OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

UNIDO RESEARCH PROGRAMME

COMBATING MARGINALIZATION AND POVERTY THROUGH INDUSTRIAL DEVELOPMENT ‹COMPID›

Technological development in low-income countries: policy options for sustainable growth

UNIDO
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

‹COMPID›

COMBATING MARGINALIZATION AND POVERTY
THROUGH INDUSTRIAL DEVELOPMENT

Technological development in low-income countries: policy options for sustainable growth

By

Michael Rock
Bryn Mawr College, United States of America

David Angel
Clark University, United States of America

Backstopping Officer
Frank Van Rompaey
Strategic Research and Economics Branch
Programme Coordination and Field Operations Division, UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2006

Acknowledgements

Throughout the implementation period, the authors of the report worked in close cooperation with selected staff in the substantive Branches of UNIDO. An in-depth field study was carried out in Ghana with the assistance of Akmel Akpa, UNIDO Representative and Mimi Groenbech, Ghana. National experts were engaged for conducting a country survey appraisal in 27 low-income countries as follows: Mohammed Kabirul Islam (Bangladesh); Rory Narvaez (Bolivia); Seng Bunly (Cambodia); Gabriel Feudjeu (Cameroon); Vy Abel Oualeka (Côte d'Ivoire); Endeshaw Bekele Haile (Ethiopia); Felicia Owusu-Bonsu (Ghana); Hector Caballero (Honduras); Wisnu Gardjito (Indonesia); Charles Otiso Orina (Kenya); Makkamjan Abdulkadyrov (Kyrgyzstan); Mamadou Traore (Mali); Sarantungalag Bazarragchaa (Mongolia); Constantino Marrengula (Mozambique); Lok Nath Sharma (Nepal); Pedro Blandon (Nicaragua); Ignatius Okoye Obi (Nigeria); Hatam Hakimov (Uzbekistan); Abdul Ghani Mohamed (Yemen); Jean-Claude Cyimana (Rwanda); Amadou Ndiaye (Senegal); Ranasinghe Hm (Sri Lanka); Dalia Khalil Haskim Amin (Sudan); Robinah Sabano (Uganda); Tran Ngoc Ca (Viet Nam); Isaac Changani (Zambia); and Mongosuthu C. Halimana (Zimbabwe).

The report was reviewed by the in-house focal points, Ned Clarence Smith, Ouseph Padickakudi and Jaime Moll de Alba. Larry Westphal, as a member of the external peer review group, vetted the report. Frank Van Rompaey was responsible for backstopping the project. Maria Fermie was responsible for copy-editing and finalizing the manuscript. Overall guidance was provided initially by Jørgen Estrup and, later, by Frédéric Richard.

Contents

Explanatory notes

The following is a list of the terms and symbols that have been used throughout the report.

References to dollars ($) are to United States dollars, unless otherwise stated.

The term "billion" signifies a thousand million.

Countries are referred to by the names that were in official use at the time the relevant data were collected.

In accordance with the World Bank definition of low-income economies (economies with a gross national income per capita of $767 or less (2003)), the following 61 countries are listed as *low-income countries*: Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of Congo, Democratic Republic of Korea, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, India, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Moldova, Mongolia, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Republic of Congo, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Tajikistan and United Republic of Tanzania. The number of countries included in this list is subject to revision up or down depending on the changing economic status of the countries.

The term "newly industrializing countries" is used to describe developing economies, be they countries, provinces or areas, where there has been particularly rapid industrial growth. It does not imply any political division within the ranks of developing countries and is not officially endorsed by UNIDO.

The following symbols and terms have been used in tables:

Two dots (..) indicate that data are not available or are not separately reported.

A dash (-) indicates that the amount is nil or negligible.

Totals may not add precisely because of rounding.

The following abbreviations and acronyms appear in the report:

ISO: International Organization for Standardization;

OECD: Organization for Economic Cooperation and Development.

OVERVIEW

The purpose of the report on *Technological development in low-income countries: policy options for sustainable growth* is to develop a conceptual policy framework that can be used as a guide, not a blueprint, by UNIDO to assist its Member States and the private sector in low-income countries to design and implement technology strategies which are environmentally sound. The focus on technological development and capability-building, derives from the core proposition that technological effort and learning within industry is, and will remain, central to efforts to generate poverty-reducing growth[1] in and for low-income countries to meet the Millennium Development Goals.[2] Technological effort and learning allow industrial firms in countries to acquire the technological capabilities necessary to take advantage of the opportunities created through macroeconomic and political stability, trade and investment liberalization and economic globalization.[3] Putting in place the policies, institutional structures and resources that support technology upgrading within low-income countries is thus a critical point of policy intervention.

While much is known about how to design and implement technology strategies in middle- and higher-income developing countries (UNIDO [91 and 92]; UNIDO [90]; Bennett [14]; Hobday [35]; Kim and Nelson [49]; Amsden [5 and 6]; Kim [48]; Teubal [87]; Battat, Frank and Shen [12]; Justman and Teubal [42]; Hobday [33]; Nelson [65]; Bell and Pavitt [13]; Lall [52]; Wade [98]; Dahlman, Ross-Larson and Westphal [21]), very little is known about how this can be done by low-income, marginalized countries. Initial conditions in these countries are not particularly conducive to long-term industrial development strategies, particularly if those strategies are rooted in building the technological capabilities of indigenous firms (UNIDO [94]). Furthermore, while the literature offers some insights into how to link technology strategies to industrial environmental management strategies in the rapidly industrializing countries of East Asia, through what is labelled policy integration (Angel and Rock [7, 8 and 9]; Rock and Kim [80]; Rock [76]), even less is known about environmentally sound industrial development in low-income countries. Therefore, developing the envisaged framework is a daunting task, which should be approached in a stepwise fashion.

Chapter I develops a conceptual policy framework for analysing technological development in low-income countries. The focus is on the critical core elements of technological development and on the multiple pathways used by firms and governments to engender technological activity within indigenous firms. In addition, an outline is presented on what is known about how countries have integrated industrial environmental management strategies into their high-speed technological catch-up industrial development strategies. The focus here is on what is labelled

[1]The importance of technological learning and innovation for productivity growth and industrial development is treated in detail in UNIDO's *Industrial Development Report 2002/2003.*

[2]General Assembly resolution 55/2.

[3]The case for technological capability building is presented in UNIDO's *Industrial Development Report 2005.*

policy integration—the direct integration of policy processes that build technological capabilities and enhance the environmental performance of industrial firms in developing countries. Based on these reviews, a policy framework is drawn up for designing and implementing technology strategies in low-income countries aimed at generating productivity-enhancing, environmentally sound industrial growth.

Chapter II presents a series of empirical analyses and applications of the conceptual policy framework for these countries. Three separate empirical analyses are presented. First, an empirical examination is made of the extent to which low-income countries are positioned to engage successfully in environmentally sound technological development. Following the structure of the conceptual policy framework, the empirical analysis is organized around specific *pathways* for technological capability-building, to examine whether the requisite *enabling conditions, policy process, technology infrastructure* and *policy integration* are in place to successfully pursue one or more technological pathways, in particular in low-income countries. Secondly, a concrete case study is presented on the application of the policy framework, focusing on efforts to build technological capability in the ready-made garment industry in Ghana. Thirdly, the application of policy integration is documented as an approach to link technological capability-building to industrial environmental management, by means of a case study on the operation of supply chains in the manufacturing sector of electronics in Penang, Malaysia.

Empirical research shows, inter alia, that many of the enabling conditions for successful technological development, industrial environmental management and poverty-reducing industrial growth are either absent or poorly developed in the low-income countries. In some of the poorest countries, current levels of infrastructure, human capital and governments' bureaucratic capabilities are so far below the minimum threshold of sufficiency that it is difficult to imagine the successful achievement of the Millennium Development Goals in the absence of major new development initiatives and large-scale increases in development aid. In countries where enabling conditions are stronger, it is necessary to carefully consider the policy process in use and institutional capability available, in order to derive appropriate policy options for technological development. In the report, survey data are used to probe more deeply into policy process and institutional effectiveness—something that aggregate published data do not permit. The report also demonstrates how to apply the conceptual policy framework as a "gap analysis" for individual countries.

In chapter III, the implications of the conceptual policy framework and the allied empirical analyses for UNIDO operations are reviewed. It is felt that the conceptual framework and associated empirical work has overarching implications for the process and approach adopted by UNIDO to promote productivity enhancement. Hence, three elements are singled out for particular attention:

- Policy process;
- Diagnostics;
- Policy integration.

The report also identifies specific implications for particular UNIDO service modules, focusing mainly on the work of:

- Service Module 2: Investment Promotion and Technology Promotion;
- Service Module 8: Environmental Management—with particular emphasis on national cleaner production centres;
- Service Module 3: Industrial Competitiveness and Trade—with a particular focus on standards and productivity centres;
- Service Module 4: Private Sector Development—(specifically on business development services).

In summary, the conceptual policy framework developed in the report identifies five core elements for promoting technological development and industrial environmental management:

- Enabling conditions;
- Policy process;
- Technology infrastructure;
- Policy integration;
- Technological development pathways.

The empirical analysis in chapter II clearly demonstrates that one of the major challenges facing low-income countries is their weak position with respect to many of the basic enabling conditions necessary for successfully promoting technological capability-building by firms. While it is well understood, it is nonetheless worth repeating that efforts made by UNIDO to promote technological development need to be coordinated with broader development initiatives to strengthen the underlying enabling conditions for private sector development in low-income countries.

In addition to the emphasis on enabling conditions, the policy framework developed in the report identifies five critical elements of a policy process for successful technological capability-building. Successful technological development in low-income countries requires the adoption of a policy process:

- Marked by a national strategy of industrial development;
- Centred on a principle of embedded autonomy between firms and governments;
- Market-building in its orientation;
- Promotes links to the global economy for services and technological know-how;
- Engages in policy integration.

The report argues that these five broad principles need to guide the technical assistance approach adopted by UNIDO to support environmentally sound technological development in low-income countries.

I. CONCEPTUAL FRAMEWORK AND RESEARCH REVIEW

It is widely recognized that conscious effort by both individual firms and Governments is necessary for building technological capabilities in indigenous industrial firms in developing countries, if they are to produce efficiently, thrive and grow, generate numerous well paid jobs and compete in the global economy (UNIDO [90]; Lall [52]; Dahlman, Ross-Larson and Westphal [21]). For their part, firms must commit substantial resources to a long-term, incremental and cumulative, but difficult, uncertain and risky effort to expand their technological capabilities (UNIDO [90]). Governments, in turn, can assist firms by maintaining political and macroeconomic stability, creating an institutional framework—including strong bureaucratic capabilities and embedded autonomy with industrial firms—and an incentive system that encourages firms to engage in this difficult, risky and costly process. This can be done by ensuring flexibility in factor markets, helping firms to overcome market and coordination failures, and providing the services of needed support institutions (ibid. [90]).

This means that neither a minimalist State nor just opening an economy to trade and foreign direct investment, as suggested by the Washington Consensus (Williamson [103]; World Bank [105]), is sufficient to ensure that indigenous firms will build their technological capabilities or learn how to do so (UNIDO [90]). Countries need institutions and strategies to take advantage of economic openness to climb the ladder of technology upgrading (Chang [19]). In this chapter, a conceptual framework is developed to understand better the role that governments can play in supporting technological development of industrial firms. As indicated, the appropriate question to be asked is not *whether* governments should be involved in promoting technological development of firms, but *how* such intervention can be successful in low-income countries within the context of the current global economy.

First, a review is made of what is known about technological development of firms in developing countries (with a particular focus on the situation of low-income countries). Secondly, ways are examined to find out how technological development can be linked to improving the environmental performance of industry. Based on these reviews, a policy framework is outlined for designing and implementing environmentally sound technological development strategies and policies in low-income countries.

A. WHAT IS KNOWN ABOUT TECHNOLOGICAL DEVELOPMENT IN DEVELOPING COUNTRIES?

To answer this question, first the role of firms is treated. Then the potential contribution of governments is considered for securing the basic enabling conditions to induce firms to invest in technological development. Once the basic enabling conditions have been identified, the

institutional and policy frameworks are examined within which firms and governments can successfully interact in technological development, drawing upon the experience of the East Asian newly industrializing countries.

1. The role of firms

Technological development is primarily a firm-level effort. It involves trial and error and gaining tacit experience with particular technologies (Lall [52]). As is presently known, there are significant differences in the willingness of firms to undertake and succeed in these tasks. If this were not the case, productivity and efficiency differences between firms using the same technology in the same industry, both within and between countries, would be less than observed (Tybout [89]). In the same vein, differences in the degree to which firms in the same industry in the same country adapt and improve existing industrial technologies to new needs or create new comparative advantages in increasingly technology-intensive sectors would also be smaller than observed (Bell and Pavitt [13]).

In developing countries, technological development is largely an imitative, rather than an innovative, process. In other words, firms in developing countries build their technological capabilities, in essence, by importing and adapting already existing technologies, rather than by engaging in basic research, applied research and development, or new product innovation. Firms in developing countries often start the process of technological development with very limited technological capabilities. As such, they are confronted with a particularly daunting set of problems and choices. They must first match their choice of foreign technology to local needs, conditions and constraints (Dahlman, Ross-Larson and Westphal [21]). Doing so requires firms to scan the technological horizon to identify and assess the technological possibilities open to them. This is both a time-consuming and costly endeavour.

Before deciding on the choice, firms must assess the costs and benefits of that choice. This includes assessing the possibilities that each distinct technology holds for acquiring additional capabilities. As different technologies offer substantially different opportunities for adaptation and improvement, initial technology choices tend to limit the capabilities that firms can acquire. Moreover, since it is difficult for firms to learn across diverse technological dimensions, particular technology choices tend to move firms along particular technology trajectories. This means that initial technology choices and subsequent technological activity are very likely to be path dependent, thus making the initial technology choice decision doubly important.

Once firms have narrowed their search to particular technologies, they must decide precisely how to acquire all the elements—information, means and understanding—associated with their technology choices (Dahlman, Ross-Larson and Westphal [21]). Options include relying on foreign direct investment, licensing agreements, turnkey projects, purchase of individual pieces of capital equipment and/or acquiring technological capabilities through technical assistance (Dahlman, Ross-Larson and Westphal [21]). As might be expected, each option and/or combination of options offers unique advantages and disadvantages. Having settled on the technology choices and options for acquiring all the elements associated with particular technologies, firms must then invest in the arduous tasks of acquiring the investment, production and linkage capabilities offered by the technologies they have chosen.

