	50	47.6	41	11	29	63.2	54	8	21	6.7	6	38	117.5
1987	29	55	264	46	11	21	145.3	26	13	25	159.4	28	53	568.7
1988	41	67	582.9	56	14	23	322.2	31	6	10	134.3	13	61	1,039.4
1989	64	58	1,375.7	68	28	25	418.9	21	18	16	228.5	11	110	2,033.1
1990	143	69	2,778.4	62	25	12	1132.1	25	38	18	567.3	13	206	4,477.8
1991	102	62	1,733	76	28	17	87.8	4	35	21	466.6	20	165	2,287.4
1992	93	60	535.5	55	38	25	249.8	26	24	15	181.3	19	155	966.6
1993	88	52	1,559.2	75	30	18	107.8	5	51	30	413	20	169	2,080
1994	92	52	4,606.3	88	41	23	138.1	3	43	24	472.8	9	176	5,217.2
1995	95	55	943.5	31	29	17	202.8	7	50	29	1,942.3	63	174	3,088.6
1996	118	61	11,159.5	92	28	15	280.8	2	46	24	670.9	6	192	12,111.2
1997	71	53	4,755.20	88	18	14	52.6	1	44	33	582.9	11	133	5,390.70
1998	49	40	1,071.90	65	26	21	208	13	46	38	370.2	22	121	1,650.10
Total	1,021		31,516.7		336		3,414		433		6,217.8		1790	41,148.50

Source: MIDA

Many of the world's largest semiconductor makers, including Intel, NEC, Motorola, AMD, Hitachi, Texas Instruments, Fujitsu, Samsung, Hewlett Packard and Intersil have operations in Malaysia.

In parallel with a shift in output, which will be discussed in section 4.2, trade patterns since 1990 show a shift from low value added components to certain categories of higher value added items, the most conspicuous growth taking place in computer exports. A breakdown of exports is shown in Table 5.

Table 5. Electronics exports (RM million, FOB)

Code	Description	1994	1995	1996	1997	1998
751	Office equipment	542	571	514	458	504
752	Automatic data processors	3089	5479	9874	16277	21078
759	Replacement parts 751&752	9508	11954	12261	14937	24122
761	TV receivers	4528	5614	5242	4601	5270
762	Radio receivers	7421	8738	7713	6898	7947
762	Sound recording & reproducing equipment	6008	7000	6966	6278	7430
764	Telecommunications equipment	8258	9489	9982	11543	14561
771	Electrical machinery	1316	1351	1334	1564	1720
772	Electrical apparatus	2272	3011	3983	4980	9714
773	Electrical parts	699	884	1076	1028	1264
774	Electrical medical equipment	6	14	19	27	52
775	Appliances	505	578	657	732	871
776	Valves, tubes, photocells	24816	33197	35509	40887	54483
778	Electrical parts	1463	1788	1672	2130	3057
	Total	70431	89668	96802	112340	152073

Source: BNM, various issues

Table 6 illustrates the industry's high dependence on imported components. But a comparison with the previous table also shows a trend towards an improved trade balance for electronics. Among others, the tables show that Malaysia became a net exporter of electrical apparatus and parts in 1998.

Table 6. Electronics imports (RM million, CIF)

Code	Description	1994	1995	1996	1997	1998
751	Office equipment	218	269	219	204	119
752	Automatic data processors	1052	1425	2370	3165	3733
759	Replacement parts 751&752	3677	5367	7363	10220	9979
761	TV receivers	99	78	44	39	36
762	Radio receivers	257	284	298	211	161
762	Sound recording & reproducing equipment	364	378	161	139	132
764	Telecommunications equipment	7609	9083	7752	8382	7463
771	Electrical machinery	1765	1753	2083	2213	2561
772	Electrical apparatus	6512	6806	6755	7364	9428
773	Electrical parts	1315	1563	1442	1553	1256
774	Electrical medical equipment	93	135	183	197	293
775	Appliances	391	424	344	283	242
776	Valves, tubes, photocells	28146	39258	42334	45812	64201
778	Electrical parts	4024	4671	4744	5262	5645
	Total	55522	71494	76092	85044	105249

Source: National Bank of Malaysia

In the global value chain, Malaysia finds itself in the same category as China and Thailand, behind the Republic of Korea, Taiwan and Singapore. Malaysian firms are still far from the stage achieved by the major transnational electronics firms, who tend to concentrate on R&D and maintaining the global market position of their brands, subcontracting other activities. The continuing heavy dependence of assembly is a threat to Malaysia's position, as the People's Republic of China is a major low-cost competitor. Thailand and the Philippines both also enjoy a cost advantage over Malaysia.

4.2 Product groups

Over the years, the output structure of the Malaysian electronics industry has shifted away from components, although this is still the major product category. After peaking in the early 1990s, the output of consumer electronics has decreased again. By 1998, electronics components accounted for 44.6 per cent of output, industrial electronics for 41.3 per cent and consumer electronics for 14.1 per cent. The range of equipment produced is shown in Table 7.

Table 7. Main electronic products made or assembled in Malaysia

Semiconductor devices	Other electronic components	Consumer/industrial electronic equipment
Linear and digital integrated circuits,	Capacitors, headframes, switches, resistors	Colour TV receivers
Memories and microprocessors	Relays, coils, quartz crystals	Audio products
Opto-electronics	Oscillators, magnetic heads	Video cassette players and recorders
Discrete devices	Connectors, transformers	Paging systems, walkie talkies
Hybrids	Wire harness	Telephone sets
Arrays	Disc drive parts	Digital transmission equipment, satellite receivers
High-reliability military products	Audio cassette mechanisms, micro motors, circuit boards, etc.	Personal computers, monitors, CD-ROM drives, Keyboards and printers, Telecommunication equipment

Semiconductors and other components for computers and telecommunications equipment are by far the most significant segments of the electronic components sector, accounting for approximately 80 per cent of total production. Assembly and final testing activities dominate the component production. Local firms (Unisem, Carsem and Globetronics) have been started by former staff from foreign plants undertaking these activities, and in this way know-how has been transferred. But the activities, and therefore the know-how, have so far not included the high value added operations in the industry.

Although the government has given much encouragement to wafer fabrication in Malaysia, it is still limited to largely experimental production at Malaysian Institute of Microelectronics Systems (MIMOS). Two joint-venture chip-fabrication firms, 1st Silicon in Sarawak and Silterra in Kulim, were producing 0.25 micron and 0.18 micron wafers by 2001.

Semiconductors are used in a very wide range of end products, as Figure 4 shows (please see next page). Computers are by far the most important of these. The rapid growth of complementary industries – hard disk drives, CD ROMS, micro-processors, etc. – has boosted the semiconductor industry worldwide. Malaysia's computer industry is still comparatively small, but nevertheless it is growing rapidly, as the export figures show. The international personal computer market offers great opportunities for further expansion.

Electronics contract manufacturers (ECMs) also have a good growth potential. They do not supply goods under their own brand names, but offer specialist production and design capabilities to electronic market leaders that are moving out of these operations. The demand for these capabilities is estimated to have grown by 25 per cent yearly during the 1990s.

A few local companies in Malaysia are ECMs; prominent among them are Globetronics, Shinca, Trans Capital, Unisem, Carsem, and Unico. But plants of foreign MNCs have superior process capabilities and are better able to cope with increasingly rapid technology, design, product and market changes because of direct connections with their overseas plants and networks. Among the most important technological issues with which many local firms cannot cope are the growing requirements to:

- Develop new packaging designs to accommodate higher pin counts and increasing integration in smaller components.

- Develop technological competence to respond to quick changes and overcome the problems of product obsolescence.

- Develop efficient production capabilities that are agile and swift to meet changes in product design.

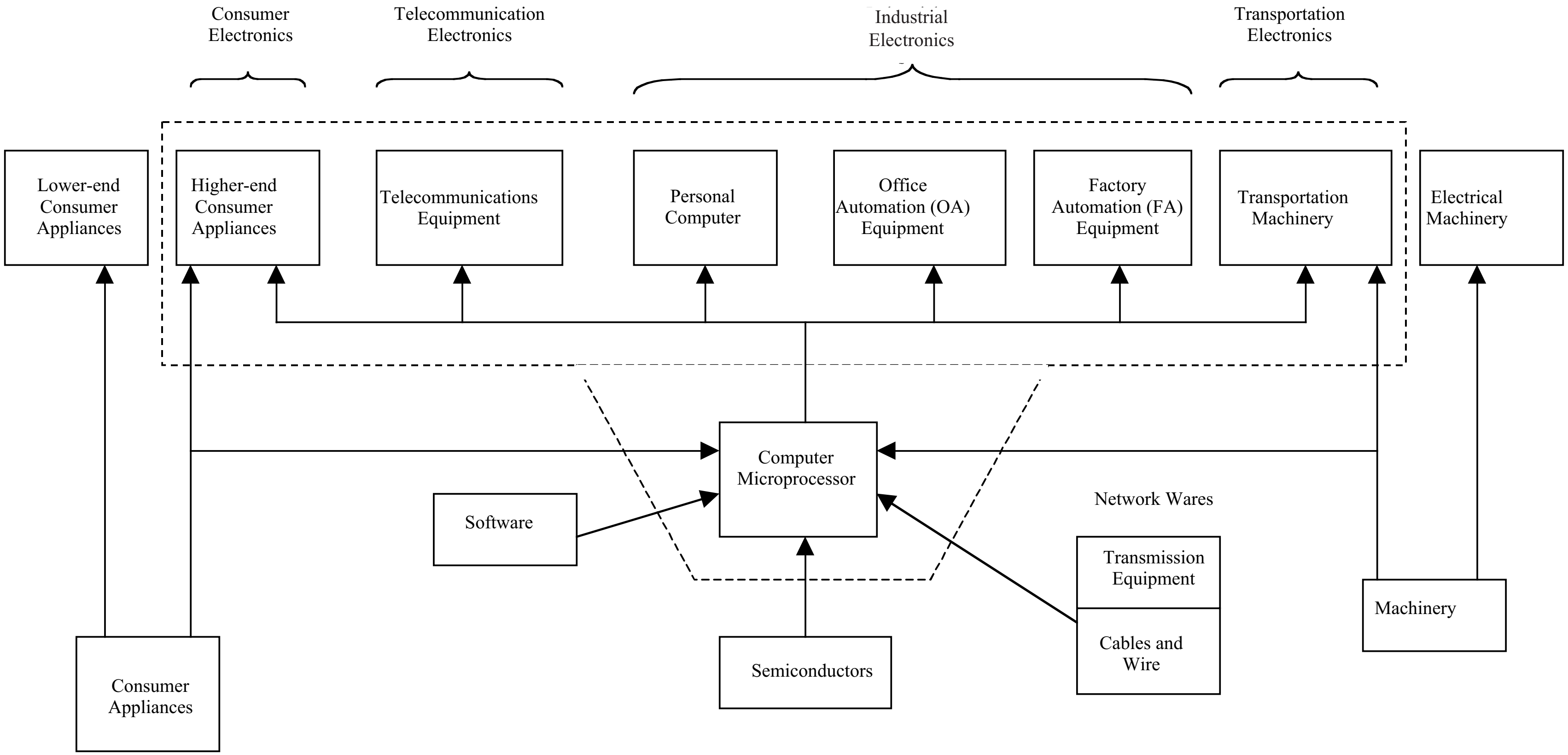
4.3 Innovation

In terms of product innovation, the most innovative firms in Malaysia are the MNCs, who have access to R&D capacities at headquarters. Local firms have been limited to less sophisticated products. But there are local firms, such as Sapura, which have developed in-house product innovation capacities and improve on existing products – in the case of Sapura, voice-activated telephones. Interviews with 26 electronics firms in 1999 showed that very few firms undertook R&D.

Innovative product design is likewise dominated by MNCs. There is some evidence of diffusion and the development of design capacity in local firms. Sapura has a special research unit, and among others recruited two key R&D engineers who worked for MNCs.

With regard to process innovation, there are more signs that Malaysian firms are near the cutting edge, at least in the area of assembly and test operations. All component firms interviewed in 1999 had introduced process improvements that made them leaner and more flexible, helping them to meet market fluctuations. Diffusion from MNCs to local firms is taking place.

Figure 4 Product groups in the Malaysian electronics industry



The development of local vendor capacities has resulted in a gradual sharing of development tasks between Intel and Malaysian firms. Advanced Micro Devices, Motorola Malaysia, Hewlett Packard, Hitachi Semiconductor and Litronix are also involved in joint innovation with local firms, though less intensively.

While Malaysian firms are on the whole not yet ready for major innovations, incremental innovation, especially in the form of minor improvements, is quite common. All producers of components consider their work force capable of minor improvements in the way in which work is organized, lowering costs. The MNCs systematically encourage employees at all levels in this respect. Formal and informal channels tap and direct the innovative capacity of staff.

Case studies of rapidly growing, locally owned innovative firms, providing clues to the new firm creation process within the Malaysian context, can be found in Annex 1.

5. ELECTRONICS INDUSTRY LOCATIONS AND CLUSTERS

5.1 Overview of the regions

The main strengths of the Malaysian electronics industry are in two areas. In the North of the country, a world class capability in the assembly and testing of semiconductors and components, computers and peripherals, machine tool support, and consumer electronics has been created around Penang. In the Klang Valley in Central Malaysia, where Malaysia's first electrical goods/electronics firm was set up in 1965, the focus is on components, telecommunications and consumer electronics. Central Malaysia is to become a global centre for IT under IMP2, through the Multimedia Super Corridor (MSC) project (see Section 6.3).

In addition, Johor has built up an electrical goods industry and in recent years electronics factories have been established in this state. Because of its location in the south of the country, it benefits from spillovers from both the Klang Valley and Singapore.

Sarawak and Sabah were late starters in the electronics industry, the first firms being set up in the 1990s following efforts by the Government to move labour-intensive firms to the Eastern Corridor and East Malaysia through Pioneer Status and Investment Tax Allowance incentives (see Section 6.1). Most of the plants operating in Sabah and Sarawak are labour-intensive.

The first wafer fabrication plant at Sama Jaya Free Industrial Zone (FIZ) in Sarawak, 1st Silicon, became operational in 2000. It might have a snowball effect and attract other wafer fabricators. This joint venture between the State of Sarawak and Khazanah Holdings uses the latest technology. It can attract similar investments, acting as a catalyst and removing the risks associated with new operations if adequate infrastructure investment takes place and efforts are made to develop the supplier base.

Because the electronics industry has only recently started to develop in Sarawak and Sabah, the following sections will concentrate on Penang and the Northern region, the central region and Johor.

5.2 Regional capabilities

Penang and North Malaysia

Many supplier firms in Penang have passed through the second and third stages of technology absorption and diffusion. The first phase of technology absorption involves the use of imported equipment and material in production. The second and third phases deal with adaptation and re-manufacturing of equipment and materials respectively. Firms reach the fourth stage when they acquire original equipment manufacturing (OEM) status. Several of Penang's supplier firms have developed their own process engineering and OEM capabilities. Eng Teknology and Atlan have become regional MNCs with subsidiaries in Indonesia, Thailand, Philippines and China.

The high level of technology diffusion in Penang compared to other states in Malaysia is due to a much higher proportion of local outsourcing by MNCs and local firms. An active, coordinated location policy pursued by the Penang regional government and the Penang Development Corporation (PDC) attracted foreign firms specializing in a variety of electronic products, which again resulted in a potential for synergies. Some of the MNCs helped spawn local suppliers. Intel, Motorola and Dell are exceptional in their commitment to local innovation and opportunities for driving cluster dynamics. They are developmental firms within the Penang context, in that they have enhanced the skill and entrepreneurial base of the region, which is a prerequisite for an endogenous process of technological diversification and sectoral speciation.

A very important factor is also the number of scientists and engineers, which is several times the Malaysian average. In addition, the Penang Skills Development Corporation (PSDC – see Box 2 on page 50) has become a major factor in supplying qualified labour to the region's enterprises.

Intel supported the modernization of companies such as LKT, Metfab, Prodelcon, Rapid Synergy, SEM and Eng Teknologi and former Intel staff founded Shintel, Samatech, UNICO, Globetronics and Shinca (see Box 1). Motorola was instrumental in the modernization of Wong Engineering and the opening of BCM. Dell has its Asian headquarters in Penang. Dell products made in Penang are first generation products. This increases the challenges and opportunities for local suppliers.

Box 1. Eng Technology and UNICO – two Malaysian operators in global markets

Eng Technology reported holding 26 per cent share in the worldwide disk drive actuator (a precision component) market in 2000; its customers are the who's who of the world disk drive and semi-conductor industry (Rasiah 2001). The firm was created in 1974 to provide jigs and fixtures. It graduated to precision die sets and tooling for the rapidly growing electronics industry. In 2001, Eng Technology consisted of five main subsidiaries employing 500 people. It is also involved in a series of joint ventures in Penang, the Philippines, Thailand and China supplying actuators on a JIT basis.

Intel Cooperative established UNICO in 1992; the first product was the assembly of motherboards for Intel Penang (P. Lim 1991; K.H. Lim 1997). Several Intel managers were seconded during the start up. Management has rapidly integrated upstream: from a printed circuit board assembler, UNICO became an original equipment manufacturer (OEM) and own-design manufacturer (ODM) box product manufacturer through alliances with companies in Canada and Europe. In 1996, UNICO signed four joint venture agreements to manufacture PC workstations, Pentium notebook computers, modems, CD-ROM drives, and digital enhanced cordless telephones. UNICO expected to become a US$ 1 billion firm by 2002.

New firm creation helped increase the extent of specialization in Penang, and a network of second and third tier suppliers, from which large suppliers source their components, now exists, which also includes firms in the metalworking, machinery and plastics industries. In 1998, local sourcing as a share of total purchases by 10 major firms was 40-50 per cent for consumer electronics, 4-10 per cent for semiconductor components, 20-40 per cent for other electronics components and communication equipment and 13-60 per cent for computers and peripherals.[1]

In Penang an industrial cluster has emerged, but the lack of progress towards new product development capabilities (TM 4 and TM 5 in Table 1) and of an open-systems business model is limiting growth, which is also slowed down by rising production costs and increasing competition from China and the Philippines. In spite of encouraging developments such as the opening of the first independent design studio, Altera, skills needed for operations like chip design, systems integration and applications engineering remain in short supply. If the Penang cluster is to become a driver of a productivity-based development strategy, the production and organizational capabilities of industrial enterprises must be further upgraded and more efforts are needed to ensure an adequate supply of relevant skills.

Central Malaysia

In the early years of the electronics industry, the Klang Valley benefited greatly from the location of the capital Kuala Lumpur in the valley: it received strong federal support and support from the Malaysian Industrial Development Authority (MIDA). Matsushita, the first electronics MNC to locate in Malaysia (in 1965), selected the Klang Valley. In later years, Negeri Sembilan and Melaka benefited from the spillover effects from expansion in the Klang Valley, when a number of MNCs seeking sites with cheaper land and lower wage costs relocated there.

The concentration of electronics firms and institutions in the region offers considerable scope for clustering, but the central region lacks network cohesion – it is a loose agglomeration of firms and institutions. The region has a large production capability in consumer electronics and related components. However, most of the parts and components are sourced from global production networks coordinated at the headquarters of MNCs, which includes parts sourced from subsidiaries in Malaysia, or Malaysian firms in Penang. Interviews with 16 firms in the central states by Rajah Rasiah and Colin Chang (1999) suggest that MNC electronics component firms source only 2-10 per cent of their inputs locally, and in a number of cases the firms involved are JVs with enterprises from Singapore and Taiwan.

A study of the linkages between four electronics companies and four local and indigenous suppliers in the Klang Valley (Rasiah 1999a) found that the latter has evolved little over the years:

> 'The first-tier local vendors (those who had the first links with the electronics sector firms) still perform low-end activities outsourced by MNCs. Few second

[1] Data derived from Penang Development Corporation surveys.

> tier firms exist. When they do exist, the first-tier firms are either owned by Japanese firms, or both the first and second tiers are owned by Taiwanese, Singaporean and South Korean firms. Hence the division of labour between firms is very low, while within firms high.'

Part of the problem is the comparative passivity of the state economic development corporations (SEDCs) in promoting regional dynamism (MIDA is a national agency). As a senior officer of Motorola put it:

> 'Private firms generally do not individually search and canvass for greater inter-firm collaboration and sourcing... It was possible in Penang because of the dynamic role of PDC, which created deliberation councils and took on a proactive role of promoting and matching firms. We will be glad to assist if some reliable organization assumes such a role here.' (Rasiah and Chang1999)

Only a small number of domestic firms, in short, is integrated in supplier networks with MNCs, and none supply core components. Local supplier firms' areas have hardly passed the first or adoption stage of technology transfer, and even when MNCs have been involved in supplier upgrading this has tended to focus on low-tech activities. (Some additional assistance comes through the support of business councils representing the different foreign nationalities. Examples include Japan's JETRO and JACTIM and the American Business Council. The Japanese, German and French have promoted their own training centres in the Klang Valley – see Annex 2) Most firms have not developed beyond TM2 (see Table 1) yet and concentrate on process improvements. Because of their low technology level, the local firms do not outsource much themselves. They are not exporting directly.

There are some fairly large local firms, but these tend not to have links with MNCs, apart from the fact that former MCS staff has been instrumental in their growth. These firms include Sapura and OYL Electronics, producers and exporters of telecommunications equipment and air-conditioners, respectively. In addition, there is Unisem in Perak, a chip assembler. There is quite a large number of MNC staff now who would be potential independent entrepreneurs, and a more active attitude of the State Economic Development Corporation (SEDC) could result in a larger number of start-ups. But, as elsewhere in Malaysia, the supply of technical and R&D personnel would have to be increased to create a critical mass for technological innovation. The Selangor Human Resource Development Centre (SHDRC) is an attempt to bridge the human resource gaps, but it has not been very successful in doing this so far.

Johor

The prime motivation for relocating electronics industries to Johor was the need to shift labour-intensive production stages out of Singapore from the late 1970s onwards. The process was speeded up after the launching of the Singapore-Johor-Riau (SIJORI) growth triangle in 1989).

The Johor region has a high-volume production capability particularly in computer peripheral and consumer electronics assembly, which has spread to printed circuit boards, disk drives, television sets, video and audio equipment and, more recently, to capacitors, resistors and other components. Activities in Johor firms are generally at the bottom end of the electronics value added chain, even though they have increasingly become automated due to rising wage costs. An even smaller number of firms in Johor has developed beyond TM2 (see Table 1) than in Klang Valley. None of the MNCs are involved in formal product R&D. Minor adaptations and process development are the most sophisticated activities.