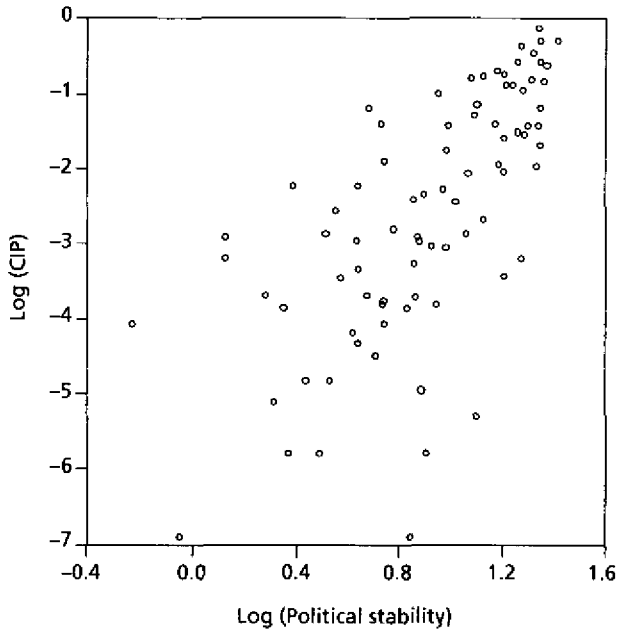
With respect to investment capabilities, firms must learn how to organize and oversee all activities associated with establishing and/or expanding a given factory (Lall [52]). This means they must be able to carry out investment feasibility studies of possible projects, develop training programmes to impart particular skills and learn how to make the technology work in a particular setting (Lall [52]). This normally involves adapting the technology to local conditions as well as choosing and supervising hardware suppliers and construction contracts.

Once the technology is installed, emphasis shifts to acquiring production capabilities, or the capability to improve the operation of a factory, to learn how to optimize the operation of facilities, including raw material control, production scheduling, quality control, troubleshooting, adapting processes and products to changing circumstances and to repair and maintain equipment as needed (Lall [52]). Finally, firms must develop linkage capabilities that enable them to transmit information, skills and technology to and receive information, skills and technology and other inputs of components and raw materials from suppliers, subcontractors and technology institutes (Lall [52]).

2. The role of governments in securing enabling conditions

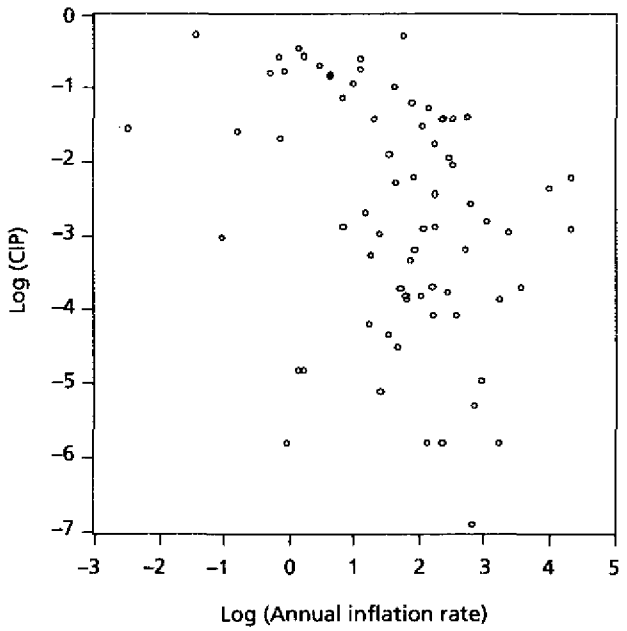
Since all firms are embedded in a larger socio-political and economic environment, government policies have an enormous impact on whether firms invest in building their technological capabilities, how much they invest in capabilities-building and how successful they are in building their capabilities. To begin with, governments must provide the basic *enabling conditions* for firms to invest in technological capability-building. A key enabling condition is the need to ensure sufficient political stability so that firms can reap the gains from long-term investments in technological development.

FIGURE I.
POLITICAL STABILITY AND UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX



As figure I shows, political stability exerts a powerful influence on one important measure, UNIDO's competitive industrial performance index, of the degree to which firms in particular countries have successfully built their technological capabilities and of the resulting level of industrial technological development of that country.[4] Political instability shortens time horizons and encourages capital flight, undermining firms' and countries' industrial competitiveness. It turns out that macroeconomic stability—a competitive exchange rate, relatively low inflation, and sustainable fiscal and current account deficits—is equally important. Evidence of this is provided in figure II, which shows the relationship between a country's competitive industrial performance index and the inflation rate.

FIGURE II.
INFLATION AND UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX



Similarly, as can be seen in figure III, openness to trade (as measured by the Dollar Index (Dollar [22])) is equally important. But, as is argued below, openness on its own, without formal policies and institutions, including industrial polices, designed to encourage and assist firms to increase their technological capabilities, is not sufficient to ensure technological development.

The competitiveness of industrial firms also depends on the quality and cost of infrastructural services—transport, communication and power—and the availability of a requisite amount of skilled and unskilled labour at the right wage rates. In most developing countries, governments exert a dominant influence on the cost, quality and supply of both. If the costs of infrastructural services and labour are too high or the quality and reliability too low, firms will find it difficult to compete in world markets and their industrial competitiveness will be low (figures IV and V).

[4]It is understood that the correlations presented in this and the next set of figures do not, on their own, convey causation.

FIGURE III.

OVERVALUATION OF THE EXCHANGE RATE (DOLLAR INDEX) AND UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX

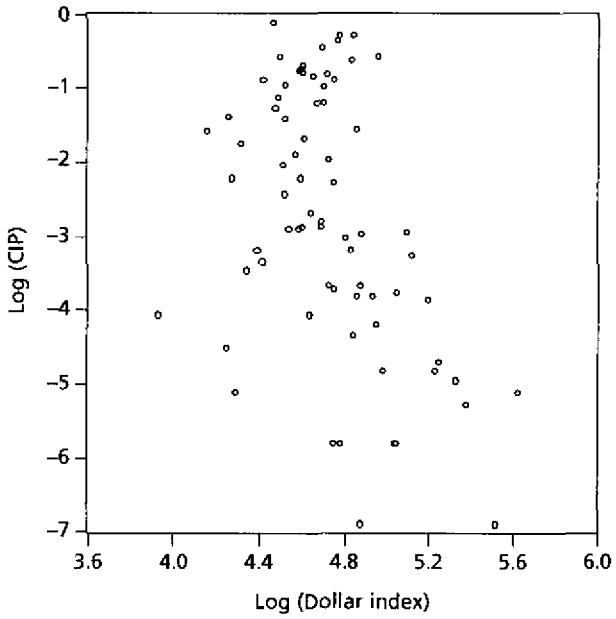


FIGURE IV.

UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX AND HUMAN SKILLS INDEX

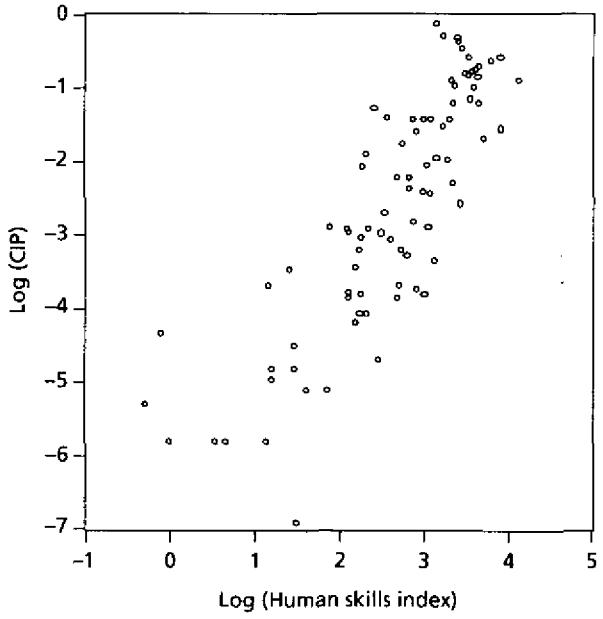
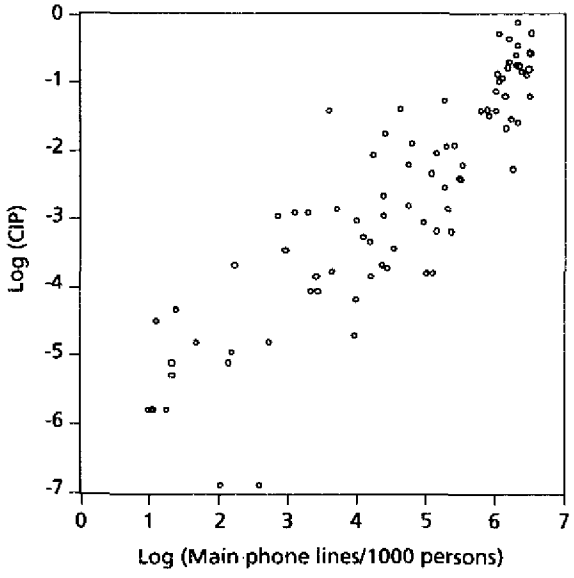


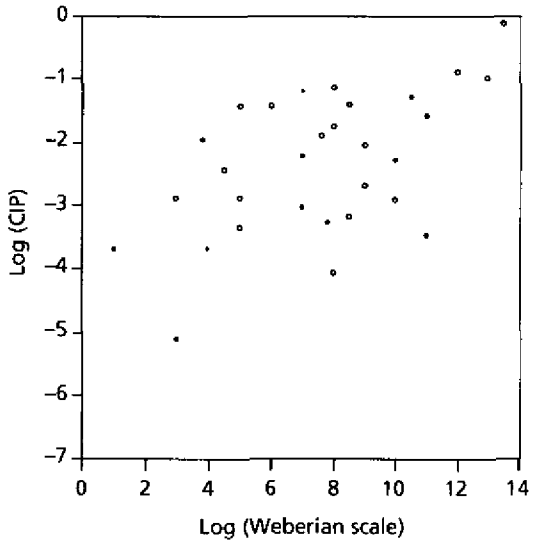
FIGURE V.
UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX (CIP) AND PHYSICAL INFRASTRUCTURE DEVELOPMENT (MAIN TELEPHONE LINES PER THOUSAND PERSONS)



Beyond this, governments must establish and sustain a long-term vision for industrial growth and must also help firms overcome market and coordination failures (UNIDO [90]). Most governments have difficulty doing this without creating, possessing and sustaining a competent, relatively well paid and non-corrupt bureaucracy. As is currently evident, creating such a bureaucracy is time consuming and costly (Evans and Rauch [27]; Evans [26]). It requires a merit-based recruitment system, salaries that are comparable with those in the private sector, prospects for career development in government agencies that offer long-term opportunities for advancement, a public service problem-solving institutional esprit de corps and embedded autonomy with the private sector (Evans and Rauch [27]). As figure VI reveals, competent, relatively well paid and non-corrupt bureaucracies, with a high degree of embedded autonomy with the private sector, are important contributors to the competitiveness of a country's industries. It can be concluded, therefore, that governments must invest in creating a relatively competent, goal-oriented and corruption-free bureaucracy, if they expect to become effective in stimulating technological development in private sector firms.

Governments, as a whole, play a key role in establishing broad enabling conditions that support firm-based technological capability-building. These enabling conditions include: political and macroeconomic stability; openness to trade and investment; appropriate infrastructure; and investments in human capital. But beyond these basic enabling conditions, is there a more direct role for governments in promoting technological development? Specifically, what is the precise structure of interaction between firms and governments that would support technological development in low-income countries? To address these issues of institutional approach, the experience of the East Asian newly industrializing countries in engaging in rapid industrial growth and technological upgrading is reviewed.

FIGURE VI.
BUREAUCRATIC EFFICIENCY (WEBERIAN SCALE) AND UNIDO'S COMPETITIVE INDUSTRIAL PERFORMANCE INDEX



3. The role of governments in industrial policy: the experience of East Asia

What approach did the East Asian newly industrializing countries adopt in pursuit of technological development? As it turns out, a considerable variety of approaches exist across and within countries. Three broad approaches are described.[5] In the first instance, the core features of each approach are identified. Subsequently, how those core and non-core elements were combined to generate critical mass in capabilities building is demonstrated.

The first approach, followed by Taiwan Province of China, focused on building public sector institutions to create a national technology system that was closely linked through embedded autonomy to the Province's small and medium enterprises and the global economy (Wade [98]). A public sector investment promotion agency identified industries and technologies thought to be most applicable to each stage of industrial development (Wade [98]).

A public sector science and technology institute acquired these technologies, reverse engineered them and diffused them to the Province's numerous small and medium enterprises (Wade [98]). A public sector export-marketing agency then helped these firms overcome information failures associated with serving markets of developed countries (Keesing [46]; Wade [98]). Another public sector agency linked the Province's larger firms to clusters of smaller firms that ultimately became suppliers to those larger firms. In numerous instances, State-owned enterprises in upstream industries were used to acquire technological capabilities in scale-intensive industries and to supply downstream users with high quality and competitively-priced intermediate inputs (Wade [98]).

[5]These broad approaches aim to identify the *dominant* approach to technological development within particular countries. In actual practice, governments in most East Asian countries (or regions) adopted elements of more than one approach to technological upgrading. Thus, for example, while Taiwan Province of China focused most of its technological development strategy on small and medium enterprises, it also promoted larger firms in upstream industries (Wade, 1990). Similarly, Thailand focused most of its upgrading efforts on large firms even though it also promoted (largely unsuccessfully) technological development in small and medium enterprises (Rock [76]).

A second approach, followed by the Republic of Korea, and to a lesser extent by Indonesia and Thailand, focused on new Government institutions and new incentives for building large indigenous national firms that could compete globally with multinational corporations of developed countries. The approach of the Republic of Korea for building technologically competent national firms was rooted in a unique institutional framework that enabled the Government to allocate performance-based promotional privileges, particularly subsidized credit from State-owned banks, to a small number of what turned out to be very large conglomerates (Amsden [5]; Jones and Sakong [41]; Rhee and others [68]; Westphal [101]). Those firms also relied heavily on the Government's Foreign Capital Inducement Act, which severely restricted foreign direct investment and rigorously reviewed requests of these firms for licensing and technical assistance agreements to ensure that such agreements enhanced the building of firm-level technological capabilities (Mardon [60]).

The Governments of Thailand and Indonesia were not only less capable than the Government of the Republic of Korea, but Government-business relationships were also more prone to rent-seeking activities (Rock [71, 73 and 74]; MacIntyre [57 and 58]). Besides, Governments in both countries were also more open to foreign direct investment. Owing to this, promotional privileges tended to be somewhat less performance based. Nonetheless, Governments in both countries targeted promotional privileges to a relatively few, in what turned out to be very large national firms engaged in joint ventures with large multinational corporations of developed countries (Rock [73 and 74]). As in the Republic of Korea, national firms dominated the industrial economy. Initially, many of the joint ventures between these large national firms and multinational corporations served local rather than export markets. Over time, however, promotional privileges shifted to encourage the exports of manufactures.