Some of the local firms in the region supply MNCs, but all are limited to non-core components. MNCs have not done much to upgrade local suppliers. Many of them use advanced manufacturing methods, but when they need specialized components, these are sourced elsewhere. There are few connections among the many plants. The bigger and more successful local and indigenous firms tend to have few production links with MNCs. The absence of developed open business networks is an obstacle to network development in the state and has also limited the developmental roles exhibited by MNCs in other locations.

Intermediary organizations such as the Johor SEDC are not active enough in gathering and disseminating information, identifying and addressing common needs, evaluating production capabilities as well as opportunities for technology and skills development, R&D, and networking. An official from the SEDC reported:

> ‘We rely considerably on Singapore’s promotional efforts. Singapore spends heavily on promotion, while we absorb some of the synergies because of our close location and to the division of labour that has emerged in the industry. Our activities do not stretch to co-ordinating firms’ activities. We only do that when we have equity participation in the firms. As for others, we see it as getting too involved in activities outside our area. If firms establish strong linkages in Johor, that is good for us. But it should come from firms’ own initiatives’. (Rasiah and Chang, Interview 1999)

Johor lacks an adequate supply skilled workers and professionals, part of the problem being migration to Singapore. Here again, the state authorities and institutions could be more active, among others in trying to attract experienced managers and technical specialists back from Singapore. Staff training in companies is also limited, although there are some exceptions such as ST Microelectronics (formerly SGS-Thomson), Seagate and Solectron. This is another obstacle to technological capability building.

5.3 Clustering and innovation: strengths and weaknesses

The strengths and weaknesses of the three regions can be summarized as follows.

Penang and North Malaysia

Strengths: a well-developed manufacturing base, enterprise networks

- Penang offers MNCs a powerful production platform.
- MNCs have developed world class manufacturing capabilities in single-product mass production, with a number of examples of multiple product flow.

- MNCs from the USA tend to rely on the focus and network business model, horizontal integration, collective learning, and private-public partnering for skill formation and technology management.

- An open system industrial district is emerging in which virtually all the activities required to rapidly develop high-volume production on a JIT basis are co-located.

- The electronics industry is driven by MNCs that participate in product-based competition. These forces can be used to strengthen local capabilities.

- PDC is an exemplary intermediary organization, acting on collective needs and helping local firms to seize the development opportunities created by the MNCs.

- The PSDC is an outstanding example of private-public co-operation to meet industry's external skills demands.

- Company skill formation has created a strong "invisible college", which has considerably increased the region's social capital.

- Some local capabilities in new product design have been developed; with the right strategy, the region could move further into sophisticated technological services.

- Strong networking relationships. Some of the partnering capabilities found in Silicon Valley have been transplanted under the guidance of the PDC.

- Higher than average supply of scientists and engineers.

Weaknesses: inadequate innovation and human capital formation

- There is a shortage of technical and engineering personnel, even though business networks in the state have helped to co-ordinate salary scales and staff hiring, reducing staff poaching.

- Penang lacks an adequate stream of innovators – individuals, firms and institutions – to generate the rapid innovations necessary to move to TM4 and TM5.

- Unless supplier firms become world-class process and product innovators, Penang will not be able to achieve the extent of differentiation and speciation achieved in Taiwan.

- Penang lacks venture capitalists (whose emergence should be stimulated by the local open system with its strong networking relationships), which is an obstacle to creating or attracting new innovative firms.

The Kelang Valley and Central West Malaysia

Strengths: a well-developed manufacturing base

- The central region offers MNCs a powerful production platform with a good infrastructure, political stability and long experience in electronics production.

- MNCs have developed world-class mass production capabilities including JIT and TQM systems.

- Many large companies invest heavily in shop-floor skills. With the right policy, the potential created can be utilised to spawn a critical mass of dynamic firms.

- MNCs have quick turnaround capabilities and the federal administrative authorities deal quickly and favourably with requests related to infrastructure and legal issues.

- Some indigenous firms in the Klang Valley firms have built high volume production capabilities and have increasing R&D, technology acquisition, and technology management capabilities, stimulating other local firms.

Weaknesses: weak networks, innovation and human capital formation

- The institutional mechanisms in the region have not seized the development opportunities offered by the presence of MNCs or stimulated inter-firm links and systemic networks between firms and institutions.

- Partly for this reason, the electronics industry is a loose configuration of firms with weak supply networks, and certainly no horizontal networks. The extent of differentiation and division of labour among firms in the central region remains limited.

- The lack of institutional support in the region has restricted the number of experienced staff creating new firms.

- Skills development centres in the individual states are not meeting the demand for industry-level skills, and firms complain about the ineffectiveness of various other, national training institutions and funds.

- The lack of professional skills among others seriously limits research into market opportunities and developments.

- The Klang Valley has most of the universities in the country, but there is little R&D for the electronics industry, which tends to be restricted to process development activities.

- Malaysian firms lack access to venture capital.

Johor

Strengths: an attractive region for re-location of labour intensive production

- Johor offers MNCs a powerful production platform, with good infrastructure, political stability and over 20 years of electronics production experience.

- Some MNCs have world class manufacturing capabilities (mass production and process improvement capabilities, including JIT and TQM systems).

- Johor's location attracts low value added labour-intensive activities from MNCs in Singapore.
- MNCs enjoy quick turnaround capabilities. Administrative co-ordination between Johor and Singapore has been smooth, although the SIJORI growth triangle at present lacks a customs union.
- Johor has a skilled and professional labour force, which, with the right policy, could form the basis for innovative new firms in the state.

Weaknesses: weak networks, innovation and human capital formation

- Few MNCs are located in Johor, and inter-firm networks have hardly evolved. Most firms are at the bottom of the production capabilities spectrum. Horizontal integration, inter-firm differentiation and technological variation between local firms have been limited. A vertical division of labour between local firms generally does not exist. Local and indigenous firms have not been able to meet the rising precision demands of MNCs. As a supplier base, Johor has mainly been serving Singapore's needs.
- The Johor SEDC has not actively identified and promoted the collective needs of firms to seize development opportunities created by the presence of MNCs.
- The business-government coordinating and deliberation council has been passive, limiting the extent of private participation in government planning, among others in the field of industry-level skills training.
- Johor's Industrial Manpower Training Center (Puspatri) offers training programmes but firms say coordination and response has been disappointing. Involvement from, especially, SMEs has been low.
- The deficit in technical and engineering personnel is made worse by the steady brain drain caused by the higher salaries offered in Singapore.
- Johor has only one university, the Universiti Teknologi Malaysia, and electronics industry-driven R&D generated by this university is still limited, with a focus on process development.
- Local and indigenous firms involvement in market prospecting and market development research is underdeveloped.
- Venture capital is not available and the state government is not active enough in stimulating its emergence.

6. THE POLICY AND SUPPORT FRAMEWORK

6.1 The First Industrial Master Plan

The First Industrial Master Plan 1986-95 (IMP) of the Ministry of International Trade and Industry (MITI) had three broad objectives:

- To ensure the continued expansion of the economy through the accelerated growth of the manufacturing sector;
- To promote the optimal and efficient use of the nation's natural resources through value added manufacturing; and
- To lay the foundation for the development of indigenous technological capabilities.

Fiscal incentives – many of them created in the 1960s and 1970s to attract labour-intensive investments by large foreign firms - were key instruments in realizing the objectives of IMP. Their effectiveness is in some respects limited by inadequate Government capacity to monitor their impact on enterprise decisions and activities. As from 2003, export incentives will have to be phased out under WTO and AFTA agreements. Others, such as training and R&D incentives, can no longer give preferential treatment to domestic firms. The incentives that still apply are discussed below; in addition, the institutional support infrastructure created will be discussed briefly.

Pioneer Status (PS) and the Investment Tax Allowance (ITA) are incentives offered by the Malaysian Government to projects under the 'promoted product' or 'promoted activity' categories. Since the late 1980s, the emphasis has been on strategic and high-tech industries rather than volume of investment and jobs created. Under PS, an approved company can obtain tax exemption on 70 per cent of is statutory income for a period of five years, commencing from the date of production. Under ITA, the tax allowance is 60 per cent, also for a period of five years. For companies located in the states of Kelantan, Pahang, Terengganu, Sabah and Sarawak, higher rates apply for similar periods. This is intended to stimulate the dispersal of industry, but most industries are still found in Penang, Kedah, Selangor, Negeri Sembilan and Melaka in the western corridor of peninsular Malaysia.

High-tech companies must meet the following conditions in order to qualify for the above incentives:

- local R&D expenditure to gross sales should be at least 1 per cent on an annual basis. Companies are allowed a period of 3 years from date of operation to comply; or

- the percentage of science and technical graduates in total work force should be at least 7 per cent.

Some investments, such as strategic investments of national importance qualify for full exemption under PS and ITA. The criteria to qualify for strategic project status are:

- Investment of more than RM100 million;
- Integrated manufacturing activities;
- Backward and forward linkages;
- High-tech products;
- Approved R&D facilities.

The Reinvestment Allowance (RA) is granted to manufacturing companies for the expansion of production capacity, modernization and upgrading of plant and machinery, and product diversification. It takes the form of a tax allowance of 60 per cent of capital expenditure incurred, but full deductions are possible in case of very significant investments. This incentive is important to the electronics industry because of its rapidly changing technologies, shortening product cycles, and intense global competition. The incentives offered by the RA should be re-assessed in the light of industrial promotion efforts by lower wage countries like the People's Republic of China, India and Philippines.

R&D activities in Malaysia can qualify for a range of tax incentives that include the following:

- ITA of 50 per cent on qualifying capital expenditure incurred within 10 years;
- Double deduction on expenditure incurred for R&D, including the use of services of approved research institutes, R&D companies or contract R&D companies, as well as on cash contributions to research institutes;
- Buildings used for the purpose of approved R&D;
- Capital allowance on capital expenditure for R&D; and
- Machinery/equipment, materials, raw materials/component parts and samples.

In addition, there are significant financial incentives for R&D:

- The Technology Acquisition Fund (TAF), helping Malaysian industries to obtain strategic technology from foreign sources;
- The Industry R&D Grant Scheme (IGS), encouraging Malaysian companies to be

more innovative in using and adapting existing technologies and creating new technologies, products and processes;

- The Commercialisation of R&D Fund (CRDF), enhancing competitiveness and promoting the commercialisation of indigenous technology.

- The Intensification of Research in Priority Areas (IRPA) fund, supporting basic research in Malaysian universities and other research organizations. Under the Seventh Malaysia Plan (1996-2000), the Malaysian government allocated sum of RM 1 billion to IRPA, but it was superseded by grants supplied through the Eighth Malaysia Plan launched in 2001.

While grants for R&D are available to contract R&D companies, R&D companies providing R&D services in Malaysia to other companies and in-house R&D, only the last type is common in Malaysia.

For training and skills development, five different types of incentive are available. The most widely used in the Human Resource Development Fund (HRDF), coordinated by the Human Resource Development Council (HRDC). It requires firms with 50 or more employees to contribute 1 per cent of their payroll to the Fund, which they can then use to reclaim approved training expenses. The HRDF surplus maintains the administration and subsidises training in SMEs. This mechanism actually supports MNCs indirectly, as SMEs can become local suppliers. A similar fund is being considered for SMEs with more than 10 employees and a paid-up capital of up to RM 2.5 million. SMEs, however, qualify for twice the amount of money paid in.

The 1 per cent payroll penalty is a strong incentive to increase training. In addition to the training required by the move towards flexible production systems, the HRDF and its predecessor were reported as being instrumental in pushing MNCs such as Intel and Motorola to start their own training centres as well as supporting the formation of the Penang Skills Development Centre in 1989 (see Box 2). Indigenous electronics firms are still far behind in this respect.

Box 2. The Penang Skills Development Centre

The Penang Skills Development Centre (PSDC) was the result of joint efforts of the State Government of Penang, the Penang Development Corporation and industry, in particular MNCs. No less than 24 firms were founder members of the PSDC. The mission of PSDC is to promote shared learning in manufacturing and service industries through HRD initiatives.

By 1998, the Centre had 81 member companies employing 75,000 workers. The Management Council has members from government, industry and the education sector. All companies are entitled to send representatives to the Training Committee, which is subdivided into sub-committees whose task include overseeing training needs analysis and definition, the preparation of an annual programme, evaluating feedback and the effectiveness of courses, encouraging resource sharing among members, and support to fund-raising activities. By 1997-1998, the number of courses had increased from 32 to 495, and nearly 40,000 employees had followed courses.

Other training incentives include:

- Double deduction of expenses incurred for approved training (for firms with less than 50 employees);

- Deduction of contributions in cash to a non-profit technical or vocational training institution;

- Exemption from import duties, sales tax and excise duties for imported machinery, equipment and materials used for training personnel;

- ITA for new investment to upgrade training equipment or expansion of training capacities.

The Government also supports vendor development. To promote linkages between large foreign or domestic firms and local SMEs, tax deductions are available for the expenses of employee training, product development, testing and factory auditing. Vendors can be given pioneer status for five years, or for 10 years if the scheme enables them to achieve world-class standards in terms of price, quality and capacity. During this period, the costs incurred are fully deductible.

The Government is encouraging the establishment of international procurement centres (IPCs), which are locally incorporated companies of local or foreign owners whose activity is business-business trade. Through the IPCs, the Government intends to make Malaysia a major distribution centre. The incentives are available to locally incorporated companies under the Companies Act 1965, with a minimum paid-up capital of RM 0.5 million, a minimum total business spending of RM 1.5 million per annum, and a minimum annual business turnover of RM 100 million. Goods must be handled directly through Malaysian ports and airports.

The incentives include:

- Approval of expatriate posts needed for the IPCs;

- One or more foreign currency accounts with any licensed commercial bank to retain export proceeds without any limit;

- Entering into foreign exchange forward contracts with any licensed commercial bank to sell forward export proceeds based on projected sales;

- Exemption from the requirements of the Ministry of Domestic Trade and Consumer Affairs guidelines on foreign equity ownership on wholesale and retail trade;

- Duty-free imports of raw materials, components, or finished products into Free Industrial Zones (FIZs) or Licensed Manufacturing Warehouses (LMW) for repackaging, cargo consolidation and integration before distribution.

Finally, there was a wide rage of export incentives in Malaysia. As indicated above, these will have to be phased out from 2003 under WTO and AFTA agreements.

An institutional infrastructure to stimulate technological upgrading has been set up in Malaysia, partly to encourage technology transfer, partly to stimulate R&D. Apart from some state-level development agencies which play an active role in technology promotion (see Chapter 5), important elements in this infrastructure include:

- The Kulim and the Bukit Jalil Technology Parks, established in the early 1990s. The Kulim Hi-Tech Park (KHTP) in Kedah houses corporate, academic, and government tenants specialising in R&D activities related to electronics. It has benefited from spill over effects from Penang's electronics industry. Tenants include firms like Intel Products, Empak, Fuji Electric, MEMC Electronics Materials and Hitachi. The Bukit Jalil High Tech Park is one of the locations designated under the MSC project (see Section 6.3) to attract knowledge-based IT companies.

- The Technology Transfer Unit (TTU), started in 1975 within the Ministry of Trade and Industry to coordinate technology transfer agreements. TTU began screening investments in the late 1980s.

- The Technology Councils, on which both the public and private sector are represented. These play an important role in technology governance, assisting firms in catching up and moving towards the technological frontier. The leading example is the Penang Industrial Co-ordinating Council (PICC). Similar councils have suffered from a lack of participation from industrial partners. The Malaysian Industry-Government High Technology (MIGHT) has been charged with creating stronger partnering networks.

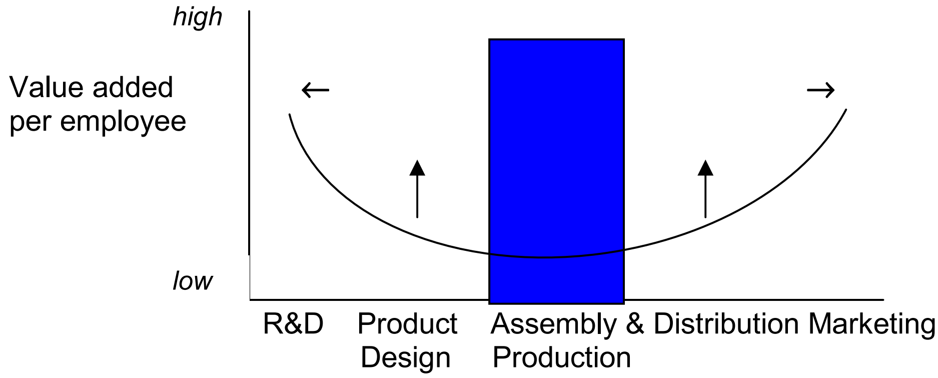
- The recently privatized Malaysian Institute of Microelectronics System (MIMOS). It supports start-ups in the electronics industry, with the assistance of the Malaysian Technology Development Corporation (MTDC) whose task is to identify and financially support promising high-tech firms or projects. Its small wafer fabrication plant, facilities for testing and packaging, and initiatives for design, innovation and R&D, act as a catalyst for spin-offs. MIMOS is situated in the MSC area and will coordinate efforts with the Government on the future direction of the electronics industry.

Annex 2 provides additional information on institutional support.

6.2 The Second Industrial Master Plan

The goal of IMP2 is that Malaysia will be an advanced industrialised nation by the year 2020. IMP2 builds on the successes of the IMP. At the core of IMP2 is the concept of the 'Manufacturing ++ Strategy'. This 'entails not only moving along the value chain but more importantly will place emphasis on productivity-driven growth, such that value added per employee improves to a higher plane at all levels of the value chain' (MITI 1996, 31). Figure 5 shows how an overall increase in value added per employee is to be combined with a move towards higher value added activities including R&D and marketing.

Figure 5. The 'Manufacturing ++ Strategy'



Source: IMP 2

To attain its goal, IMP2 identified the following strategic directions for the electronics industry:

- *Developing the value chain*. The IMP2 strategy is to encourage the MNC's to increase higher value added activities in Malaysia through:
  - The encouragement and establishment of integrated manufacturing centres;
  - A review of the laws governing Free Zones (FZs) and Licensed Manufacturing Warehouses (LMWs); and
  - A review of fiscal obstacles to the establishment of operational headquarters, world headquarters and international procurement offices in Malaysia.

- *Deepening the supply chain*. The focus here is on the development of capacities in indigenous firms through:
  - Vertical and horizontal strengthening of supply chains;
  - Encouraging cluster building; and
  - Reviewing equity and export conditions.

- *Moving to a higher technology plane*. The acquisition of essential new technologies and core competencies are critical for R&D, product development activities, and to enhance productivity. This it to be achieved by:
  - Acquiring capabilities to design and produce wafers;
  - The development of local technological capabilities; and
  - Providing specialised technology parks for high-tech industries.

- *Developing the information technology (IT) and multimedia industry*. IMP2 expects this sector to be the next engine of growth and has identified the following applications for development in the MSC (see Section 6.3), all of which offer great opportunities to indigenous electronics producers:

- Electronic government;
- Telemedicine;
- R&D;
- Remote manufacturing;
- Borderless marketing centres;
- Multimedia funds haven;
- Multipurpose smart cards; and
- Smart schools.

- *Developing world-class Malaysian-owned companies*. Malaysia now has many companies that meet international quality standards. These standards can be used to create world-class and world-scale producers and suppliers. IMP2 wants to achieve this by:

  - Supporting indigenous subcontracting companies to become original equipment manufacturers (OEMs) and original brand manufacturers (OBMs);
  - Providing government incentives to indigenous firms for the development of know-how and skills needed in high value added activities;
  - Liberal admission policies for expatriates with technical or other special skills; and
  - Export promotion programmes for Malaysian brand name products.

6.3 Government support schemes for IMP2

A number of action plans were launched to realize the strategy. Under the action plans, the following support schemes were initiated:

- The Malaysian Industrial Development Authority (MIDA) set up a special division to assist the electronics industry in line with IMP2. Assistance takes the form of incentives, information dissemination, and rapid project approval, advice on factory locations, and liaison with respective state governments for investors.

- The Multimedia Super Corridor (MSC) is a Government initiative, launched in 1996, to provide new impetus to the electronics industry. It is a strategic project to attract major electronics and multimedia firms by providing highly sophisticated infrastructure in a strategic location: the corridor encompasses the Kuala Lumpur City Centre (KLCC), the Government's administrative centre, Putrajaya and Kuala Lumpur International Airport (KLIA). The Government has also established Cyberjaya, Malaysia's first 'intelligent city', in the MSC to promote the electronics industry. Cyberjaya will particularly stress R&D in electronics and IT. The MSC is expected to have spin-off effects on research, development, IT innovations, and R&D in product development; to create spin-offs in the development of service industries in IT and in the electronics and electrical sectors; and to boost international trade.

The MSC may be seen as a spatially compact electronics cluster with close linkages and numerous complementarities. Its importance is underlined by the fact that the Prime Minister's Department is in charge of MSC. The Multimedia Development Corporation (MDC) oversees the development of the MSC. In addition, an International Advisory Panel (IAP) with prominent figures in the IT industry worldwide has been set up to provide advice to the Government on strategic issues related to the MSC.

- Financial assistance is made available for R&D. Examples include the Industrial Technical Assistance Fund (ITAF) and the Intensification of Research in Priority Areas (IRPA) Fund. The funding can be sourced through MITI, MIDA and the Small and Medium-Scale- Industry Development Corporation (SMIDEC).

- The government has allocated RM100 million allocation to the Multimedia Grant Scheme. The purpose of the scheme is to help SMEs to participate in the MSC. SMEs involved in multimedia, telecommunications, and IT are eligible for up to 50% funding if they qualify for MSC status, and also in cases of joint venture companies where Malaysians have majority equity. The funding is primarily meant to conduct research. At the end of 1998, 136 were companies operating under the scheme. The main categories were software (35 per cent), content development (19 per cent), systems integration (16 per cent) and telecommunications (10 per cent).

6.4 The promotion of clusters

A major vehicle for achieving the goals of IMP2 is cluster building, a cluster being defined as:

> '...An agglomeration of inter-linked or related activities comprising industries, suppliers, critical supporting business services, requisite infrastructure and institutions...The cluster-based industrial development approach with its emphasis on linkages... will enable policy makers and industrialists to operate in a focused, integrated and comprehensive framework'. (MITI 1996, 22, 23).

In the electronics industry context, the focus is on connectivity among electronics companies, supplier firms, R&D organizations, electronics associated service facilities, training and HRD institutions, infrastructure and amenities, and relevant government agencies. All these should work together for more innovation, R&D, competitiveness, and new product development along the value added chain. Missing links (in terms of domestic enterprises) in the value chain are to be identified and investment in these areas is to be promoted. It is recognized that clusters dominated by MNCs will continue to play an important role; but there is a strong domestic potential in several manufacturing industries. The objective of IMP2 is to develop a number of domestic technology-driven clusters in these branches through policy support, including clusters in the electrical and electronics industry. The MSC (see Section 6.3) can be seen as the most ambitious attempt to create such a cluster.