The third approach, followed by Malaysia and Singapore, initially focused on creating an institutional framework and developing the physical and human infrastructure necessary to attract multinational corporations of developed countries (Lee [54]; Huff [36]; Times Academic Press [85]; Raisah [66]). In both countries, premier investment promotion agencies scoured the globe for firms and industries. In both countries, modern industrial parks and export processing zones were built to meet the needs of foreign investors for reliable, high quality and reasonably priced infrastructure services. They also invested in skilled labour, they controlled wage rates and severely restricted rights of workers to unionize and strike (Huff [36]; Jomo and Todd [40]). In the first instance, this approach to technological development did not assume the necessity of creating an indigenously-owned industrial base or an indigenous class of entrepreneurs.

Subsequently, Governments in both Malaysia and Singapore extended this model to include the participation of indigenous small and medium enterprises in the global value chains of multinational corporations located in each country (Battat, Frank and Shen [12]; Raisah [67]). In both instances, this was accomplished through programmes for upgrading local industry or vendor development programmes that linked investment promotion agencies, multinational corporations and domestic small and medium enterprises in long-term relationships. Domestic suppliers were thus able to meet the quality, price and on-time delivery specifications of their multinational buyers. Along the way, various local small and medium enterprises supplying the multinational corporations with various intermediate inputs acquired substantial technological capabilities.

In each of these cases, the Governments developed increasingly capable bureaucracies that adopted long-term visions of industrial growth, maintained political and macroeconomic stability, as well as flexible factor markets. They also provided institutional frameworks and governance structures that incited entrepreneurs through trade, credit and industrial policies to invest and take risks, finance and/or provide high quality infrastructure and an increasingly skilled labour force, and build high quality support institutions deeply embedded in the private sector. In each instance, none of this was easy to achieve. To begin with, capable Government bureaucracies had to be created and sustained. Since none of the reform-minded Governments that led new industrial development strategies inherited well developed and capable bureaucracies, creating them was a difficult, time-consuming and costly process.

In conjunction with the development of bureaucratic capabilities, the Governments learned through long, pragmatic, often tortuous, trial-and-error processes, how to deal with each of the related matters required to bring their vision of industrial development to fruition. There was not a single instance where Governments were able to develop and follow a well defined blueprint, such as the Washington Consensus. In virtually every case, political and macroeconomic stability followed a period of instability in one or both. After re-establishing political and/or macroeconomic stability, new political leaders worked out how, with the help of their advisers, to take advantage of political and/or economic crises to create a new political economy of growth centred around industrial development and the export of manufactures. This meant that political leaders had to find ways to link their newly created visions for industrial development to their long-term political needs. Without this, it is doubtful whether they would have developed and/or sustained their commitments to industrial development (Rock [81]; Kang [43]).

In countries with large agricultural populations, modernization of smallholder food crops (rice) proved to be an important and critical catalyst for designing industrial development strategies. Some (Grabowski [31]) have argued that East Asia's development originated in agriculture. Others (Kay [45]; Johnston and Mellor [39]; Mellor and Johnston [63]; Johnston and Kilby [38], Murphy, Shleifer and Visny [64]; Erh-Cheng [25]; Timmer [86]; Rock [78]) have argued that successes in smallholder agriculture stimulated industrial development by increasing local incomes and the demand for manufactures, reducing poverty, freeing labour for urban industrial work, and either earning foreign exchange or freeing foreign exchange from having to import food. Heavy investment in education, in particular, primary education and subsequently in secondary, tertiary and engineering education, was equally critical (Haggard [32]; Campos and Root [18]). Without such investment, it is doubtful whether these countries would have been able to provide industrial investors with sufficient quantities of unskilled, semi-skilled and skilled labour at the right wage rates needed to make their investments profitable. Establishing incentives and institutions for long-term industrial and technological development was also a long and protracted process. To start with, each of these Governments established and maintained flexible markets, in particular for labour, more often than not by repressing unions, and passing and enforcing very tough anti-union legislation. Governments in those countries also used industrial, credit and trade policies to create unique incentive structures and institutions to promote industrial development.

The Government of the Republic of Korea relied heavily on administrative allocation of heavily subsidized credit from State-owned banks, a centralized performance-based export targeting

system, and maintained tight control over foreign direct investment and licensing and technical assistance agreements to stimulate the chaebol to engage in high-speed technological upgrading. Taiwan Province of China, for its part, used State-owned enterprises in upstream industries, an aggressive industrial promotion agency, a highly capable science and technology institute to acquire technological capabilities from abroad, reverse engineer them, and diffuse them to a large number of relatively small firms, and a public sector export-marketing agency to market exports in developed countries.

The large-scale indigenous firms in Indonesia and Thailand relied on lucrative promotional privileges and on local content provisions in investment promotion agreements with foreign joint venture partners. As regulation stipulated that indigenous firms had to be majority partners in joint ventures with foreign firms, the Governments asserted incessant pressure on multinational corporations to transfer technologies to their joint venture partners. Governments in Malaysia and Singapore offered substantial promotional privileges, excellent infrastructure facilities and a highly skilled labour force to get multinational corporations to locate there. Over time, both Governments learned how to calibrate promotional privileges to attract higher value-added operations and to link local small and medium enterprises to international production networks of multinational corporations.

Along the way, Governments in these countries (or regions) built and sustained more, rather than less, successful industrial support institutions tightly linked to the needs of the private sector. The Republic of Korea and Taiwan Province of China built and sustained rather successful export-marketing agencies (Rock [70]; Keesing, [46]). Taiwan Province of China also created a high-technology industrial park and a highly successful science and technology institute (Wade [98]), and together with Indonesia, Malaysia, Singapore and Thailand relied heavily on industrial parks and export processing zones as locations for many of the joint venture activities between local and foreign firms and the activities of promoted foreign firms.

Governments in virtually all these countries (or regions) created enormously successful investment promotion agencies. In the Republic of Korea, Singapore, Taiwan Province of China and, to a lesser degree, Malaysia, investment promotion agencies acted as one-stop investment shops and regularly targeted particular foreign firms and industries for promotional privileges. In Indonesia and Thailand, investment promotion agencies were less successful in industrial targeting, as they were more prone to rent-seeking. Nevertheless, investment promotion agencies in both these countries were very successful in showering the bulk of promotional privileges on a small number of firms that grew to dominate the industrial economy (Rock [71] and 73]).

The critical point here is that the Governments of the East Asian newly industrializing countries played an important and active role in promoting technological development within firms. There was no single approach taken by the East Asian newly industrializing countries; rather there was considerable variety in the specific approach taken across different countries in East Asia. The critical questions on what can be learned from the experience of the East Asian newly industrializing countries and what approaches can be adopted for technological development in low-income countries are also treated. But first, another dimension of policy process is considered, namely, ways in which countries in East Asia have linked together technological upgrading and industrial environmental management within an integrated policy framework.

B. FROM TECHNOLOGY UPGRADING TO IMPROVED INDUSTRIAL ENVIRONMENTAL PERFORMANCE

One of the key objectives of the present report is to understand the ways in which technological development can be linked to the objectives of industrial environmental management in low-income countries. As it happens, the East Asian newly industrializing countries provide important insights into how this might be achieved. Governments in several rapidly industrializing East Asian countries have demonstrated the capacity to integrate industrial environmental management strategies into their technological capabilities-building programmes within an approach that is labelled policy integration. Policy integration begins with building and strengthening traditional environmental regulatory systems. It extends beyond this regulatory process to the direct integration of economic and environmental goals within the operations of mainstream agencies of economic and industrial development.

Starting with a description on the role of environmental regulatory agencies in East Asia, there are a number of features shared by such effective agencies within the region. First, these agencies adopted *aggressive performance goals and clear performance expectations* that were consistently pursued and implemented. Typically, these goals were rooted in national environmental legislation, which authorized the establishment of a cabinet-level environmental agency, such as the State Environmental Protection Administration in China, or the Ministry of Environment in Singapore, that was responsible for setting ambient environmental standards and had the capability to link the achievements of these ambient standards to emission limits for firms and industries (Rock [76]). Typically, emission limits were based on the best available technology, which does not entail excessive costs. No country is known to achieve substantial improvement in the environmental performance of industry without the presence of a strong national agency on environmental protection.

Secondly, clear performance expectations require rigorous and *consistent enforcement* of emissions and ambient environmental standards. Irrespective of the level of a country's environmental performance goals, modest or ambitious, when pollution management policies are unevenly and inconsistently applied, it translates into unclear and uncertain messages concerning performance expectations and results in higher levels of malfeasance and erosion of benefits for leading firms. An important first step for influencing basic industrial decision-making, therefore, is a national environmental regulatory system that provides clear performance expectations that are consistently enforced. Consistent regulatory enforcement is a prerequisite for widespread compliance with environmental standards and for achieving environmental performance goals. Effective enforcement requires policies, rules and resources, and a level of institutional "reach" that stretches from the national to the regional and local scale.

Thirdly, these increasingly capable pollution management agencies also *adopted appropriate policy tools*. In the context of East Asian development, it was imperative that environmental regulatory institutions use the policy tools that allowed economic actors full flexibility when selecting cost-effective strategies for meeting environmental performance expectations. Typically, this involved some combination of ambient environmental standards and emissions standards, multimedia pollution control, pollution charges and resource pricing that reflected environmental costs. It also involved the use of other market-based instruments, such as emissions trading, as

well as various forms of informal, private law and community-based regulation, such as public disclosure of environmental performance information (Vincent and Afsah [3]; World Bank [106]). In most cases, flexibility was obtained through case-specific decision-making, for example, allowing regulatory personnel some flexibility of response based on their knowledge of local circumstance.

Fourthly, the most effective environmental regulatory agencies had the *capacity to learn and adapt to change.* Successful environmental regulatory agencies in East Asia were pragmatic, opportunistic, had flexibility of response, coordination across scales, capacity to learn from experience and to adapt to changing economic and political circumstances (Rock [76]). This was especially important with respect to the selection and implementation of policy tools, as clearly seen in the innovative use of community-based and informal systems of regulation in China (Rock [76]), Indonesia (Vincent and Afsah [4]) and other developing Asian countries (World Bank [106]). They also developed regulatory systems *rich in information*, which began by standardizing information on environmental performance; the bedrock of regulatory compliance.

Information was further enriched by covering a broader set of economic, technological and social characteristics, including the economic circumstance of firms, the track record of good faith behaviour or of malfeasance and the availability of alternative production processes and technologies that offer industrial environmental management at a lower cost. Thus, such information richness typically extended beyond the limits of the regulatory agencies themselves; it included information developed by industrial policy agencies on the energy, water and materials intensities of industrial production by disaggregated industrial sector (Angel and Rock [9]; Rock [76]). However, policies and strategies for industrial environmental management did not stop with the creation and empowerment of traditional environmental agencies.

In a significant number of countries (and regions)—from Malaysia and Singapore in South-East Asia and to China (including Taiwan Province of China) in North-East Asia—policy-makers increasingly turned to what is labelled *policy integration*, or the direct integration of policy processes that build technological capabilities and enhance the environmental performance of industry (Angel and Rock [7, 8 and 9]; Rock and Kim [80], Rock [74 and 76]). Instead of addressing environmental performance exclusively through the external pressure of freestanding environmental agencies, policy integration helped internalize environmental considerations within the basic economic decision-making of firms and industries and within the policies of the industrial development agencies that bore primary responsibility for promoting industrial growth.

Integration of environmental considerations into institutions of industrial policy followed somewhat different pathways. Nevertheless, they all depended on three dimensions of policy integration:

- Forging relations with powerful State institutions of industrial development;
- Identifying cost-effective technological options for reducing abatement costs;
- Adopting an information-driven approach to promote demand for industrial environmental management.

Close relations with industrial development agencies proved critical for gaining support to improve the industrial environmental performance of Government and businesses and to

identify cost-effective abatement options. They also provided opportunities for lowering the energy, water and material intensities of production. The manner in which this was done varied quite significantly from country to country.

Singapore's pathway to policy integration (Angel and Rock [8 and 9]) linked the promotional decisions of its investment promotion agency, the Economic Development Board and the decisions on infrastructure by the premier infrastructure agency, the Jurong Town Corporation, to a requirement, whereby firms receiving support from both these agencies had to meet the environmental requirements of its environmental agency, the Ministry of the Environment. This gave the Ministry of the Environment an important seat at Singapore's industrial policy table. Singapore's decision (Rock [76]) to elevate its environmental agency to co-equal status with its industrial promotion agency and its premier infrastructure agency reflected the decision to build the economy as a clean, green first-world oasis for multinational corporations in South-East Asia.

As is well known, the country's Economic Development Board scoured the world for industries and firms it wanted to attract. It offered promotional privileges—typically, tax holidays, accelerated depreciation allowances and access to space in one of the country's premier industrial estates administered by the Jurong Town Corporation to get firms, in particular industries, to locate in Singapore (Huff [37]). But before promotional privileges were granted by the Economic Development Board and the necessary space was allocated by the Jurong Town Corporation, the Ministry of the Environment had to approve of the production process of each firm and its plan to abate pollution to meet the tough emissions standards of the country. Occasionally, particular industries were rejected by the Ministry of the Environment as they were too polluting, but very often through close cooperation with these firms, cost-effective treatment technologies were identified. The Ministry of the Environment also worked closely with the Jurong Town Corporation to ensure that the most polluting industries were located as far as possible from residential and commercial areas. In so doing, the Ministry of the Environment helped Jurong Town Corporation to shrink the geographic distribution of hazardous activities and to locate similar activities with similar waste streams in specific areas. This facilitated several common solutions to pollution problems.

The Government of Taiwan Province of China (Angel and Rock [8 and 9]; Rock [76]) followed another pathway to policy integration by developing an industrial environmental programme based on ratcheting up the industrial environmental performance of firms and industries, defined in terms of the energy, materials, water and pollution intensities of industrial value-added, to meet international best practices. Because its premier industrial policy agency, the Industrial Development Board in the Ministry of Economic Affairs, opposed the environmental cleanup, fearing it would undermine the profitability of industry at a time industry was being "hollowed out" by rising wage rates and an appreciating currency, the environmental programme of the Government initially bypassed the Industrial Development Board.

By creating a strong environmental agency and granting the environmental agency legal authority, technical capabilities and the administrative discretion to impose sanctions on firms that failed to meet emissions standards, the Government made the industrial policy agency aware of its serious intention on environmental cleanup. This led the industrial policy agency to formulate, with the consent of the Government, its own substantial industrial environmental

management programme. As soon as the environmental agency began imposing sanctions on polluters, the Industrial Development Board realized that it needed to develop its own environmental strategy. Thus, a pollution-prevention, waste-minimization programme was successfully developed jointly with the Taiwan Environmental Protection Agency (Rock [72 and 78]).

The Industrial Development Board not only offered promotional privileges to firms purchasing pollution control equipment, but also used its promotional privileges to foster the development of an indigenous environmental goods and services industry, which it hoped would become export-oriented. In fact, as has been typical of the export promotion programmes of the Industrial Development Board, it set quantitative export targets for this industry and access to promotional privileges appeared to be dependent on meeting those targets. Very surprisingly, the Industrial Development Board invested in creating a state-of-the-art research programme on the energy, water, materials and pollution intensities of the Province's industries that was carried out by the Industrial Technology Research Institute, the premier science and technology institute in Taiwan Province of China. As a result, Taiwan Province of China followed a pathway to industrial environmental management that integrated environmental considerations, in particular those relating to energy, water, materials and pollution intensities of firm- and sector-specific production, into a national innovation system.