IMP2 has identified nine key supplier categories that require development in order for the clustering process to be carried out efficiently. They are:

- Parts and components;
- Business support services;
- Logistic services;
- Technical business services;
- Electronic commerce;
- R&D;
- Manufacturing materials;
- Machinery; and
- Packaging.

In support of cluster building four issues must be addressed:

- Human resources development in general as well as the ability to advance and renew the skills required for specific clusters;
- The ability of industries to acquire new technology and develop and commercialize applications;
- Improvements in the business environment (policies, incentives and services).
- The provision of advanced infrastructure and environmental protection systems, as well as specialized industrial parks for the clusters.

Despite heavy emphasis on and investment in the MSC, significant development and clustering dynamics have yet to emerge in the central region. A number of foreign companies have located offices in the MSC, but the leading ICT companies-such as MicroSoft, IBM, Alcatel, and Cisco-have yet to start any significant operations. The deficiency of human capital has remained a basic problem. Despite waivers in the MSC region to general immigration requirements, Malaysia has to compete for immigrant labour with ICT centers in the US, Ireland, Singapore, and Germany. The location of the MSC is designed to anchor IT activities in the heart of the Klang Valley rather than appropriate clustering capabilities already established in Penang. To achieve the IMP2 objectives, enterprise capabilities in new product development, technology management, and networking must be substantially advanced in the Central and Southern states.

7. TOWARDS A NEW COMPETITIVE ADVANTAGE AND DYNAMIC CLUSTER DEVELOPMENT

7.1 Malaysia's strengths and weaknesses

Malaysia's current situation reveals a number of strengths:

- The country has built up strong capabilities in assembling and packaging chips.
- Malaysia is part of a global production system spearheaded by MNCs linking Silicon Valley, Tokyo, and Taiwan with a regional system composed of Singapore, Malaysia, and surrounding lower wage areas. The knowledge embedded in these companies can, with appropriate policies, be tapped to local advantage.
- An R&D capability in product redesign for Asian markets is emerging around Intel, HP, Dell and Motorola.
- Some SMEs have developed the capability to supply components to the MNCs, and some have even developed the potential for export. They are, therefore, slowly moving up the value chain.
- There are some strong elements in the policy and institutional support system. Under IMP2, a number of major programmes are being implemented to help Malaysia move towards a technology-driven economy, and PDC has a world reputation for successful local industrial policy, especially in the electronics sector.

But there are also weaknesses:

- The Malaysian electric and electronics industry is losing its competitive edge in labour intensive assembly, packaging, and testing operations.
- With some exceptions, foreign investment has not resulted in the introduction of integrated production systems into Malaysia or high value added or advanced manufacturing links in the industrial chain.
- The domestic electronics industry base is still fairly weak, in terms of market shares, dynamism, technological innovativeness and industrial diversity.
- Networking among firms, whether between MNCs and local firms or among local firms, is not developed yet. Existing Malaysian electronics clusters are *externally integrated*. Operational units within each of the three regions are not networked *within* the region.
- Notwithstanding the achievements of IMP 2 and PDC, the support infrastructure for innovative industrial development is fairly weak.

- There is a shortage of skilled labour, entrepreneurs, engineers and technologists for the industry.

7.2 Policy Challenges

Building on Malaysia's strengths and overcoming its weaknesses to achieve sustained development towards higher value added, technologically innovative activities in the electronics sector will require that the country's policy makers and entrepreneurs address a number of inter-related challenges which were identified in the discussion above:

- Creating dynamic firms.
- Building production capabilities.
- Building networking capabilities.
- Technology management.
- Technology transition.
- Skill formation.
- Integration of governance efforts.

Creating dynamic firms

The firm is the agent of industrial change. Its technology capabilities, which are linked to its ability to seize opportunities in the rapidly changing electronics market, are the drivers of high growth. The first challenge of industrial policy is to promote the creation of innovative firms, firms that are learning and teaching firms that contribute to technological advance and to skill formation.

A business strategy of focus and network (focusing on a core capability and partnering for complementary capabilities) can trigger complementary growth dynamics, at the firm, the regional and the national level: the open-systems model, which results from this strategy, is a business system that continuously creates opportunities for more entrepreneurial firms. Collectively, firms in an open-systems business model raise performance standards in rapid new product development and disruptive innovation, as distinct from continuous improvement or incremental innovation). Fast growing, technologically driven firms also provide the managerial experience critical to its reproduction in yet more firms.

A recipe for the creation of new, dynamic, innovative firms does not exist but there are enough successful examples. As a basis for future policies, policy makers must examine the process and identify bottlenecks to the flow of dynamic firm creation in Malaysia. Efforts to attract foreign investment should focus on developing technological and production capabilities by partnering with firms that are world leaders in electronics production and technology. Not all international firms are dynamic and innovative. The aim must therefore be to attract firms with an advanced production capabilities spectrum and strong technology management and networking capabilities, and then to develop the institutional framework that can foster the diffusion of their practices and trigger (regional) growth dynamics.

A related policy implication in this context is that Government programmes such as the Vendor Development Programme should focus less on filling product gaps and more on capability development, which would help a higher proportion of firms to become innovative firms.

Penang has the greater number of innovative, dynamic foreign and locally owned electronics firms. What can we learn about the process of new firm creation in Penang?

One lesson is that Penang's firm creation process has been linked to supplier development programmes of MNCs, which helped to stimulate a development process involving technology transfer and capability development. An example of how dynamic firms can be created as part of a spin-off process is Motorola's supplier development programme in BCM Electronics (see Box 3).

Box 3. Motorola's supplier development programme for BCM Electronics

BCM sales have more than doubled every year and employment has grown from 120 in 1994 to 1,500 in 2000. Over the same period its technical capabilities have advanced each year in line with a technology development plan.

A five-year manufacturing know-how transfer and skill formation development programme drove the technology capability growth path. The manufacturing know-how transfer had the following sequence:

- Back-end (final assembly) manufacturing of accessory products – 1993-4
- Front-end building of accessory products (surface mount technology transfer, skill transfer) – 1995
- Materials procurement, stockroom and storage management (planning, buying, vendor interface, minibank [1]) – 1996
- Turnkey management (materials sourcing, materials procurement) – 1997

Engineering know-how was increased in the following steps:

- Materials quality engineering (failure analysis, vendor development, vendor process characterization) – 1996
- Process/reverse engineering (internal process characterization, root cause analysis and design of experiments, statistical process control methods, product enhancement, prototyping, pilot manufacturing) – 1997
- Research and development procurement (phone systems, radio frequency technologies) – 1998

From doing manual assembly of cable connectors and belt clips in 1994, BCM's technical capability growth path has progressed to large pitch to fine pitch surface mount technology (miniaturization of integrated circuits), from basic radio frequency to digital and analogue VHF/UHF radio frequency, and to systems integration.

[1] A system whereby a bank takes over part of the stock administration.

Elements of this and similar supplier upgrading programmes are developed at and diffused by PSDC. In this way the skill needs of firms can be matched with the education curriculum development.

Other regions in Malaysia would benefit from studying the Penang example and using the lessons to develop programmes that are appropriate for their own situation. In this document, Annex 3 summarizes the lessons that can be learned from a selection of successful electronics firms – foreign and domestic – that operate in Malaysia.

Building production capabilities

The production capabilities spectrum shown in Table 1 offers criteria for locating plants in the global production order and identifies the specific challenges to advancing a region's productivity. These challenges can focus industrial policy initiatives. Successful initiatives require organizational change methodologies that work at the enterprise level within the context of specific regions.

A number of organizational change methodologies is available to decision makers.[2] An outstanding example is Iawo Kobayashi's 20 keys methodology (Kobayashi 1988). It has been introduced in groups of companies in Slovenia, Jamaica, Honduras and Moldova, and provides criteria for comparing a plant with international competitors. A system for self-assessment that can be conducted by the work force following a brief training programme identifies five levels of performance for each of 20 organizational characteristics of a firm. The methodology is therefore based on the principle that those required to make the new system work are involved in designing and developing the new practices. The five levels for each key offer criteria that can become operational goals to guide production improvement action plans and evaluate workforce performance. An example of a successful national policy to advance productivity is the quality movement developed in Japan that targeted the skill formation process.[3]

Building networking capabilities

The emergence of systems integration capabilities in technology has fostered open-system networks and developed because of them. In both cases, the business model of focus and network underlies and reinforces speciation and inter-firm networking. As networking capabilities of a region become more robust, the region takes on the semblance of a collective entrepreneur, a composite of networking firms that forms the basis of regional growth dynamics.

Malaysia as a whole has considerable potential, enhanced by the Internet, to develop such composites of networking firms, with a competitive advantage in flexible mass

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[2] Shiba, Graham, and Walden (1993) describe an organizational change methodology that involved a group of companies working together. Case studies of the role of regional agencies in enterprise transitions to more advanced manufacturing capabilities can be found in Forrant (1998) and Forrant and Flynn (1998). Philip Shapira (1998) surveys the Manufacturing Extension Partnership, a joint initiative of federal and state governments in the United States to develop a national infrastructure to support 'the deployment of new technologies and improved business practices among small and mid-sized manufacturing enterprises' in the 1990s.

[3] Lessons from the Japanese industrial modernization programme are discussed in Best (1990).

production in which one-piece flow (where each piece is independently designed) is integrated with specialist design capability. Manufacturing to order, as presently practised by Dell in Penang, is a first step in this direction. Dell has extended the principle of flow to the supply system via the Internet, which drives down the supply chain cycle time to levels previously achieved only by closed networks with unchanging design specifications. This strength of the 'old' just-in-time and captive supplier network, however, did not involve design information. The open-systems protocol of the Internet enables seamless integration of design information across virtually all computer systems and resource planning systems.[4] This is a second step in the use of the networking capability of the Internet to enhance competitiveness.

The third step is the use of advanced information technologies such as CAD/CAM/CAE for collaborative product development processing. But for such product design tools to be effective, the various departments of the enterprise must be internally networked and aligned or process integrated. Otherwise, information technology gives rise to isolated islands of computerization in which information is proprietary and communication is limited.

Network capabilities also foster innovation. Chapter 2 argued that the process of industrial speciation cannot take place within a single firm – it happens in networks where new entrants can focus on a technological capability and find partners for the complementary capabilities. Regions with open-systems networks have low barriers to entry for new, specialist firms. Such conditions make it possible for the electronics industry to become an integral element in a much wider concept: the information and communications industry.

In the context of regional strategy, policymakers and support institutions must work with entrepreneurs in creating these open networks. Again, the progress made in Penang can be an inspiration for other regions.

Technology management

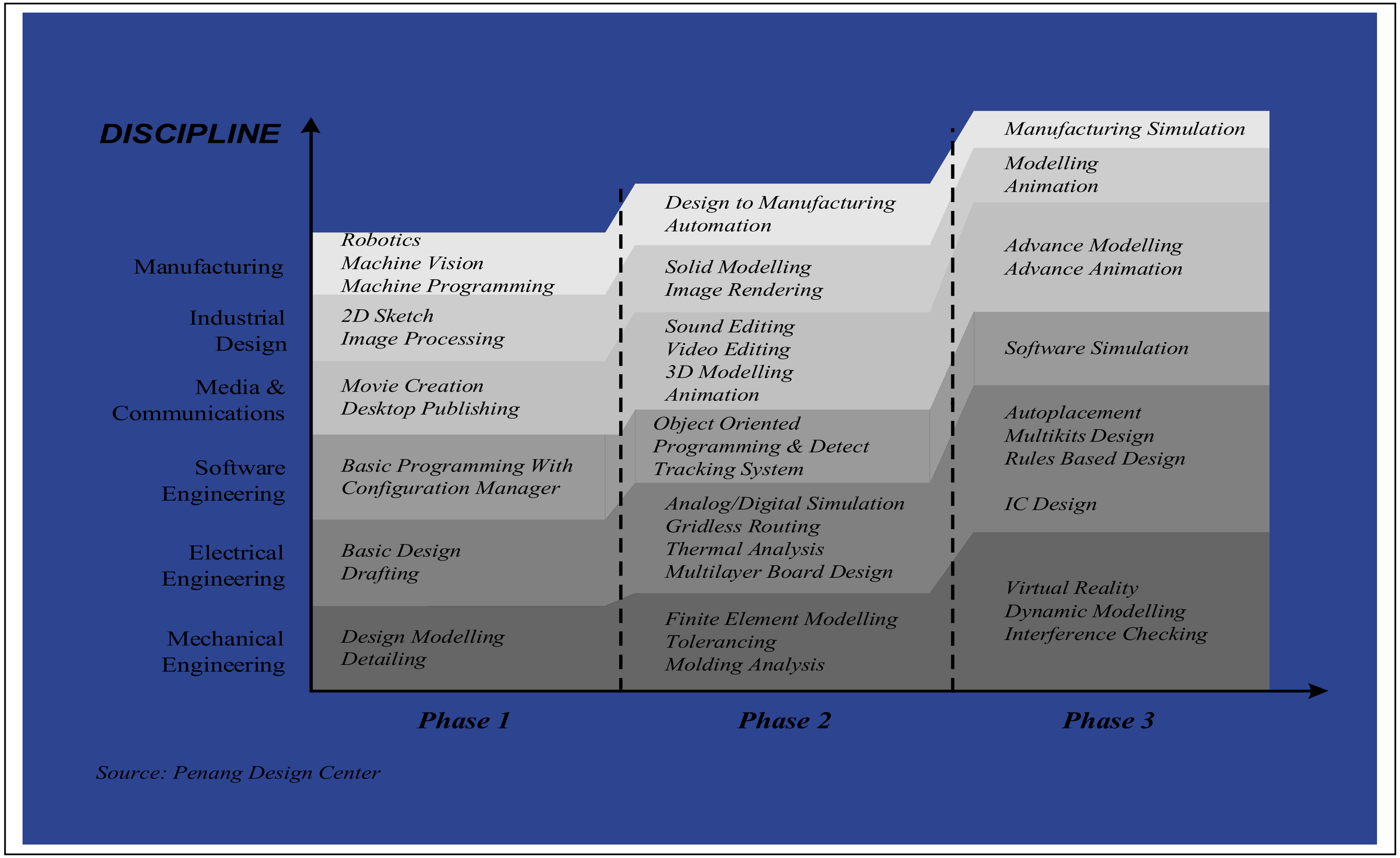
The transition to a productivity triad which will support not only manufacturing but also product development and technology management capabilities (TM 4 and TM 5 in Table 1) will require the development of a critical mass of firms with systems integration capabilities. Penang is fortunate in having leading models within the region. Intel and Motorola's design centres are a microcosm of the kinds of capabilities that must become regional for Penang to make the transition from a region with many elements of a static electronics cluster to a dynamic cluster made up of a regionally networked system of enterprises.

Both design centres have carefully conceived programmes for developing design capabilities. Figure 6 shows the range of programmes of Intel's Penang Design Centre.

Figure 6. Design capabilities and skills integration at the Penang Design Centre
(please see next page)

[4] See *Fortune* 1999 for an example of a value network involving Internet-facilitated partnering across multiple countries.

Figure 6 Design capabilities and skills integration at the Penang Design Centre



Source: Penang Design Center

Firms like Intel and Motorola are exceptional in their commitment to local innovation and opportunities for creating cluster dynamics. But most importantly, they are carriers of systems integration capabilities in both the technological and organizational dimensions. Regional governments and business communities must make the most of the opportunities offered by these MNCs, among others through a regional skill formation process that supplies the right engineering and science skills. This issue will be discussed below.

Technology transition

One major role of industrial policy is to establish technology roadmaps to coordinate and mobilize investment decisions in key industries, support the application of systems integration in the IT related industries and allocate R&D funding for the knowledge-intensive industries. This requires an understanding of technological trajectories, as discussed in Chapter 1, to identify likely areas of technological change.

The predictability of technological change was used to great effect in the United States, where Sematech was formed in 1987 to improve chip-manufacturing capability:

> '… its founders organised a series of industry wide workshops to identify the technological advances required for U.S. semiconductor and supplier industries to catch up with Japanese industries. The outcome, in March 1988, was a timeline and the specifications for a sequence of technological generations that would lead to parity by 1994—a "road map for semiconductor technology". The timeline specifications required a demonstration of a 0.8 micron technology... in 1989... and 0.25 micron technology in 1994.' (Moore 1996, 173)

The Semiconductor Industry Association coordinated the activities of the Semiconductor Research Consortium (established to organize and focus university research) and Sematech. These agencies

> '…provided a road map for 15 years, pointing out key technology needs and the times at which those technologies would be required to keep the semiconductor industry on the historic productivity curve of a 30 percent reduction in cost per function per year'. (Moore 1996, 173).

The same principle can be used for partnerships between Malaysian firms and governmental research programmes. The US experience – and everyday experience in all industries across the globe – in addition illustrates the potential role that networked groups of firms can play in shaping technological and industrial change. Not only at the national but also at the regional level, industrial policy can shape the technological trajectory of enterprises by coordinating research activities in potential areas of development indicated by technology trajectories.

Skill formation

Exploring the links between technology development and growth focuses attention on the most important contribution that policy makers can make to growth: human capital development. To become an advanced industrialized nation by the year 2020, Malaysia will need a tenfold increase in the share of scientists and engineers. Making the transition to more advanced models of technology management or into more advanced technology domains will be blocked without major efforts to create a strong know-how and skill base. This is true at both national and regional levels. A region, which can design and execute an HRD strategy anticipating rather than reacting to technology transitions, has a competitive advantage over regions that lack such capability. Such strategies will have to be designed and executed in cooperation with the educational and business sector.

As explained in Section 2.3, the strategies should not overlook the critical importance of mid-level skills in, for example, the transition from electronic, circuit switched networks to ones based on optical, packet switched technology – without these, the economic growth potential of investment in research will be lost.

Human resource development programmes should be linked to inter-sectoral transitions toward activities and products demanding more capabilities for knowledge-intensive, complex products. Success can be measured by movement toward the west and east poles of Figure 2. This means developing and diffusing skills embodied in new product development and systems integration capabilities associated with TM 4 and TM 5.

Improving shop-floor skills raises the issues of the size, quality, and specialized abilities of the teacher pool and of the appropriateness of the curriculum. Successful programmes have a common feature: teacher training is designed into the programme. The magnitude of the challenge can be illustrated by the additional university staff needed to increase the flow of engineers and scientists at BSc level in Penang to a level where the requirements of an advanced industrial sector can be met: the estimate is 800. Other regions in Malaysia would need a far larger number to catch up with Penang.

The link between human resource development and dynamic, innovative firms can be reinforced by a strategy that encourages students and researchers to test new ideas for their commercial viability. Incubators for science and technology start-ups are a well-known feature of the economic landscape in many countries, and similar initiatives can be successful in a developing economy, as the example of Beijing's 'Silicon Valley', discussed in Section 3.3, shows.

Given the fact that start-ups will not be able to pay the full price for the services provided in an incubator, long-term financial support would usually be needed to ensure their functioning and to meet the demand. This can however be seen as an investment in the future: if enterprises are created that indirectly recoup the investment by becoming commercially successful, then there is a net gain to the national economy. National and/or regional policy (possibly linked to a joint public-private sector effort) therefore has an essential role to play. Costs can be brought down by virtual incubators mainly relying on Internet services, which are operating successfully in, for example, some Central European transition economies as a result of UNIDO support.[5]

Integration of governance efforts

The electronics regions in Malaysia have different approaches to economic governance. The central region enjoys an incomparable range of governmental agencies with

[5] See UNIDO, *High-Tech Incubation Systems for the Central European Transition Countries*, forthcoming.

industrial policy related missions. Yet, most would agree that the performance of most such agencies is mixed. The fault is not in the effort of officials in the central region. There is no evidence to suggest officials are more or less hard working in all three regions. What differs is the degree of *alignment* of governmental development agencies with each other and of governmental agencies as a whole with the development challenges of the firms. Industrial policymaking in the central and southern clusters is piecemeal. There is no government agency aligning governmental initiatives and programmes, for example in the area of human resource development, and adapting them to the specific needs of the regional electronics industry.

Penang, far removed from the central government's main offices, has been more successful in electronics development. The region has developed advanced governmental capabilities for addressing issues requiring collective action, and the PDC plays the alignment role for the electronics cluster. The response to the severe downturn in 1985 is an example. The Penang Industrial Coordination Council was established and industrial leaders developed a series of action plans under the auspices of the PDC. The history of success at networking reduced the barriers to working together and facilitated a rapid institutional response to the threat.

PDC's policy of working with industry leaders to address common problems has helped to create a 'social infrastructure' for developing focus-and-network business models. *Regional networking capabilities* are now strong in Penang. Networking within firms and clusters, as described above, is complemented by close cooperation between firms and other players in the economy – government and development support institutions as well as education and research institutions. The Northern region thus has developed an organizational capability to address the interrelationships captured by the productivity triad. 'White spots' on the regional industrial chart between specific government instruments and target populations are soon discovered by the network, and dealt with.

The lessons of development governance in Penang can be applied to other parts of Malaysia. Development institutions such as the state economic development corporations can emulate the success of PDC and become key actors in promoting systemic links within regional clusters. Within Penang, the lessons learned can be used to target a third group of companies: the large/fast growing companies seeking to develop independent product development and technology management capabilities.

7.3 A stronger productivity triad in the electronics industry

As followers, Malaysia's electronics clusters have an uphill struggle in increasing industrial value added as highest value added accrues to the pioneers making the transition to a more advanced capability triad. But followers have the advantage that the path to higher value added is more clearly mapped. The challenge is to accumulate the relevant know-how, internalize it and diffuse it across the country. With the right strategies and support mechanisms, each region can acquire a distinctive technology capability trajectory and competitive advantage.

How can Malaysia go about this?

The answer can be explained in terms of the domains of the productivity triad. Strategies allowing firms and the country as a whole to catch up will have to cover production, business organization and education. A national or regional productivity triad cannot be managed by individual actions alone because of the multiplicity of interdependencies and feedback effects. It is therefore the task of government – first and foremost at the national level, but also at the regional level - to develop policies, agencies, and institutions that align activities relevant to the three domains of the productivity triad, so that all three advance in a balanced way. Annex 4 briefly outlines a methodology that has been used by UNIDO to initiate cooperation at the level of the region. The Penang experience will be useful in showing how in the Malaysian context the triad of actors in the development process – firms, government and the research/education sector – can identify and act on collective needs, and help local enterprises to seize the opportunities created by the presence of MNCs.