Malaysia's pathway to policy integration focused on promoting close relationships between the country's relatively weak environmental agency and firms in the crude palm oil industry, a powerful industry association and a prominent palm oil research institute, for cleaning up wastewater emissions of crude palm oil (Angel and Rock [8 and 9]; Rock [76]). The country's (Angel and Rock [9]; Rock [76]) decision to link its environmental agency, the Department of the Environment, with crude palm oil mills, a crude palm oil industry association and palm oil research institute, the Palm Oil Research Institute of Malaysia, reflected a political reality that crude palm oil mills could not be shut down without undermining the Government's most successful rural anti-poverty programme. Through this programme, managed by the Federal Land Development Authority, new small-farmer palm oil farms were developed—complete with infrastructure clustered around larger palm oil estates and crude palm oil mills. Following racial riots in 1969 and the subsequent announcement of Malaysia's New Economic Policy, which was designed to reduce poverty among rural ethnic Malays, the Government financed (both privately and by the Federal Land Development Authority) palm oil production schemes, and crude palm oil production grew exponentially as Malaysia captured a large share of the world crude palm oil market. But this came at a substantial environmental cost, as wastes of crude palm oil soon clogged a large number of major rivers in the country. Trapped between the economic success of its small-farmer palm oil schemes and growing complaints on wastes of crude palm oil from rural ethnic Malays, the Government set out on a pragmatic search for cost-effective treatment technologies.

Once these technologies were identified by the Palm Oil Research Institute of Malaysia and evidence accumulated that crude palm oil mills were adopting these treatment technologies without undermining the profitability or exports of the industry, the Department of the Environment imposed emission standards and ratcheted them up over time as more cost-effective treatment technologies emerged. The result was an effective de-linking of pollution from the scale of palm oil production and exports.

One could ask why policy integration works. Case evidence suggests that the following aspects are crucial for ensuring that policy integration works. First, linking new environmental agencies to more powerful economic development and industrial policy agencies in East Asia helped gain critical support for environmental management within the Government and from business for industrial environmental management. It fostered trust and confidence between environmental and economic development, and industrial policy agencies and the business community over a shared need to clean up the environment without imposing costs on firms that endangered their profitability, growth and export potential. The involvement of economic development agencies was a powerful sign to the business community of the seriousness of the Government's commitment to the goal of industrial environmental management, as well as to the commitment to finding solutions that did not impose unreasonable costs on firms and industries. Experience with particular policy tools, such as the progressive phasing of stricter emissions requirements based on advances in best available technologies that did not involve excessive costs, increased confidence that improved industrial environmental performance and strengthened economic performance were goals that could be jointly pursued.

Another key benefit obtained from linking environmental protection agencies to development agencies in the case evidence relates to lowering abatement costs. Inter-agency cooperation facilitated access to important information on the costs of abatement and the impact of those costs on profitability and the ability of regulated firms to export. Most importantly, it facilitated joint efforts to seek cost-effective abatement technologies and explore ways to reduce pollution intensities and intensities of the use of energy, water and materials. Reducing abatement costs and energy, material, water and pollution intensities were and are particularly important to firms and Governments in East Asia. This is because both were and are convinced that improved industrial environmental performance cannot be achieved at the expense of poverty reduction, increasing incomes, economic diversification and expanding export bases.

A second key aspect to making policy integration work is success in identifying technological options that reduce the costs of abatement. As mentioned earlier, the Department of the Environment in Malaysia invested heavily in a worldwide search for the best available treatment technologies that would not entail excessive costs for treating wastes of crude palm oil. Finding none, it worked closely with the Palm Oil Research Institute of Malaysia to develop a treatment technology that worked. Once identified, the Department of the Environment used its relationships with the Palm Oil Research Institute of Malaysia and the crude palm oil industry to initiate the adoption of this new treatment technology. As soon as this treatment technology showed signs of working without undermining the profitability and export potential of the crude palm oil industry, the Department of the Environment raised emissions standards, ultimately de-linking crude palm oil production and exports from wastes of crude palm oil (Angel and Rock [8 and 9]; Rock [76]).

In the early days, the Ministry of Environment in Singapore invested heavily in a worldwide search for the most cost-effective abatement technologies (Angel and Rock [8 and 9; Rock [76]). This empowered the Ministry of Environment by making it acutely aware of best available treatment technologies that did not entail excessive costs. Since many promoted firms in Singapore had little experience with pollution control, the Ministry of Environment used this information to develop a list of reputable producers of environmental goods and services, which

it shared with promoted firms. This reduced information barriers for those firms and eased their transition to less polluting technologies. Over time, the Ministry of Environment insisted that firms seeking promotional privileges provide information on whether they plan to use cleaner technologies, whether they were willing to substitute materials use to reduce the toxic intensity of production, and how they intend to reduce water use in light of the scarcity of fresh water in Singapore. Since the Ministry of Environment had the requisite knowledge on international best practices and maintained close relations with promoted firms, it was able to help firms to lower abatement costs and decrease energy, water, materials and pollution intensities.

The Government of Taiwan Province of China (Angel and Rock [8 and 9]; Rock [72 and 76]) empowered the Industrial Development Board to identify cost-minimizing treatment technologies, lower the costs of abatement and reduce the energy, water, materials and pollution intensities of production. As in Malaysia and Singapore, the Industrial Development Board invested in information gathering on the costs of alternative treatment technologies for the firms and industries it promoted. It also invested in a practical joint programme with the Taiwan Environmental Protection Administration in pollution prevention and waste minimization. This included co-locating similar small and medium enterprises in industrial parks and empowering the enterprises in those estates to jointly manage pollution reduction.

The Industrial Development Board, however, went well beyond these activities. It subsidized the purchase of pollution-control equipment by offering tax reductions and accelerated depreciation allowances and access to subsidized credit for the purchase of pollution control equipment. Since the Industrial Development Board ultimately viewed the development of an indigenous environmental goods and services industry as one of the many steps in its promotional strategy, it subsidized the creation of an indigenous environmental goods and services industry, which it hoped would become export-oriented. It also engaged in state-of-the-art research on the energy, water, materials and pollution intensities of industries in Taiwan Province of China that included benchmarking performance against international best practices.

Thirdly, the case evidence also suggests that each of those regulatory agencies in rapidly industrializing countries (or regions) in East Asia routinely relied (and rely) heavily on information and disclosure-based industrial environmental management strategies. Long-, medium- and short-term ambient environmental goals for air, water and land were (and are) set to drive performance and to communicate to the public the progress made. Similarly, short-, medium- and long-term emissions standards were (and are) set to enhance the performance of firms and to report to the public the degree to which industry was (and is) complying with quantitative standards. In both instances, initial standards have been well below international best practice. This reflects the highly pragmatic step-at-a-time process used to achieve improved environmental outcomes in East Asia. It also enables those in regulatory agencies to learn about the difficulties associated with meeting quantitative environmental goals. While initial standards have been relatively easy to achieve, regulatory agencies made regulated firms aware that both ambient and emissions standards would be tightened over time.

The experiences of Malaysia, Singapore and Taiwan Province of China demonstrate that policy integration is practically possible and that it works. The advantages of developing an environmental policy through policy integration as opposed to stand alone environmental agencies acting alone are clear. Policy integration fosters critical mutual trust and support for industrial

environmental management in economic development and industrial policy agencies as well as within the private sector. Without this support, stand alone environmental agencies have little chance of success. It provides regulatory agencies with inside information on the costs of abatement and those of reducing the energy, water, materials and pollution intensities of economic activity. It facilitates joint searches for least-cost solutions to environmental problems, frees regulatory agencies from having to use the most blunt instruments to gain compliance, and it makes regulatory agencies sensitive to the needs of balancing industrial environmental management with the other goals of development.

By linking the use of information to evaluate and disclose performance, it strengthens public support for industrial environmental management. The experiences in East Asia suggest that there are at least two distinct ways to link environmental considerations to the task of technological development. One option is to follow the example of Singapore: integrating the environmental concerns of traditional environmental regulatory agencies with the promotional activities of national investment promotion agencies. Since most developing countries have an investment promotion agency and an environmental regulatory agency, all that is required is that investment promotion agencies attach a condition for granting promotional privileges to promoted firms as soon as they have demonstrated their ability to meet the emissions requirements of regulatory agencies.

A fourth, and perhaps more fruitful, approach to linking industrial environmental management to technological development is demonstrated by Malaysia's Industrial Linkage Programme and its Vendor Development Programme that links indigenous small and medium enterprises to global value chains of multinational corporations located in Malaysia. In many developing countries, small and medium enterprises are the largest source of industrial pollution. They often operate below the radarscope of national regulatory authorities and avoid effective environmental regulation. At the same time, much of the cause of poor environmental performance lies in the limited technical, financial and managerial capabilities of these firms.

Firm-centred approaches to policy integration address some of the critical needs of small and medium enterprises by providing credit financing, tax depreciation of capital investments, managerial training and technological upgrading, all of which typically yield economic and environmental benefits. The challenge of traditional cleaner production programmes for small and medium enterprises is how to reach the multitude of firms involved, many of which may be unregistered. Policy integration thus extends beyond the range of organizations at the national, regional and local scale, with responsibility and capability for improving the economic *and* environmental performance.

C. TOWARDS A POLICY FRAMEWORK

Drawing on the results of the review, the elements of a policy framework for pursuing environmentally sound technological development policies in low-income countries are outlined. The framework presented here comprises five core elements: *(a)* enabling conditions; *(b)* policy process; *(c)* technological infrastructure; *(d)* policy integration; and *(e)* pathways for technological development. Schematically, the five core elements defined below can be viewed as building on each other to create a coherent overall policy framework:

(a) Enabling conditions. As demonstrated earlier in this chapter, it is now well recognized that non-technological enabling conditions, in particular those that ensure macroeconomic stability, resource allocation consistent with dynamic comparative advantage, rapid accumulation of human and physical capital, are important for technological development. In fact, there are no examples in any developing country where technological development has occurred in the absence of these basic, underlying non-technological policies;

(b) Policy process. Owing to market and coordination failures, successful technological development requires the development and implementation of a set of explicit policies to facilitate technological learning in private sector firms. But what defines the elements of an effective policy process? The analysis suggests that successful technological development in low-income countries requires the adoption of a policy process marked by a *national strategy of industrial development,* centred round a principle of *embedded autonomy* between firms and governments, that is *market-building* in its orientation, and that promotes *links to the global economy for services and technological know-how* within a framework of *policy integration.*

The review of the literature on successful technological upgrading in East Asia indicates that countries that have succeeded in technological development have typically done so as part of an overall strategy for industrial development. Bennett [14] provides a useful overview of different strategies open to late-industrializers, defined in terms of different routes in technology transfer. The first route involves technology transfer through trade and aid to strengthen indigenous production for domestic markets. The second route promotes technology transfer through foreign direct investment and contracting to build export-oriented firms. And the third route promotes technology transfer through the supply chain of capital equipment and materials to develop local subcontracting capability.

Irrespective of the technological development strategy pursued, the analysis suggests that technological capabilities-building is promoted through the emergence of embedded autonomy. The concept of embedded autonomy was first introduced by Evans [26] in the context of his review of rapid technology catch-up in the East Asian newly industrializing countries. Embedded autonomy addresses one of the fundamental dilemmas of the industrial development process, namely, how to work closely with firms without becoming captured by the interests of firms. It is known that firms are the locus of information on technological development processes, industries and markets. In order to maximize the effectiveness of industrial policy, Governments need to maximize their access to such information. This typically entails working closely with firms and industries, that is to say, institutions of industrial development need to be embedded in the economy. At the same time, these institutions need to retain a degree of autonomy from firms, allowing them to make decisions that are in the best interest of the economy as a whole. Evans [26] describes the way in which embedded autonomy arises out of a strong bureaucracy that is performance-based.

Embedded autonomy leads to a third critical element of policy process. It must be market-focused and demand-driven. The tendency over the past two decades has been to "push" particular supply-driven policy interventions, often on an ad hoc basis without regard for an integrated national industrial development strategy or for the capability or interest on the part of the private sector. Governments need to design a wide range of demand-increasing incentives, or a demand-increasing incentive system that rewards firms for engaging in technological learning (Teubal [88]). This system must recognize that competition from the global

economy can stimulate the demand for technological learning (Westphal [102]), in particular if technological upgrading policies accept that most technological learning occurs within firms and is largely the consequence of flows in technology and mobility of people between firms (Arnold and others [10]). The policy process taken must "leverage" support services provided by markets and be linked to the global economy and to foreign firms working within the global economy. Participation in the global economy through trade and foreign investment represents the best opportunity for low-income countries for industrial development. This participation must be a driver for building the knowledge necessary to engage and succeed in environmentally sustainable technological upgrading and can, for example, occur through international joint ventures and through participation in global value chains. Finally, the policy process must link technological development to industrial environmental management within a framework of policy integration;

(c) Technological infrastructure. As mentioned earlier, industrial development also requires the building of a set of institutions or what Justman and Teubel [42] label technological infrastructure and technological infrastructure policies to support technological and environmental upgrading. The elements of such technological infrastructure (Justman and Teubel [42]) include investment promotion agencies, industrial estate and export processing zone authorities, export-marketing institutions, national standards/metrology agencies, science and technology institutes and environmental regulatory agencies. Governments of the East Asian newly industrializing countries and elsewhere began the technological upgrading process by creating national investment promotion agencies charged with attracting foreign capital and promoting particular sectors or firms. Investment promotion agencies often worked closely with physical infrastructure support agencies in ports and airports and with export processing zones and industrial estates;

(d) Policy integration. As already stated, once governments and firms focus attention on improving the ambient environmental quality and the environmental performance of industrial firms, governments must invest in building and financing credible command and control environmental regulatory agencies that set ambient and emission standards and monitor firm and plant-level performance relative to air, water, solid and toxic waste emission standards. But as was also evidenced, governments went well beyond the creation of credible environmental regulatory agencies. They used their embedded autonomy with firms and their bureaucratic capabilities to link new environmental agencies through policy integration to firms and institutions of industrial policy;

(e) Pathways to technological development. The fifth element of the conceptual framework is that of technological development pathways.[6] The review of the development experience in East Asia and elsewhere indicates that technological development has been most successful when institutions for technological development had a clear understanding of particular pathways of technological capabilities-building. Those technological pathways go beyond general statements on industrial development strategy (such as a desire to be "export-oriented" or to promote "inward technology transfer"). They define particular organizational arrangements through which technological capability-building occurs, such as through joint ventures between foreign and domestic firms, or through participation in global value chains.

[6]The concept of technological development pathways is different from that of routes to industrial development as used by Bennett [14] and others. Technological development pathways refer to the actual mechanisms through which routes to industrial development might be pursued.

Specifying the policy framework at this level of precision is necessary for two major reasons. First, research has indicated that the conditions necessary to achieve technological development vary across pathways, whether it is through foreign direct investment or participation in global value chains. The ways in which a country invests in technological development must consider the prominence of one or more pathways of technological upgrading. Secondly, recent changes in the global economy, including the growing importance of global production networks and of regulations of the World Trade Organization limiting the use of policy instruments that favour domestic firms over international investors, have shifted the likely returns to different approaches to technological development. As a consequence, it is important for Governments to analyse the feasibility of technological capability-building in the context of their own resource and institutional circumstance.

In the analysis that follows, discussions focus on three particular pathways used by Governments and firms in developing countries towards technological development:

- Through national technology and innovation systems—pathway I;
- By linking large national firms to multinational corporations through joint venture arrangements or licensing agreements—pathway II;
- Through linking small and medium enterprises to global value chains of multinational corporations—pathway III.

These three pathways were instrumental in the success of East Asian newly industrializing countries in achieving rapid industry-led growth.

As indicated, the conditions necessary to achieve technological capability-building vary across the three pathways. Table 1 describes a policy profile for each pathway. The policy profile variables are grouped into four categories: *(a)* enabling conditions, including political stability, openness to the global economy, macroeconomic stability, human skills base and physical infrastructure development; *(b)* policy process, including bureaucratic competence and the degree of embedded autonomy; *(c)* technological infrastructure and technology support institutions; and *(d)* policy integration, including an effective command and control regulatory agency, scarcity pricing for energy and other resources, and the degree to which a country's regulatory agency is integrated, through policy integration, with its institutions of industrial policy.

Table 1 also recommends the values each of these variables must take for technological development and sustainable industrial development to succeed in the pathway identified. Thus, for example, the conditions for pursuing the first pathway—building a national technology and innovation system—are particularly demanding. Political stability and macroeconomic stability, openness to trade and investment, human skills, a Government's bureaucratic capability and its embedded autonomy must be high. In addition, the level of human skills and infrastructure development must be equally high. Finally, if industrial development is to be sustainable, energy prices must be market-based, technological environmental capabilities in firms must be substantial and environmental regulations must be stringent.

TABLE 1.

CONCEPTUAL FRAMEWORK MATRIX

Pathways to technological development	*Through the development of national technology systems*	*Through linked learning in joint ventures and licensing agreements between large domestic firms and large multinational corporations*	*Through linked learning of small firms participating in global value chains*
Core elements	***Conditions***		
Political stability	Must be high	Must be high	Must be high
Macroeconomic stability	Dollar index, inflation and fiscal deficits should be low	Dollar index, inflation and fiscal deficits should be low	Dollar index, inflation and fiscal deficits should be low
Openness to trade and investment	Can start low	Must be high	Must be high
Physical infrastructure	Must be well developed	Must be well developed particularly in industrial estates, export processing zones and licensed manufacturing warehouses	Must be well developed particularly in industrial estates, export processing zones and licensed manufacturing warehouses
Labour force	Must be well educated, particularly need a large number of well trained engineers	Must be well educated, particularly need a large number of well trained engineers	Must have a literate labour force that can work in factories
Policy process			
Industrial development strategy	Government and business stakeholders must agree on a long-run industrial development strategy	Government and business stakeholders must agree on a long-run industrial development strategy	Government and business stakeholders must agree on a long-run industrial development strategy
Embedded autonomy	Must be high	Can be limited to pockets of efficiency in investment promotion agencies, industrial estate, export processing zone and licensed manufacturing warehouse authorities	Can be limited to pockets of efficiency in investment promotion agencies and in agencies serving the needs of small local firms
Bureaucratic competence in public sector bureaucracy —supporting embedded autonomy	Must be high, particularly in peak pilot institutions that establish national vision for industrial development and coordinate policy across an array of public and private sector actors	Can be limited to pockets of efficiency in peak pilot institutions that establish a vision for industrial development and coordinate policy across a small number of public sector agencies	Can be limited to pockets of efficiency needed to serve small local firms
Government-business networks	Must be dense and limited to clear performance goals that are monitored	Must be dense and limited to clear performance goals in a small number of public sector agencies and a similarly small number of large domestic firms that are promoted by Government policies	Can be limited to a small number of industry associations in promoted industries, initially focused on entry-level capabilities building in resource-based and labour-intensive manufactures
Technological infrastructure and technology support institutions*	Must be market-driven, externally (internationally) oriented, and focused on the real needs of the private sector	Must be market-driven, externally (internationally) oriented, and focused on the real needs of the private sector	Must be market-driven, externally (internationally) oriented, and focused on the real needs of the private sector
Policy integration linking the environmental regulatory agency to the institutions of industrial policy	Must be high	Can be limited to links to large national firms and multinational corporations	Can be limited to linkages between multinational corporations and the local small and medium enterprises that supply them
Environmental regulatory agency	Must be competent and capable of setting, monitoring and enforcing realistic emissions standards	Must be competent and capable of setting, monitoring and enforcing realistic emissions standards	Must be competent and capable of setting, monitoring and enforcing realistic emissions standards
Regulatory stringency	Must be high	Must be high	Must be high
Energy (and other environmental) prices	Should be market-based and/or reflect true scarcity values	Should be market-based and/or reflect true scarcity values	Should be market-based and/or reflect true scarcity values

*For a listing of these, see annex I.

In laying out these policy profiles, the experiences of the East Asian newly industrializing countries and other developing countries have been heavily drawn on. While elements of those technological policies and institutions often appear in developing countries, they are generally thought to have been most successful in the first- and second-tier East Asian newly industrializing countries (Westphal [102]). Annex I includes a more detailed database of these technology policies and institutions in the East Asian newly industrializing countries.

The policy framework, as a whole, focuses on five core elements:

- Enabling conditions;
- Policy process;
- Technological infrastructure;
- Policy integration;
- Pathway for technological development.

In the next chapter, the empirical application of this policy framework in low-income countries is treated. Particular use is made of the fifth element of the framework, pathway for technological development, as it provides greatest traction with the circumstances of individual low-income countries.

II. EMPIRICAL ANALYSIS

In this chapter, the conceptual policy framework is applied to the actual experience of low-income countries. Three separate empirical analyses are presented. First, an empirical examination is made of the extent to which low-income countries are positioned to successfully engage in environmentally sound technological development. Following the structure of the conceptual framework, the empirical analysis is organized around specific *pathways* for technological development, examining whether the requisite *enabling conditions*, *policy process*, and *technology support institutions* are in place to successfully pursue one or more technological pathways in specific low-income countries. Secondly, a concrete case study is provided on the application of the policy framework, focusing on efforts to build technological capability in the ready-made garment industry in Ghana. Thirdly, the application of policy integration is documented as an approach to linking technological capability-building to industrial environmental management through a case study on the operation of supply chains in the electronics manufacturing sector in Penang, Malaysia.

A. APPLYING THE CONCEPTUAL POLICY FRAMEWORK TO LOW-INCOME COUNTRIES

In this section, the conceptual framework is applied to the empirical circumstance of low-income countries. This is done in three stages. First, a look is taken at what published data reveals on the situation of low-income countries with respect to enabling conditions. Survey data are then used to probe into the policy process and institutional effectiveness in low-income countries—something that aggregate published data do not permit. Finally, how the conceptual policy framework can be operationalized as a "gap analysis" for individual countries is demonstrated.

1. The situation of low-income countries in the aggregate

The empirical analysis begins by considering the situation of low-income countries as a group with respect to the policy profiles defined in table 1. At this initial stage of the analysis, the variables used to map countries onto policy profiles are limited to data on enabling conditions. Table 1 identifies how the low-income countries in the developing world and sub-Saharan Africa compare on the set of enabling variables. Table 2 demonstrates that low-income countries suffer from a number of pathologies making it difficult for them to emulate the successes of technological development and that of industrial environmental management of any of the East Asian newly industrializing countries. Essentially, they suffer from substantially more political and macroeconomic instability, very limited infrastructure development and are less connected to the global economy than the East Asian newly industrializing countries.

TABLE 2.
COMPARISON OF ENABLING CONDITIONS ACROSS GROUPS OF DEVELOPING COUNTRIES

	East Asian (1975)	*All low-income developing countries*	*Low-income countries in sub-Saharan Africa*
Political stability	.48 (for 2000)	−.53	−.46
Inflation rate[a]	6.3	29.5	32.6
Trade share in GDP (exports + imports)/GDP[a]	83.2	59.7	60.1
Share of foreign direct investment in GDP[a]	2.68	1.53	1.44
Gross primary enrolment rate[a]	103	88.6	90.3
Gross secondary enrolment rate[a]	42	37.4	36.8
Number of main telephone trunk lines per 1,000 persons[a]	48.0	18.3	27.2

Source: World Bank [107] and Kaufmann and others [44].
Note: Except for the variable political stability, which is taken from Kaufmann and others [44], all other variables are from World Bank [107].
[a]Percentage.

2. Going beyond published data: survey research

While published data provide compelling evidence on the weak position with respect to enabling conditions of low-income countries in the aggregate, the data do not allow an effective disaggregation of low-income countries into subgroups associated with particular policy profiles. This is largely because the data do not contain sufficient information on the institutional conditions in low-income countries that are identified as crucial to successful technological capability-building. Further, because of the importance of being demand-focused and on "leveraging markets", the character of specific institutions and policies becomes as important as any overall measure of institutional capability.

To meet the task of identifying subgroupings of low-income countries on the basis of pathways for technological upgrading, a survey instrument was developed to collect primary data on the presence and effectiveness of strategies, institutions and policies supporting technological and environmental upgrading among a sample of low-income countries.[7] In this section, the data gathered through the survey are combined with published data on enabling conditions and firm-level capabilities to identify clusters of low-income countries, based on the presence of enabling conditions and institutions identified as necessary for pursuing the three pathways for technological and environmental upgrading. These data are then used to conduct a preliminary gap analysis for a sample of low-income countries with respect to the prospect for engaging in technological and environmental upgrading.

Survey protocol

The first task was to develop a low-cost approach for gathering information on the presence and effectiveness of strategies, institutions and policies known to support technological and environmental upgrading within low-income countries. Assessing the strategy and institutional and policy effectiveness is a tremendously daunting task. There are at least three ways in which

[7]The actual country sample was derived from a broader group of countries. To ensure sufficient variation in country conditions while still maintaining homogeneity, in terms of levels of economic development, the gross national income per capita mark was raised to $950.

this can be done. One could undertake in-depth and extensive case studies of individual countries. Another widely used approach involves a modified Delphi-method to draw out convergent views of key stakeholders with respect to the strategy and the effectiveness of policies and institutions that support a particular upgrading strategy. Neither of these research protocols met the criterion of a parsimonious and low-cost tool that could be applied to a significant number of low-income countries.

For this reason, the approach adopted here uses a modified version of the technology-needs-assessment tool developed by Hobday [35]. This technology needs assessment requires key stakeholders in a country to complete a relatively short questionnaire on the institutional capabilities in that country. Aggregation of survey responses generates both an overall score on the needs assessment tool as well as an identification of areas of strength and weakness. This technology needs assessment was adapted to cover the range of strategies, institutions and policies pertinent to the three pathways leading toward technological and environmental upgrading as well as to provide sufficient policy-specific information to conduct a gap analysis.

In order to ensure that the modified technology-needs-assessment tool met the needs of the report, a draft survey instrument was pre-tested in four low-income countries. Based on the feedback received from this pre-test phase, a revised survey instrument was prepared. As shown in annex B, the survey instrument contains three main sections:

- Vision and strategy;
- Institutions and policies;
- Institutional capability.

The last category includes questions on the capabilities of public and private institutions, including private sector industrial firms. The protocol for collecting data is as follows. In each of the countries chosen for data collection, approximately 10 key respondents were selected for participation in the survey. Respondents from four different groupings were selected, on the basis of their direct knowledge of the presence and effectiveness of technology upgrading initiatives within the country. Respondents were selected from four different groupings: Government agencies; industry associations; multilateral development agencies; and research institutes. In each case, a national expert appointed by UNIDO contacted the respondent and the survey was completed during a personal interview. Data were obtained from a total of 27 low-income countries and from an aggregate total of 273 respondents. Countries that participated in the survey are listed in table 3.

TABLE 3.
LOW-INCOME COUNTRIES IN SURVEY DATA SET

Bangladesh	Honduras	Nepal	Uganda
Bolivia	Indonesia	Nicaragua	Uzbekistan
Cambodia	Kenya	Nigeria	Viet Nam
Cameroon	Kyrgyzstan	Rwanda	Yemen
Côte d'Ivoire	Mali	Senegal	Zambia
Ethiopia	Mongolia	Sri Lanka	Zimbabwe
Ghana	Mozambique	Sudan	

In the analysis that follows, the data presented are the mean of the responses for one or more questions in the survey in each of the individual countries. It is important to emphasize that the questions in the survey data refer to the *perceived* effectiveness of institutions and policies linked to technological and environmental upgrading as assessed by survey respondents. In other words, respondents were asked to rank the effectiveness of particular policy tools or institutions on a Likert scale. In the various analyses that follow, the survey data and published data were combined to determine the opportunities for technological upgrading within these low-income countries.

Identifying clusters of low-income countries

The aim in this part of the analysis is to identify clusters of low-income countries based on current policies/institutions and the presence of necessary enabling conditions for pursuing one of the three pathways toward technological and environmental upgrading. Conceptually, the approach is as follows. Using the survey data, it is necessary to determine which pathway to technological upgrading is identified by the survey respondents as being part of a country's industrial development strategy. The survey data make it possible to assess the degree to which the key institutions and policies supporting each of the three pathways are viewed as effective by survey respondents. The rationale here is that to successfully pursue a specific pathway of technological upgrading, a country must ensure that the pathway is part of its industrial development strategy, and the key institutions and policies linked to this strategy must be assessed as effective.

On the basis of these survey data, two clusters of countries—one for high performing countries and one for low performing countries—are established relative to each of the three technological upgrading pathways. Finally, published data and survey data conditions are used to assess the degree to which the high performing countries in each of the pathway clusters have in place the necessary enabling conditions and institutional capabilities for successful technology upgrading. The rationale here is that even though a country may commit to one or more of the technology upgrading strategies, it may not have all the necessary enabling conditions and institutional resources in place to achieve the degree of success sought. The steps in this analysis are appropriately viewed as *diagnostic tools* rather than absolute statements on the prospects for pursuing one or more pathways for technological upgrading, or the likelihood of success. The intention is to provide a tool through which both UNIDO and policymakers in low-income countries can reflect upon opportunities for technology upgrading and design effective, responsive policy and institutional interventions.