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ANNEXES

Annex 1.
Summary of case studies of local firms in Penang

(Contribution by Lim Kah Hooi)

UNICO TECHNOLOGY

Structure	Production/Spin-Offs	Linkages/Supply Relationships	Other
1. Initial shareholder was Intel Cooperative. 2. Subsequently totally divested by Intel and assumed name of Unico Holdings. 3. Investment arm of Chinese Chamber of Commerce. 4. Joint venture: With Italian and Taiwanese. Discussions with UK and Canadian companies in order to diversity products base. 5. Within the next 4 years, hopes to achieve total sales of RM 1 billion.	1. Spin-off from Intel. Supplies mother boards (PCBA) and audio products for Intel. 2. With Italian company to produce modems, with Taiwanese company to produce CD-ROM drive. Proposal with UK company to produce digital enhanced cordless telephones. With Canadian company to produce 900 MHz cordless transmitting phones. 3. Already achieved status of ODM. 4. PCBA main products – motherboards, sound cards, multimedia cards. Also OEM for desktop computers.	1. Supply relationship with Intel. 2. Production linkages with Italian, Taiwanese and possibly UK and Canadian companies. 3. Sourcing of components – through synergistic linkages: PCBs from Taiwan, components from other international sources and metal parts locally.	1. Has achieved vendor breakthrough to supply to MNC's especially Intel. 2. Has successfully achieved new product diversification. 3. Has developed fairly good international connections. 4. Has little R&D though it is attempting to develop R&D expertise. 5. Complains of lack of entrepreneurial spirit in Malaysia. Malaysians more interested in working for MNCs rather than investing in start-up operations. 6. Company is a good example of a successful local company linked closely to MNCs.

GLOBETRONICS			
Structure	Production/Spin-Offs	Linkages/Supply Relationships	Other
1. 100% locally owned and has 6 plants in Penang – some with subsidiary status. 2. Some of these subsidiaries have foreign partners e.g. Sumitomo. 3. Received ISO 9002 certification. 4. Expected sales revenue of RM70 million in 1997.	1. A subcontract manufacturer. 2. Supply relationship with Intel for PCBA products. 3. Also produces advanced pig-grid arrays (PGAs), plastic lead chip carries (PLCCs), quad flat backs (QFB), ceramics, packages, etc.	1. Has some linkage relationships with Intel for PCBA products. 2. Carries out co-designing with Sumitomo. 3. Carries out some subcontracting for Intel. Intel sometimes supplies raw materials on consignment. 4. Carries out company reliability tests as well as failure analysis.	1. Company has been performing well in subcontracting and has links with MNCs and other companies. 2. Intel used to be its anchor company but now the company does not rely on Intel alone. It has successfully diversified. 3. Still maintains its core business in subcontracting. 4. Cites job-hopping and poor labour discipline as major problems. 5. It has growing upstream activities; it is active in substrate and provides testing services. It is a successfully, and expanding, local SME. 6. Company is an example of a successful local company developing good supply and subcontracting linkages.

BAKTI COMINTEL MANUFACTURING			
Structure	Production/Spin-Offs	Linkages/Supply Relationships	Other
1. Incorporated in 1993. 2. Company started through an agreement between Motorola and the Malaysian Government as part of an initiative in technology transfer. 3. Company is 100% Malaysian owned. 4. Has a workforce of over 400.	1. Product spin-offs include multitask adapters, hands-off walkie talkies, mobile, radios, microphones for walkie talkies, mother boards for mobile radios, PCBA, charges, cordless telephones, headphones for CD –ROM, CD Players. 2. It has achieved OEM status and is now an ODM as well. 3. 60% of its material and requirements are sourced locally. The 40% imported include cables, high-end electronics/engineering plastics, rubber, gaskets.	1. Works closely with Motorola – it has a vendor arrangement with Motorola. Motorola supplies Bakti approved vendor list. 2. Has supply linkages with companies in Taiwan and Singapore.	1. Uses a high degree of local content, which includes plastic moulds, parts, tapes and reels, resistors, capacitors. However some of these parts are sourced from locally based foreign companies. 2. Company is a good example of how government assistance and targeting of MNCs can help vendor development programmes. 3. Company is also an example of active local sourcing to promote the use of more local content and how an MNC can actively assist in vendor development and local content development.

ENG TEKNOLOGI			
Structure	Production/Spin-Offs	Linkages/Supply Relationships	Other
1. Eng was incorporated in 1992. 2. It was a hardware company. 3. 4 locations in Penang (2 sites), China & the Philippines. It has expanded internationally. 4. Initially started as a hardware company and then diversified into engineering, and recently into computer lines.	1. In the computer sector, Eng is principally engaged in manufacturing computer hard disk drivers. 2. Its main products include manufacturing actuators/E-blocks, assembly of hard disk drives, peripheral components and automation system designs and production assembly. 3. It also undertakes contract OEM, precision machining, batching, machining and other engineering works like plating services.	1. Eng has built up good supply networks with MNCs. 2. Maxtor and Eng developed good links for supplying Maxtor as well as Fujisashi. 3. Eng's other customer-supplier linkages were with Maxtor, Micropolis, Seagate, Corner, Quantum MIKE, Dec and Fujitsu. 4. Fujitsu is Eng's key customer now.	1. Eng is a local company which has successfully built close relationship with suppliers and buyers 2. As an OEM manufacturer it produces a range of electronic based products for supply to MNCs. Its most active line is hard disk drives. 3. Eng is an example of a local company that has succeeded in Malaysia's push for more local content. 4. Its success is also an example for other local SMEs on how to venture into the vendor sector. 5. Eng is an example of a local company that has successfully engaged in R&D. Eng's R&D outfit uses CAD/CAM work stations, FA and test equipment.

P.K. ELECTRONICS			
Structure	Production/Spin-Offs	Linkages/Supply Relationships	Others
1. PK is an indigenous company. It started operation in 1982. 2. Company has 400 employees and turnover of about RM30 million. 3. Has won a number of awards including the World Intellectual Property Organization Gold Award & the Investors Award in Geneva.	1. PK specializes in manufacturing uninterrupted power supply systems (UPS) and speed controllers, collectively referred to as power electronics. 2. PK also carries out its own innovations and some R&D to upgrade its products. 3. PK is looking into its other strategic sectors to order to improve its performance, as well as to developing its production activities.	1. 50% of its products are for the local market and 50% for export, chiefly to regional markets. It has recently stepped up promotion activities overseas. 2. PK has built up good connections and developed a market niche in the speed controller market and in power electronics. 3. It is in the process of building up international linkages.	1. PK is a successful local company that has developed its own products. 2. It has managed to move its speed controller production from OEM to ODM. 3. It is an indigenous company that has successfully made inroads into the local as well as international markets. Exports are expected to reach 80% of output. 4. PK's main strengths are in its personnel, finance, market development and good management practices. 5. It has plans to expand but is aware of the need for supply support through intermediates institutional support, technical services, HRD support, R&D and is still limited by its small output base (PK requires larger scale economies in production). 6. PK is an example of a company, which has been able to development quality products. It is a good example of a local content manufacturer.

Annex 2.
Important support services/institutions for the electrical and electronics sector

(Prepared by the Institute of Strategic and International Studies, Malaysia)

Category	Institutions/Programmes	Roles/Functions
FINANCIAL	Development Bank of Malaysia: New Entrepreneurs Fund	Promotes funding programmes to Bumiputera (indigenous) enterprises under the Asean-Japan Development Fund scheme.
INFRA-STRUCTURE	Industrial Estates	Provides basic infrastructure such as roads, water, and transportation
	Free Zones. Bayan Lepas, Prai Prai Wharf Batu Berendam Tanjung Kling Sungai Way Ampang Hulu Klang Telok Panglima Karang Johor Port Therity Industrial Land Jelapang Kinta Muara Labuan	Specially designed for manufacturing organizations producing or assembling products for export in order to enable them to enjoy minimum control and formalities in their importation of raw materials, parts, machinery, and equipment as well in their exports of finished products.
	Licensed Manufacturing Warehouses	In place of FZs if the latter are not practicable or desirable; encourages the dispersal of industries and enables companies to establish factories for the manufacture of products mainly for the export market.
	Telecommunications service TNB Celcom Binacom Binariang Kilatcom Emartel Sapura	Provides a full range of domestic and international voice message services, and data communication facilities with international circuits and optic fibre systems.
	Air-cargo facilities Subang – KL International Airport Penang International Airport Kota Kinabalu International Airport Kuching International Airport	
HRD	PSDC	PSDC offers job-skills enhancement and career advancement programs in four major categories: computers, manufacturing, management, and technical courses.
	Human Resource Development Fund	Set up for the purpose of developing and promoting the upgrading of skills in the workforce.
	Ministry of Youth & Sports	Responsible for planning, monitoring, and coordinating skills training.
	Ministry of Public Enterprises	Provides industrial training courses.

	German-Malaysia Institute	Produces highly skilled technicians in the field of production technology and industrial electronics.
	Center for Instructors and Advances	Offers courses and skill training for instructors, supervisors, and skilled workers with the objective of providing post-employment training.
	Industrial Training Institute	Provides full time training for school leavers, skill enhancement training for industrial workers, and customized industrial, mainly in electrical, electronic and mechanical subjects.
	Japanese Malaysian Training Institute	Provides training courses.
	French Malaysian Institute	Provides training courses.
	SIRIM	Provides industrial management training programmes for personnel and R&D training.
	MIMOS	Provides industrial management training programmes for personnel and R&D training.
UNIVERSITIES	Universiti Malaya	Strong in the areas of lasers and opto-electronics for industrial ecosystems as well as conservation and environment engineering research focusing on electromagnetic wave propagation, fault analysis, monolithic crystal design and separation processes.
	Universiti Sains Malaysia	Environment, computer aided translation, information technology, geographical information, distance education, and robotic visions.
	Universiti Putra Malaysia	Environment conservation and the sustained use of natural resources, increased use of automation.
	Universiti Teknologi Mara	Product research in the area of technology, applied sciences, and communication. The three main research thrusts are advanced manufacturing, processing materials and structure, and analytical and graphical computerization Others areas include engineering and design analysis, planning, simulation, software and product development.

Annex 3.
Successful electronics firms in Malaysia – the lessons

3.1 Motorola

Motorola Penang is involved in the land mobile products sector as well as the automotive energy and controls sectors. The Motorola Penang plant began to localize its management in 1989. Motorola's Seremban and Kuala Lumpur plants produce semiconductor products. Motorola's land mobile products operations comprise a hybrid/chip carrier factory, a portable radio factory, a mobile radio factory, an R&D design centre, and a logistics/distribution centre.

Emphasis on R&D

Motorola's transfer of technology from the US to the Penang plant allowed the Penang plant to develop a strong position. Co-designing efforts between Malaysian and US engineers for products meant for the US market strengthened the market position of Motorola. It also noted the need for R&D for products specifically made for the Asian region.

Improving manufacturing technology

Manual assembly made place for automation by the 1980's. By the 1990's Motorola Penang began to utilize advanced manufacturing technologies (AMT). This has reduced the amount of labour required while increasing productivity and efficiency.

Supplier development

Motorola Penang developed a local company, BCM, and encouraged it to become an ODM. Through transfer of managers to BCM and subcontracting to other local firms, skills were shared and Motorola's position in the country was strengthened. The transfer of skills built up local companies and provided a supplier ring that was able to provide quality products to Motorola.

Human resource development

Motorola's Mutiara project enhanced the skills level of its workers, leading to increased productivity and efficiency.