Cluster analysis is an exploratory statistical technique designed to allocate cases to two or more cluster groupings in ways that maximize the differences between clusters. Hence, cases are defined as individual countries, and clusters are defined by the pathway to technology upgrading. A form of cluster analysis, known as K-mean clustering, is used where the number of cluster groupings is defined a priori. Because clustering is an exploratory technique that, by design, seeks to maximize the separation between cluster groupings, statistical tests of significance are not appropriate. However, it is possible to conduct F-tests to determine whether the particular variables used influence the establishment of the clusters. Cluster analysis is performed separately for each of the three technological pathways.

In the first cluster analysis, the task is to identify a high and low performing group of countries pursuing a strategy of industrial technology upgrading by building a national technology

and innovation system, and where the key institutions and policies supporting this strategy are viewed as effective. In the second and third cluster analyses, the task is to identify clusters of countries that are viewed as more effectively pursuing a strategy of technology upgrading by linking large domestic firms to multinational firms and by promoting the participation of small and medium enterprises in global value chains. Each cluster analysis is examined in turn. Note that the clusters established for each pathway are not mutually exclusive; a country can be assigned to all three technological pathways or none at all. The cluster analysis separates those countries that have higher scores on the variables used to establish the clusters, that is, a statistical technique is used to establish a cluster of higher performers. The analysis is pursued in two stages: first, pathway clusters are identified based on current government strategies, policies and institutions, and then a review is conducted to find out whether the enabling conditions related to this pathway are in place.

(a) Establishing base clusters

National technology and innovation system. As indicated in chapter I, pursuing technology upgrading by developing a national technology and innovation system is the most demanding of the three pathways, in particular with regard to the government's institutional capability and science and technology resources. In the survey questionnaire, respondents were asked to directly assess the degree to which a government's policy includes the promotion of a national technology and innovation system. The variable NAT-TECH measures the proportion of respondents that identified this pathway as being part of the industrial development strategy of the country.

In order to measure the effectiveness of specific institutions and policies that underlie this technology upgrading strategy, a composite index, INSTIT-EFFECT, was constructed to measure the perceived effectiveness of relevant policies and institutions, including the capacity of institutions to assess technological opportunities, coordination across agencies, and the strength of standards agencies (the index sums the responses to questions C-I-1 on the questionnaire survey shown in annex B).

Using those two variables as the basis of allocating countries to a cluster, 11 of the 27 low-income countries surveyed were identified as having a strategy and institutions supportive of building a national technology and innovation system. Table 4 lists these countries along with the mean score for each cluster on the two assigning variables NAT-TECH and INSTIT-EFFECT. Cluster 1, with the higher mean scores on the two assigned variables, contains the 11 countries oriented toward technology upgrading by building a national technology system. It is very important to remember that at this stage of the analysis no assessment is made on whether these 11 countries have in place the range of enabling conditions and institutional capability necessary to successfully pursue this pathway.

Once the country grouping is cross-referenced against enabling conditions and institutional capability, as discussed below, it shows that many of the low-income countries that are attempting to pursue a pathway of technological upgrading based on building a national technology and innovation system lack the necessary conditions to succeed. This is despite the fact that some of the proximate policies and institutions are judged somewhat effective. As will be demonstrated, cross-referencing base clusters against enabling conditions identified in the policy profiles turns out to be an effective *diagnostic tool.*

TABLE 4.
CLUSTER ANALYSIS FOR NATIONAL TECHNOLOGY SYSTEM

Variable	*Cluster 1*	*Cluster 2*
	Bolivia, Cambodia, Kenya, Kyrgyzstan, Nicaragua, Nigeria, Rwanda, Senegal, Uganda, Zambia, Zimbabwe	Bangladesh, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Honduras, Indonesia, Mali, Mongolia, Mozambique, Nepal, Sri Lanka, Sudan, Uzbekistan, Viet Nam, Yemen
NAT-TECH (group mean)	0.85	0.63
INSTIT-EFFECT (mean)	13.1	10.5

Source: Survey data.

Joint ventures between large domestic firms and multinational corporations. In the case of technology upgrading via joint ventures between large domestic firms and multinational corporations, three measures drawn from the survey data are used to establish the allocation of countries to more effective and less effective clusters. The first variable JV-POLICY is the proportion of respondents who indicated that promoting joint ventures between large domestic firms and multinational firms is part of the industrial development strategy of a country. The second variable, LEAD-FIRMS, is the proportion of respondents who indicated that the industrial development strategy of the Government involves targeting for support a small number of lead firms within an industry. In the case of this pathway, the key institution responsible for promoting technology upgrading via joint ventures is the Board of Investment (BOI). The variable BOI-EFFECT measures the perceived effectiveness of the BOI in each of the surveyed countries.

Table 5 shows the assignment of countries to two clusters based on three variables, namely, JV-POLICY, LEAD-FIRMS and BOI-EFFECT. Cluster 1 scores higher on all three variables, indicating the group of countries aligned to this technology-upgrading pathway. Using the K-means cluster analysis technique, 10 of the 27 countries are assigned to the relatively high-performing cluster, or cluster 1.

TABLE 5.
CLUSTER ANALYSIS FOR JOINT VENTURES WITH MULTINATIONAL CORPORATIONS

Variable	*Cluster 1*	*Cluster 2*
	Cambodia, Ethiopia, Ghana, Honduras, Kyrgyzstan, Indonesia, Nicaragua, Nigeria, Uganda, Viet Nam	Bangladesh, Bolivia, Cameroon, Côte d'Ivoire, Kenya, Mali, Mongolia, Mozambique, Nepal, Rwanda, Senegal, Sri Lanka, Sudan, Uzbekistan, Yemen, Zambia, Zimbabwe
JV-POLICY (group mean)	1.87	1.72
LEAD FIRMS (mean)	0.92	0.70
BOI-EFFECT	0.86	0.31

Source: Survey data.

Linking small and medium enterprises to global value chains. The third pathway focuses on technological upgrading by linking small and medium enterprises to global value chains. Three variables are used to establish cluster membership for this pathway. The first variable, SME to

MNC, measures the proportion of respondents who identified the promotion of local firms as suppliers to multinational corporations as part of the industrial development strategy of the Government. The second variable, SME-EFFECT, is a composite index of the effectiveness of policies designed to support small and medium enterprises. The third variable, FIRM-CAPABILITY, is a composite index of the perceived capability of local small and medium enterprises to meet international expectations on price and quality, and to engage in reverse engineering. Of the three pathways leading toward technological upgrading, this pathway depends most directly on the capability of firms to meet international expectations on price, quality and delivery.

Table 6 shows the high and low performing groups of countries identified using these three variables. In this case, 15 countries are assigned to the relatively high performing cluster of countries aligned with the technology upgrading pathway focused on linking small and medium enterprises to global value chains. The larger number of countries assigned to this technological pathway grouping is consistent with the analysis presented in chapter I, where it was argued that the firm-centred approach of linking to global value chains is likely to provide better opportunities for a greater number of low-income countries than the other two pathways.

TABLE 6.
CLUSTER ANALYSIS FOR LINKING SMALL AND MEDIUM ENTERPRISES TO GLOBAL VALUE CHAINS

Variable	*Cluster 1*	*Cluster 2*
	Bangladesh Bolivia, Côte d'Ivoire, Ghana, Kenya, Kyrgyzstan, Nicaragua, Nigeria, Rwanda, Senegal, Sri Lanka, Uganda, Uzbekistan, Viet Nam Zimbabwe	Cambodia, Cameroon, Ethiopia Indonesia, Mali, Mongolia, Mozambique, Nepal, Sudan Yemen Zambia
SME-to-MNC (mean)	0.60	0.56
SME-EFFECT (mean)	10.8	8.30
FIRM-CAPABILITY	15.8	14.0

Source: Survey data.

It is important to re-emphasize that clusters of countries established through this statistical clustering process are diagnostic only and must be considered in the context of the presence of necessary enabling conditions and institutional capability appropriate to each of the three pathways. This being said, it must be noted that seven of the 26 low-income countries were not assigned to the grouping of any of the three technology upgrading pathways. Those seven countries are Cameroon, Mali, Mongolia, Mozambique, Nepal, Sudan and Yemen. They also rank very low on UNIDO's competitive industrial performance index.

(b) Cross-referencing high performing clusters against enabling conditions and institutional capability

The next step in the process involves cross-referencing the countries in the high performing base clusters against necessary enabling conditions and institutional capability for each of the pathways. To identify the conditions relevant to each of the technological pathways, the conceptual framework presented in table 1 is used. Published data are combined with data drawn from the questionnaire. Table 7 shows the set of enabling conditions from table 1 that are derived from World Bank data. It is important to note that if one assumes that low-income

countries must meet the average values of all of these enabling conditions variables for the East Asian newly industrializing countries early in their development histories (1975), none of the sampled low-income countries would qualify as being ready to initiate effective technological development strategies. Weaknesses are most prominent with respect to political stability (only three of the 27 countries meet this condition); physical infrastructure development (only five of the 27 countries meet this condition); and macroeconomic stability (12 of the 27 countries meet this condition).

TABLE 7.
SURVEYED COUNTRIES AND 1975 EAST ASIAN INDUSTRIALIZING COUNTRIES ENABLING CONDITIONS

	Condition					
Country	*Political stability*	*Inflation*	*TRDY*	*FDIY*	*GSER*	*Telecommunications*
Bangladesh		a			a	
Bolivia		a		a	a	a
Cambodia		a	a	a		
Cameroon		a				
Côte d'Ivoire		a				
Ethiopia		a				
Ghana			a	a		
Honduras			a	a		
Indonesia					a	
Kenya						
Kyrgyzstan			a		a	a
Mali	a			a		
Mongolia	a		a	a	a	a
Mozambique				a		
Nepal		a				
Nicaragua				a	a	
Nigeria			a			
Rwanda		a				
Senegal		a				
Sri Lanka			a		a	
Sudan		a		a		
Uganda		a		a		
Uzbekistan					a	a
Viet Nam	a	a	a	a	a	
Yemen					a	
Zambia				a		
Zimbabwe					a	

Source: Survey data.

Notes: Variables are defined in table 2.

[a]Indicates that a country currently meets the average 1975 East Asian newly industrializing countries value for this enabling condition.

The next task is to apply the minimum requirements for the basic enabling conditions—political stability, macroeconomic stability, educational attainment, infrastructure development and openness to trade and foreign direct investment—to the three technological pathway-base clusters previously identified. Since very few of the low-income countries surveyed meet more than

a few of these enabling conditions, the enabling conditions identified in table 7 were adjusted downward, or made less stringent. It is important to note that this was done for *diagnostic* purposes only. The results of the adjustment are presented in table 8 where the new and less stringent cut-off values for a country meeting a condition are identified. The table identifies which countries fail to meet the new cut-off values[8] for an enabling condition by listing the actual value for the enabling condition that is not met.

TABLE 8.
COUNTRY SAMPLE: COUNTRIES NOT MEETING ENABLING CONDITIONS

	Condition					
Country	*Political stability*	*Inflation*	*GSER*	*Main telephone lines*	*Openness to trade*	*Openness to foreign investment*
Bangladesh				3.65	33.2	0.59
Bolivia						
Cambodia	−1.37		18.1	2.36		
Cameroon			32.6	6.3		0.35
Côte d'Ivoire			22.8			
Ethiopia			17	3.65		
Ghana		27.2	35.6	11.7		
Honduras			32			
Indonesia	−1.52					−3.03
Kenya	−1.07		30	10.5		
Kyrgyzstan	−1.07					−0.17
Mali			13	3.84		
Mongolia						
Mozambique			12.0	5.01		
Nepal				12.0		
Nicaragua		70				
Nigeria	−1.10		30.3	4.36		
Rwanda	−1.84		14.5	2.27	32.6	0.45
Senegal	−1.11		17.3			
Sri Lanka	−1.77					
Sudan	−2.03		31.8	12.4	29.7	
Uganda			12.7	2.68	34.5	
Uzbekistan		47.3				0.93
Viet Nam						
Yemen	−1.53					0.06
Zambia		30	25.0	8.1		
Zimbabwe		59.9				0.32

Source: World Bank [107] and Kaufmann and others [44].

Notes: Country does not meet enabling condition (+) if political stability is < -1.0, inflation is > 25 per cent, gross secondary enrolment rate is < 40 per cent, telecommunications infrastructure is < 15 main telephone trunk lines per 1,000 persons, openness to trade (exports plus imports as a share of GDP) is < 40 per cent, and openness to FDI (FDI as a share of GDP) is < 1 per cent.

[8]The new cut-off values are as follows: for political stability, the cut-off value is less than -1.0; for inflation, the new cut-off value is more than 25 per cent; for educational attainment, the new cut-off value is a gross secondary enrolment rate less than 40 per cent; for physical infrastructure, the new cut-off value is less than 15 main phone lines per 1,000 persons or openness to trade, the new cut-off value is a trade ratio (X+M)/GDP less than 40 per cent and for openness to FDI, the new cut-off value is a foreign direct investment to gross domestic product ratio is less than 1 per cent.

In addition to the basic enabling conditions, the overview and table 1 indicate that a second set of variables—a set that measures both the capability of local firms (to meet price, quality and on-time delivery requirements) and the effectiveness of government bureaucracies are important. Table 9 shows this second set of variables based on data drawn from the questionnaire survey. The first variable is the summary index of firm-level capability previously defined as FIRM-CAPABILITY. Countries whose rating on this index was below 14 were judged as not meeting the minimum performance for this variable. The second variable is institutional effectiveness previously defined as INSTIT-EFFECT. Countries whose rating on this index was below 8 were judged as not meeting this condition. The third variable is a measure of the quality of industrial estates or IND-ESTATES. Likewise, countries whose rating on this index was below 3 were judged as not meeting this condition. In general, the cut-off levels for meeting these three survey-based conditions equate to an effectiveness that is less than a rating of "somewhat effective".

TABLE 9.
CONDITIONS DRAWN FROM SURVEY DATA

	Condition		
Country	*Capability of firms*	*Institutional effectiveness*	*Industrial estates*
Bangladesh		1.6	
Bolivia		5.8	
Cambodia			
Cameroon		5.7	2.9
Côte d'Ivoire			
Ethiopia	12.7		
Ghana			
Honduras		4.4	
Indonesia			
Kenya			
Kyrgyzstan			
Mali			
Mongolia			
Mozambique		5.8	
Nepal	13.1	5.8	
Nicaragua		7.9	
Nigeria			
Rwanda	13.5		2.6
Senegal			
Sri Lanka			
Sudan	12.8	5	
Uganda			
Uzbekistan			
Viet Nam			
Yemen	13.2	3.1	
Zambia	12.5	5.9	2.9
Zimbabwe			

Source: Survey data.

The next task is to apply these minimum requirements for enabling conditions and institutional capability to the three technological pathway-base clusters previously identified. As a diagnostic tool, however, it is appropriate to select those variables that are of particular relevance to each of the three pathways. Not all variables will be equally relevant to the three pathways.