Distribution and marketing

Motorola's logistics/distribution centre in Penang administers orders and distributes all of Motorola's products to markets in the region. The concentration of distribution and marketing allows quick reactions to customer demands and the collection of market information; which is used to improve the response to customer demands.

3.2 Intel Penang

Intel in Malaysia has a site in Penang and at Kulim Hi-tech Park. Production in Malaysia includes microprocessors, microcontrollers, motherboards, chipsets, network chips, cartridges and mobile modules. Its current products include OLGA (organic LAN grid array) and FCPGA (flip chip pin grid array).

Emphasis on R&D

Intel has transferred responsibility and technology from the US to the Penang plant. The research and product development activities have improved its market position. R&D has also provided Intel with a number of patents.

From assembly to testing

Intel Penang graduated from assembly work to testing and designing in six years. This is an achievement in itself, and shows that, with an emphasis on R&D and skill development, moving up the value added spectrum can be achieved in a relatively short period of time.

Automation

Though Intel may not have fully automated systems, the drive towards automation has reduced its reliance on low-cost labour for assembly processes and allowed personnel to develop their skills.

Logistics

Intel introduced JIT in their Penang plant to make logistics more efficient. This increased the need for strong supplier links and sound managerial control and planning practices.

Marketing

The location of the marketing unit at the production base provides knowledge of demands for product feature adjustments that can quickly be incorporated into the production process.

Human resource development

Intel has recognized the need for highly specialized personnel to acquire and keep a competitive edge, allowing the firm to continuously adjust production systems and retain flexibility.

Supplier development

To control logistics and supply, Intel Penang has created its own clusters. Human resource development includes the supplier network. The management, through value chain analysis, has being able to provide an integrated approach to developing the production chain.

3.3 TCH

Trans Capital Holding (TCH) is a Penang-based contract-manufacturing firm and manufacturer of disk drives. It has developed and introduced a new product, which helped to put TCH into the ‘inner circle’ of the disk-drive world. Among its buyers are MNCs, whose focus on innovation and new product development has enabled TCH to capture new markets at a time of slow-down in the electronics sector.

Developing strategic alliances

TCH took a minority interest in Castelwood Systems, a California-based firm set up by a TCH partner. This strategic alliance enabled the company to move up the value added chain with the Orb storage system.

Emphasis on innovation and quality

TCH’s high-speed, high-density disk drives show that, with ingenuity, firms can quickly become world-class producers of quality products.

3.4 Sapura

Sapura has three main business areas: telecommunications, information technology and metals based technology. Its core competence remains in telephone equipment, but it is exploring multimedia technologies. It has strong business relations with a number of major foreign firms.

Emphasis on R&D and innovation

Sapura’s is well ahead of other local firms on the technology trajectory thanks to its emphasis on R&D, even though it has not achieved technological breakthroughs and it still weak in process technologies. But the firm is innovative. It continues to upgrade its products and has increased its profitability.

Good connections

Sapura has built good connections with the Government, local, and foreign firms. These have enabled it to enter new markets and improved access to information and technologies; its ‘apprenticeship’ approach to technology acquisition has been a major factor in building up its R&D.

Economies of scale

Sapura has won contracts for a number of large projects that enabled it to achieve economies of scale in a relatively short time. These have helped to reduce costs and increase efficiency and profitability, allowing the firm to continue to progress along the technology trajectory.

3.5 PNE PCB

PNE PCB manufactures printed circuit boards for electronics companies operating in Singapore and the Asia Pacific region. Rising costs of operations in Singapore prompted the move of the firm to a lower operating cost center, and the Tebrau industrial area in Johor Bahru was chosen.

Good delivery track record

Reputation is a great asset in doing business in Asia. PNE PCB learned its business very quickly and proved that it was able to deliver. The relationship with customers, many major MNCs among them, was nurtured through personal, and organisational contacts.

Long-term investments

PNE would not be able to grow and remain competitive only on the basis of internally generated capital. It has built up good relations with (investment) bankers for support.

A workforce which is adaptable and eager to learn

The PCB business requires a work force that is constantly able to learn and relearn. Technologies rapidly lose their competitive edge PNE PCB's team of workers has commissioned new production lines and new processes in a short time frame.

3.6 WEM

Wearnes Electronics (M) Sdn Bhd is a subsidiary of an MNC with headquarters in Singapore. WEM was set up as the contract-manufacturing arm of WT, its main facilities being in Pontian; two more factories have been set up in Simpang Renggam and Kemaman in Terengganu.

The products that are assembled at WEM under OEM/ODM arrangements with top consumer brands such as Philips, Siemens, Heimann, Pioneer, Takara and others include telephones, computers, CD-ROM drives, car radios, deck mechanisms, flasher units and video CD players. More than 90 percent of its products are exported.

Constant upgrading of capacities

To remain ahead of potential entrants, WEM keeps upgrading its capabilities. It has made significant investments in enterprise resource planning software, training and organizational procedures, and has modified the set-up of machinery and process flows to achieve significant productivity gains.

Belonging to a strategic group of companies

The Wearnes group is a diversified conglomerate, with automotive, mining, as well as IT and electronics interests. This relationship gives WEM advantages when it comes to opportunities to develop new product groups and new products. As a conglomerate, Wearnes has the capital to invest in strategic businesses.

3.7 GTB

Globetronics Technology Bhd (GTB) is mainly involved in ceramic and plastic integrated circuit package assembly, dynamic burn-in, and visual check services for its major clients, Intel Technology Sdn Bhd (Intel) and Sumitomo Metal Electronics Devices Inc., Japan, which have also provided the Group's equipment on a consignment basis.

Strong MNC start-up support

Some of the founders of GTB were former employees of Intel. GTB was nurtured by Intel, supplying it with certain niche products.

Experienced personnel

Experienced, high-quality staff is essential to gain the respect of MNCs and build a good supplier-MNC relationship. GTB has carefully developed this asset, along with good and pro-active management.

Human resource development

GTB has given very high priority to human resource development, understanding that expenditure on good staff is an investment rather than a cost.

Aggressive product improvement

GTB has a very aggressive attitude to product development, innovation, diversification, and future development plans. This has kept its MNC market not only intact but has also allowed it to expand into new areas.

Annex 4.
An integrated approach to regional development

1. Global and local development

Enterprises nowadays rely heavily on external suppliers, sources of know-how, etc. This has increased the importance of industry clusters – firms operating in similar product markets plus closely related activities. While more and more enterprises operate on a global scale, local initiative has, as a consequence, increased in importance: geographically limited areas can reduce interaction costs among the different players, facilitating complex relationships. With the mobilization of all key local forces and resources helps to create an effective response to the challenges of the global economy to counter the trend towards increasing disparities.

For the local economy this means that:

- The character of local industry (specializations, enterprises linkages) and its ability to function in the global economy is a major determinant of competitiveness.

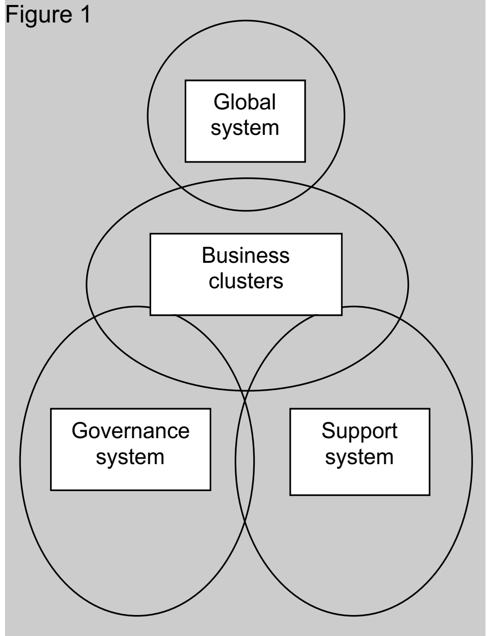
- Competitive locations are characterized by local coalitions involving the public and private sectors and other relevant players, such as education and research.

- These coalitions need capacities for coherent strategies that lead to realistic objectives, and to select effective instruments to achieve those objectives.

2. The regional economic system

Figure 1 shows the basic elements in the economy of globally competitive locations:

Figure 1



(i) *Business clusters*

Firms operating in similar product markets (plastics, electronics, etc.) including suppliers and related services

(ii)*Business support system*

- Knowledge (science, skills, advisory services);
- Financial capital;
- Natural resources;
- Physical infrastructure, utilities, the working/living environment;

(iii) *Regional governance system*

- Government agencies and private sector organizations; and
- Their institutionalized interaction.
- The regulatory system.

Four points should be made here:

- The figure shows that the elements are interlinked. The quality of the relations between the three elements is a major determinant of a region's competitiveness.

- By focusing on enterprise clusters rather than industry branches, interrelations in the economy become more visible. Even though individual firms are competitors, joint action can help corner new markets or tackle specific common problems, benefiting every firm.

- Apart from a supportive national political and economic environment, a good system of local/regional governance is essential. The strategy can only work if it is accepted by all relevant actors, which implies:

  (1) a pragmatic, step-by-step approach;
  (2) a limited range of realistic objectives; and
  (3) reshaping coalitions as objectives change over time.

- Below a critical threshold, a region cannot provide certain key services for enterprises and may quite simply be "invisible" to investors. Cooperation with other regions – also across borders - may be a crucial factor in the development of individual regions.

3. Regional strategy: creating a virtuous circle

There are four stages in a strategy, as Diagram 1 shows. Each step requires actors, instruments and processes. The real strength of a region is a core group of actors capable of mobilizing the business sector and the population in general; external expertise can supplement but never replace their understanding of a region, its problems and its potential.

Diagram 1: Stages in a regional development programme

Stage	Actor	Instrument	Process
1. Diagnosis, awareness building	Core group and steering committee	Analysis, training for key partners	Core team and steering committee building
2. Strategy framework formulation	As 1 + Working groups and stakeholders in general	Scenarios for key areas of development, training	Discussions in working groups and among stakeholders
3. Detailed strategy, execution of specific projects	As 1 + Project groups and external experts	Project proposals, support infrastructure	Creation of project teams, "work in progress" evaluations
4. Monitoring and continuous improvement	As 1 + Possibly new actors	Analysis, new scenarios, evaluation meetings	Joint learning plus any of the above as required

Monitoring - which actually starts during implementation - should lead to the first stage of a new development cycle: the idea is to create a virtuous circle of continuous improvements. Individual "rounds" should therefore not be too ambitious: objectives should be a realistic reflection of what a region can achieve in, say, one year. With that limitation, projects should have a catalytic effect, providing the region with a lever for the next development phase.

4. Sustainable development

UNIDO uses an integrated approach to development: a strategy should not only be concerned with economic competitiveness; social and environmental issues should be integrated at the conceptual level as well as in concrete actions. Social capital (social stability, education, entrepreneurial culture) and environmental capital (raw materials, a healthy living environment, attractive landscapes) are factors in economic success; therefore their "stock" must be maintained for long-term development. A competitive economy, on the other hand, helps to ensure social stability through high employment rates, provides the financial basis for a good educational system, stimulates people to be entrepreneurial and innovative, and encourages efficient resource use.

5. Regional strategy and business infrastructure

Apart from meeting concrete needs of enterprises, 'hard' business infrastructure (industrial estates, science parks, etc.) is popular with decision makers because (1) technical solutions to economic problems often seem straightforward; (2) they represent a visible achievement. But they usually require large financial investments. If these are to pay off and fulfill their promise, they should be part of a strategic process. A realistic appraisal of their potential contribution should be combined with a step-by step, demand-oriented approach to realization and expansion.