Following the analysis presented in chapter II, the enabling conditions identified as being of particular importance to technology upgrading by developing a national technology and innovation system are political stability, physical infrastructure, educational attainment and macroeconomic stability. In addition, institutional effectiveness and capability of firms are also considered to be important elements for developing a national technological and innovation system. The selection of these elements reflect the importance of a number of key factors for building a national technology and innovation system, namely, effective government institutions; adequate physical infrastructure and a reasonable human capital base. A national technology and innovation system is typically government centred, hence the importance ascribed to these governance and institutional variables. Applying those six variables to the cluster of countries, as shown in table 6, *no country* in the high performing national technology and innovation system cluster meets the necessary conditions. This is consistent with the view that building a national technology system is particularly demanding for governments of low-income countries.

Turning to the technological upgrading pathway that focuses on joint ventures between large domestic firms and multinational corporations, the following elements are identified as bearing particular relevance: political stability, infrastructure, macroeconomic stability, openness to trade and foreign direct investment and firm capability. Once again, whereas strong overall government institutional effectiveness is important, relative to building a national technology and innovation system, this pathway places greater demands on firm capability, localized effective infrastructure and on openness to trade and investment. Applying these variables to the high performing cluster of firms identified in table 7 (cluster 1), five countries within this pathway meet all the conditions, namely, Cambodia, Ghana, Honduras, Nicaragua and Viet Nam. They can also be viewed as having integrated this technological upgrading pathway into Government strategy, having adequate effectiveness in relevant institutions and policies, and meeting the defined enabling conditions to pursue technological upgrading via joint ventures between large local firms and multinational corporations.

The final technological upgrading pathway involves the participation of small and medium enterprises in global value chains. This pathway was followed by the largest group of countries surveyed. With respect to this pathway, political stability, macroeconomic stability, openness to trade and investment, and capability of firms are identified as crucial elements. They reflect the key role that partnership with global multinational corporations plays in building technological capability within global value chains. Where a multinational corporation is a source of technological know-how, the dependence on local sources of know-how is reduced.

Applying these variables to the 16 high performing countries identified in table 6, the following six countries meet all the required conditions: Bolivia, Ghana, Nicaragua, Senegal, Sri Lanka and Viet Nam. Among the sample countries, these countries are best positioned to pursue technological upgrading by linking small and medium enterprises to global value chains.

(c) Sensitivity analysis

The tools—in particular the policy profiles, the establishment of cut-off points for necessary enabling conditions and levels of institutional capability, and the rapid assessment survey instrument and data—presented earlier are best viewed as *diagnostic tools*. By examining the outcome associated with the use of those tools, UNIDO as well as the policymakers in low-income countries are able to identify which particular elements are constraints for pursuing one or more technology-upgrading pathways. The diagnostic tools can also be adjusted by considering different sets of elements, or by changing the cut-off level for a particular variable. In this section, the impact of adjusting upward and downward the cut-off values for the various enabling conditions and institutional capability variables associated with each upgrading strategy is examined. The purpose of this section is to examine the sensitivity of the cluster groups to adjustments in the identified baseline levels of variables.

Table 10 shows the cut-off values used in the original analysis along with values that are adjusted downward and upward. First, an examination is made of the impact of *lowering* the baseline conditions above which countries are viewed as having in place the necessary resources to pursue successfully one or more of the identified pathways for technological upgrading. In effect, this is tantamount to lowering the minimum level of political stability, macroeconomic stability and other enabling conditions that are judged necessary for pursuing one or more of the identified upgrading pathways. It is important to note that this is a diagnostic exercise. The cut-off conditions used in the analysis to date are in the assessment already set as *low* baseline conditions, reflecting the minimum level of capacity needed for success. Conversely, by setting cut-off values that are higher than the baseline, one is able to examine the impact on the high performance cluster groupings by raising the level of performance that must be achieved before a country is judged to be in a position to pursue successfully one or more of the technological pathways.

TABLE 10.
ADJUSTING BASELINE CUT-OFFS FOR SENSITIVITY ANALYSIS

Variable	*Baseline*	*Baseline adjusted downward (easier)*	*Baseline adjusted upward (harder)*
Political stability	-1.0	-1.5	-0.5
Phones per 1,000 persons	15	10	25
Secondary school completion[a]	40	30	50
Capability of firms	14	12	16
Institutional effectiveness	8	6	10
Industrial estates	3	2.5	3.5
Inflation[a]	25	30	20
Openness to trade (X+M)/GDP[a]	40	35	45
Openness to foreign direct investment			
Foreign direct investment/gross domestic product[a]	1	.5	1.5

Source: World Bank [107] and Kaufmann and others [44].
[a]Percentage.

As already noted, in the case of technology upgrading by building a national technology and innovation system, the following six conditions were identified as especially critical to success: political stability; physical infrastructure; educational attainment; macroeconomic stability; institutional effectiveness; and capability of firms. If the original baseline cut-off values are used for this pathway, none of the 27 surveyed low-income countries meets the conditions for pursuing technological upgrading. If the cut-off values are adjusted downward, however, then two of the 11 countries, identified in the first cluster in table 4, would meet the lowered requirements for pursuing this technological pathway, namely, Kyrgyzstan and Nicaragua. Thus, by adopting this approach as a diagnostic tool, it is possible to identify the countries for which some improvement in enabling conditions and capacities might move the country toward being able to pursue this technological pathway as well as determine the areas of weakness that need to be addressed.

As shown in table 5, 10 of the 27 countries were linked to the second identified pathway for technological upgrading (building joint ventures between multinational corporations and large domestic firms). Of the 10 countries, five meet the baseline conditions for this technological upgrading pathway, namely, Cambodia, Ghana, Honduras, Nicaragua and Viet Nam. If the cut-off values for the variables are adjusted downward, then four of the remaining five countries in the cluster also meet the lower baseline for pursuing this technological upgrading pathway, namely, Ethiopia, Indonesia, Nigeria and Uganda. Improvement in baseline conditions would enable these four countries to achieve greater success in promoting technological upgrading through joint ventures between multinational corporations and large domestic firms. If, by contrast, the higher cut-off values are used, then only Viet Nam, among the surveyed countries, meets the higher baseline for successfully pursuing this technological upgrading pathway. In other words, Viet Nam has the strongest potential with respect to the necessary conditions to pursue technological upgrading through joint ventures between large domestic firms and international multinational corporations.

The third technological pathway considered in this sensitivity analysis is that of linking small and medium enterprises to global value chains. This pathway contained the largest grouping of the low-income countries surveyed. With respect to this pathway, political stability, macroeconomic stability, openness to trade and investment and capability of firms are the relevant enabling conditions and capabilities. Using the baseline cut-off values for these variables, six countries were judged to have the necessary conditions in place for pursuing this technological upgrading pathway, namely, Bolivia, Ghana, Nicaragua, Senegal, Sri Lanka and Viet Nam. If the cut-off values are adjusted upward, then only Viet Nam meets the higher baseline. But, if the cut-off values are adjusted downward, then Kenya, Nicaragua, Nigeria and Uganda also meet the lowered standard for pursuing technological upgrading through participation in global value chains.

This simple sensitivity analysis illustrates the position of countries relative to the initial baseline used to specify the required conditions and capabilities for successfully pursuing one or more pathways for technological upgrading. In general, the sensitivity analysis indicates that the greatest changes in cluster group membership occur when the cut-off values for the baseline conditions are adjusted downward. *In other words, some of the surveyed countries are positioned somewhat below the original baseline, falling short of the necessary conditions and capabilities*

for pursuing one or more pathways for technological upgrading. The policy implication here is that it is important for these countries to continue working to improve those necessary enabling conditions and capabilities as part of their industrial development strategy. Among the surveyed low-income countries, the number of countries that are well positioned with respect to enabling conditions is small, suggesting that all countries would benefit if strong efforts were made to strengthen the basic enabling conditions necessary for pursuing technology upgrading.

3. Using the survey as the basis for a gap analysis

The cluster analysis presented earlier is a tool used to identify technological pathways for which countries are well positioned. It does not provide a fine-grained gap analysis of where a country's institutions and policies could be strengthened. In this section, the use of survey data to conduct such a gap analysis is illustrated for Ghana. The purpose here is not to provide an extensive examination of Ghana's situation, but to illustrate how the survey can be used by UNIDO and by officials in Ghana to identify gaps in existing strategies, institutions and policies that are a priority for strengthening. In the previous section, Ghana was identified as a country that is positioned to pursue technological upgrading through joint ventures between large domestic firms and multinational corporations, and by promoting the participation of small and medium enterprises in global value chains. Hence, Ghana was not identified as a country that is currently positioned to pursue technological upgrading via the development of a national system of innovation. Given this preliminary assessment, what more can be said about the strengths and weaknesses of Ghana's strategies, policies and institutions for industrial technological upgrading?

The empirical analysis of these issues proceeds in two stages. First, the survey data is used as a basis for conducting a preliminary gap analysis of strategies, institutions and policies for technological upgrading in Ghana. These survey results are then cross-referenced against a field assessment of institutional capacity for technological upgrading. Figure VII shows the mean scores for the survey respondents in Ghana to the rapid assessment survey questionnaire on the effectiveness of various technology upgrading strategies within Ghana. As can be seen, Ghana is considered relatively effective in attracting foreign investment, promoting exports as a means of upgrading, and identifying priority industries based on market opportunities. The Government is viewed as somewhat less successful in targeting technological upgrading as the key for industrial development (as compared, for example, with a focus on growing exports), and in promoting small firms as suppliers to multinational corporations.

Preliminarily—and as a diagnostic tool—this would prompt an examination in more detail to ascertain whether, within the range of industrial development concerns in Ghana, the specific issue of technological upgrading receives sufficient attention, and whether the institutions and policies needed to support technological upgrading are effective. It is common for developing countries to initially focus on promoting exports and investment in the industrial development strategy. The diagnostic analysis presented here recommends a close inspection of how and to what degree the current emphasis on exports and investment should be more closely tied to technological upgrading.

FIGURE VII.
EFFECTIVENESS OF STRATEGIES

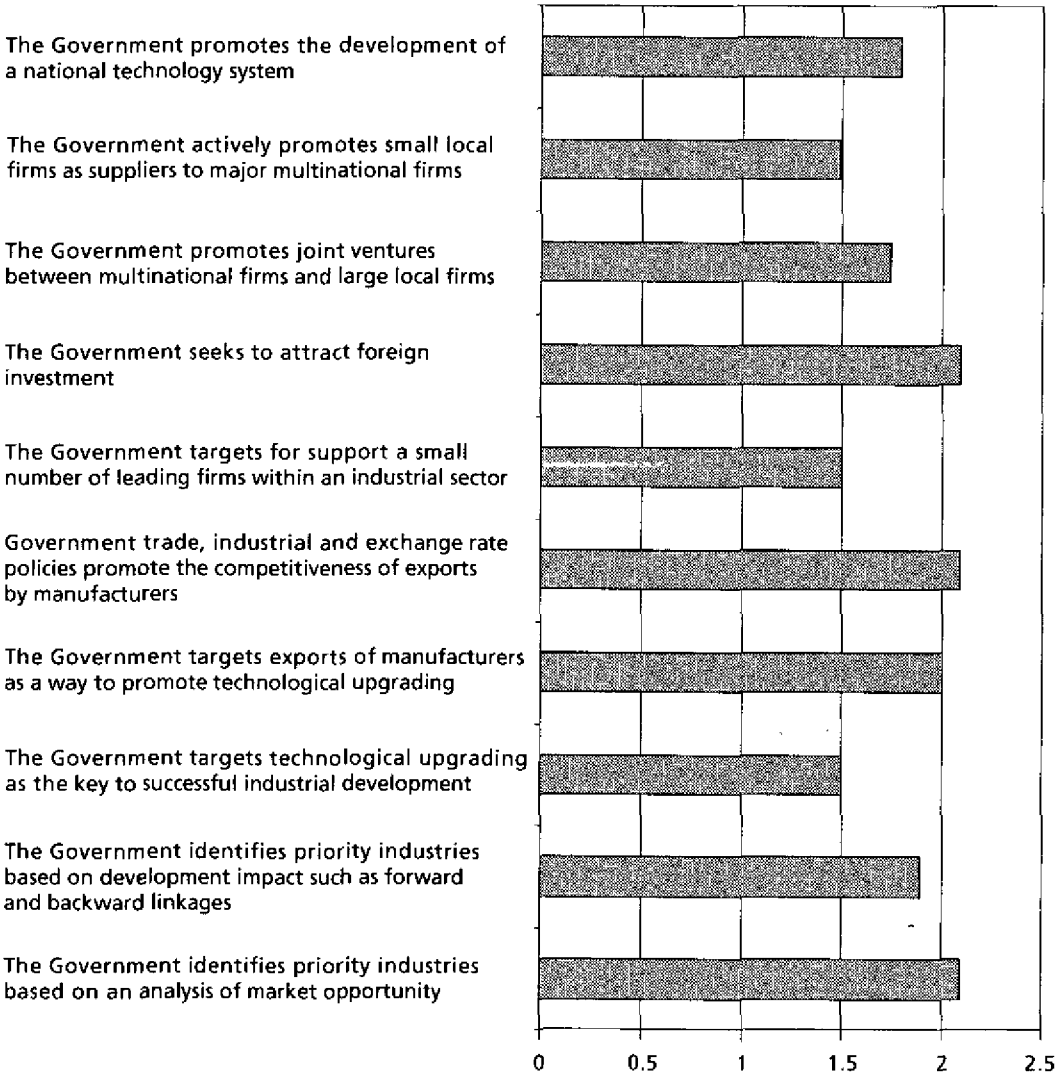


Figure VIII presents a parallel assessment of Ghana's *institutions* that support industrial technological upgrading. Consistent with the assessment of strategies, the institutions in Ghana responsible for promoting exports and investment are viewed as relatively effective. Institutions that are judged to be somewhat less effective are industrial research and development centres and Government industrial productivity centres. Both these institutions are important components of a national technology and innovation system, and the lower ranking of these institutions explains, in part, why Ghana was not identified as a country well positioned to pursue technological upgrading via a national technology and innovation system. A finding on the survey that requires further direct examination is the somewhat low rating given to the reliability of electricity and water supply in industrial estates. A reliable localized infrastructure is typically critical for promoting technological upgrading by participating in global value chains.

FIGURE VIII.
EFFECTIVENESS OF INSTITUTIONS

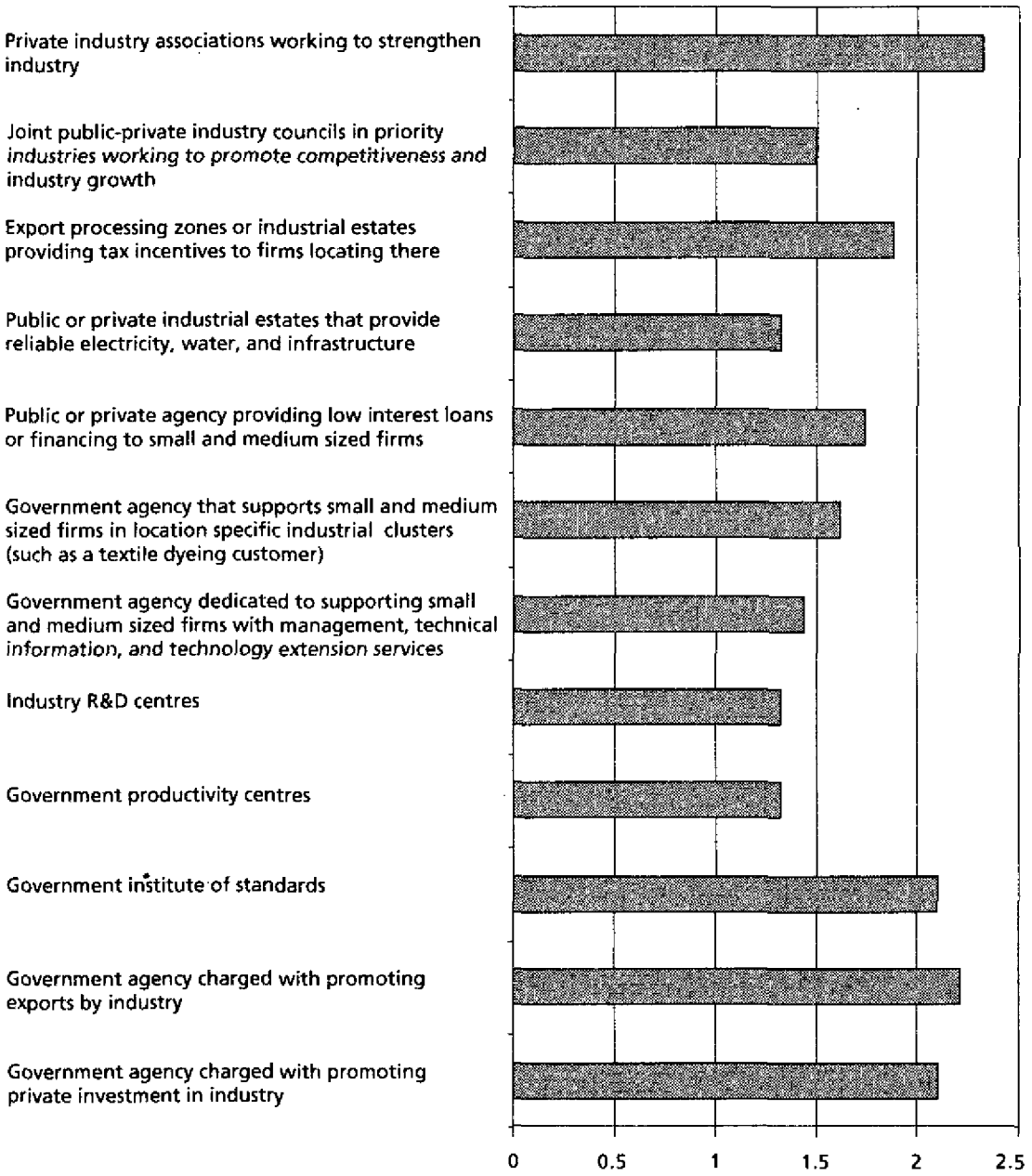
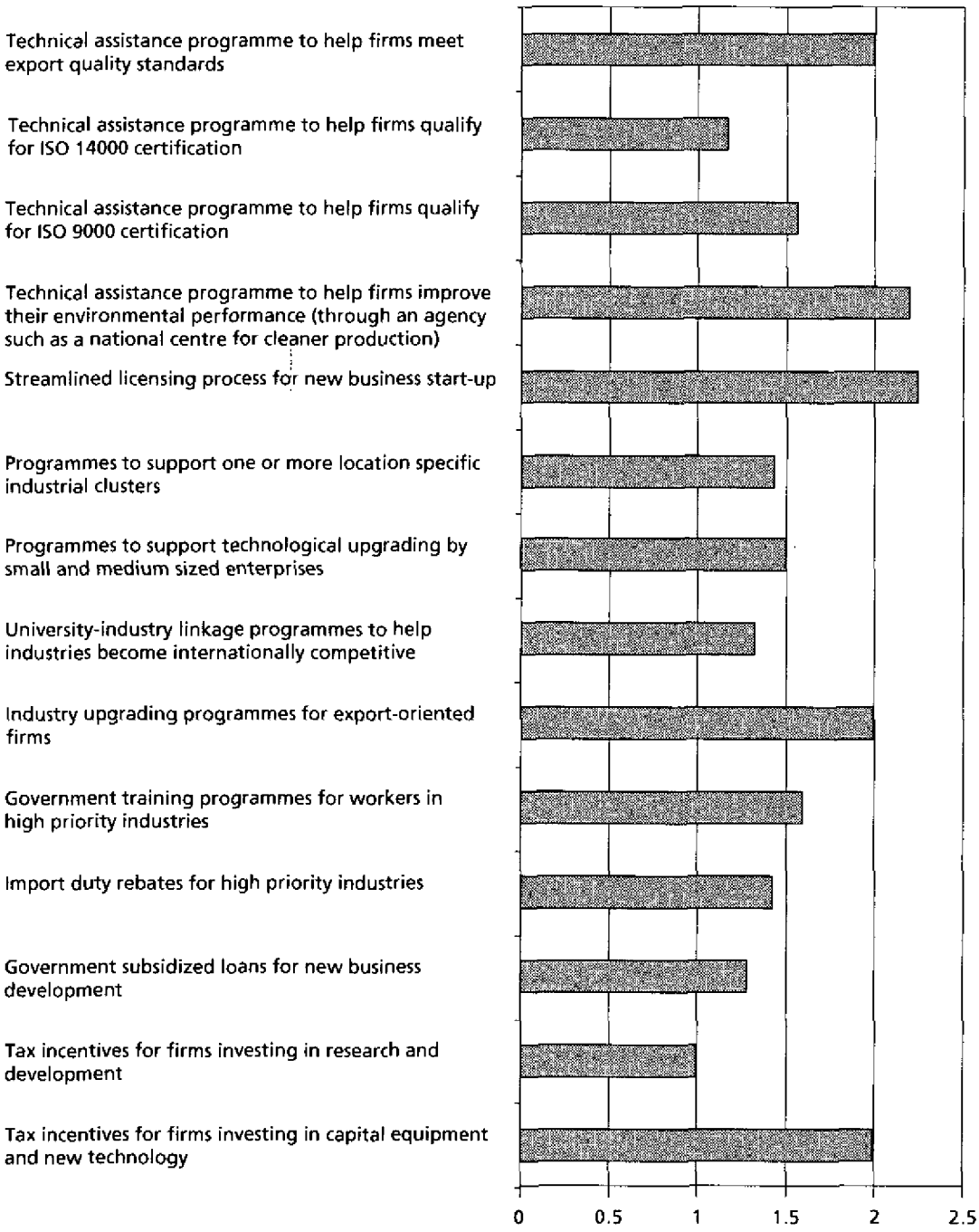


Figure IX presents the assessment of respondents on some specific *policies* that support technological upgrading and environmentally sound industrial development. Among the range of policy instruments reviewed, policies that streamline licensing procedures for new businesses are viewed as being somewhat effective, as are programmes to promote improved environmental performance. In addition, policies that promote exports are viewed as somewhat effective. The policies rated as being less effective (or not present) are tax incentives for investing in research and development, government loans for new business development, university–industry linkage programmes and technical assistance to help firms qualify for ISO 14000 certification.

FIGURE IX.
EFFECTIVENESS OF POLICIES



Taken together, this gap analysis, based on the results of the survey for upgrading strategies, institutions and policies in Ghana, raises the question to what degree is the specific strategy for technological upgrading of the Government of Ghana identified as a driving element of strategies, policies and institutions designed to increase non-traditional exports and foreign direct investment? Using the survey as a diagnostic tool and as the basis for a gap analysis suggests a lack of emphasis placed on technological upgrading. If this preliminary analysis is correct, the Government would be well advised to carefully consider the possible negative consequences of not directly targeting upgrading as a key priority.

Validating the survey diagnostic with field observation: Ghana case study

As demonstrated, using the survey diagnostic provides a parsimonious tool for conducting a rapid appraisal of strategies, institutions and policies linked to technological upgrading within a low-income country. To what degree do the findings derived from using this survey tool accord with those that would be obtained through more detailed field investigations within individual low-income countries? In this section, the survey results obtained are cross-referenced against the findings obtained through direct meetings with the agencies involved in promoting technological upgrading. Annex IV provides a list of agencies, Ministries and other organizations interviewed for the purpose of validating the results of the survey-based gap analysis. It is important to note that the field analysis did not involve a comprehensive assessment of capabilities and opportunities for technological upgrading. The field analysis was limited to validating the effectiveness of the survey diagnostic as a gap analysis tool.

The first stage in survey validation is to identify the institutions in, and policy instruments used within, the country. Table 11 identifies selected actual institutions and policies in Ghana that correspond to the institutions and policies whose effectiveness was assessed in figures VIII and IX above. As shown in table 11, Ghana has a wide range of recommended institutions and policies in place and the key focus of the Government is on enhancing the effectiveness of policies. However, effectiveness has been limited by resource constraints and uneven implementation. More generally, the overall climate for business development, as indicated, for example, by private-public sector cooperation, needs to be enhanced.

With respect to *strategies* on technology upgrading, as shown in figure VII, the diagnostic survey results indicate that promoting foreign investment and exports and identifying priority industries are strategies judged to be most effective in Ghana. The results were confirmed in the field interviews and those strategies have recently been given particular visibility through the President's special initiatives and through the creation of the Ministry for Private Sector Development. Strategies seen as less effective include promoting firms as suppliers to major multinational corporations, targeting leading firms for support and targeting technological upgrading. In general, it can be concluded that this assessment is correct. *Government strategy focuses more on promoting private investment and exports than on technology upgrading of industry.* As Ghana continues to develop its industrial development strategy, it is important that more attention be given to technology upgrading and to appropriate pathways for achieving technology upgrading of industry.

With regard to *institutions* supporting technology upgrading, as shown in figure VIII, the survey results indicate that private industry associations, for example, the Association of Ghana Industries, the Government Institute of Standards, Ghana Standards Board, the Export Promotion Agency, Ghana Export Promotion Council, the Private Investment Promotion Agency and the Ghana Investment Promotion Centre, were somewhat effective. In general, the field visits supported this conclusion. While these institutions have an appropriate mandate, they typically lack the resources and the full range of expertise to create the necessary impact. In addition, these agencies might have been more directly involved in the policy-making process than they currently are. Agencies engaged in technology upgrading, such as industrial research and development centres or productivity centres, were either viewed as less effective or did not exist.

TABLE 11.
SELECTED INSTITUTIONS AND POLICIES IN GHANA

Support institution	*Ghana institution*	*Ghana policy*
Policymaking	Ministry of Trade and Industry; Ministry of Private Sector Development	Macroeconomic policy. President's special initiatives in garments, cassava and palm oil. Accelerated and uniform goods clearance. Reduced time for business start-up. Harmonized tariffs. Privatization of State-owned enterprises.
Private industry associations	Association of Ghana Industries. Industry associations in several sectors, including food processing	Policy advocacy in areas of cost of credit, business regulation, business law. Business assistance.
Export processing zones with tax incentives	Ghana Free Zones Board	Lower income tax rates. Tax holidays. Reduced export duties. Tax holiday (0 per cent income tax for 10 years). 100 per cent foreign ownership allowed.
Industrial estates with reliable infrastructure	Export processing zone in Tema	One stop regulation. Fast-track customs clearance. Basic infrastructure recently completed.
Small and medium enterprise financing and cluster support	Banking reform	Access to capital major business concern for small and medium enterprises
Industry research and development and productivity centres	Ministry of Science and Environment	Mainly public institutions with modest links to private sector, for example, Palm Oil Research Institute, Crops Research Institute
Government Institute of Standards	Ghana Standards Board	Building basic standards infrastructure. Limited involvement in ISO 9000 or 14000 certification.
Export promotion agency	Ghana Export Promotion Council	AGOA initiatives. Some trade visits. Retention of foreign exchange earnings.
Investment promotion agency	Ghana Investment Promotion Centre	Investor trade fairs. Efforts to cultivate foreign investors in target industries under President's special initiatives. Technology transfer.
Environmental protection agency	Ghana Environmental Promotion Agency	Environmental impact assessment. Performance rating and disclosure. Recent cleaner production initiatives.

As far as *policies* are concerned, as shown in figure IX, the survey results indicate that the following programmes are perceived as somewhat effective: assistance in meeting export quality standards, for example, within the Ghana Standards Board, to improve environmental performance, for example, cleaner production activities within the Export Promotion Agency, and for streamlining the process for new business start-up, for example, within the Ministry of Industry and the Ministry of Private Sector Development, and tax incentives for investment and exports. During the interviews it was possible to document examples where progress has been made in each of these areas. For example, it is generally agreed that the time it takes to start a business in Ghana has recently been reduced. But even in these areas where policy is viewed as somewhat effective, the agencies have a long way to go in terms of meeting international performance expectations. As indicated above, the relevant agencies typically lack the resources to make a broader and deeper impact.

In general, the field analysis confirmed the overall findings of the rapid appraisal diagnostic survey. The areas of strategic and institutional focus were correctly identified in the survey, and the effectiveness of specific policy tools was reasonably calibrated. The field visits suggest that the diagnostic survey is best used for identifying the relative effectiveness of institutions and policies within a country. As used in the work reported here, the diagnostic survey did

not include a direct mechanism between country validations of results. That is to say, what is judged effective in one country is not directly calibrated against what is judged effective in another. It must be noted, however, that the survey data were shown to be effective for statistically differentiating among low-income countries with respect to overall economic performance.

The report demonstrates the use of one such diagnostic tool: a rapid appraisal survey instrument designed to provide insight into the effectiveness of strategies, institutions and policies supporting technological upgrading. The report focuses on institutional diagnosis because the "soft" policy and institutional capabilities are imperative for successful industrial development and is not well documented in existing published data.

Research in the report and elsewhere demonstrates that policies in support of technological upgrading are more likely to succeed when they are demand-driven, internationally connected and context-specific. In the next section of the report, the relevance of these three operational policy principles is demonstrated through a case study undertaken to assess the prospects for technological upgrading and economic growth in the ready-made garment sector in Ghana.

B. CASE STUDY EXAMPLE: READY-MADE GARMENTS IN GHANA

Many countries in the developing world target the garment industry as a priority sector for promoting poverty-reducing and industrial growth. Among the features of the industry that make it attractive for low-income countries are low barriers to entry, relatively simple technologies, labour intensity and the internationalization of the industry, in the context of global value chains, in this instance buyer-driven, as opposed to producer-driven value chains (as in the case of automobile assembly). Over the past 30 years, low-income countries from South-East Asia to South Asia, to Africa have targeted the industry as a sector of growth. The experience of Bangladesh, the Lao People's Democratic Republic and Sri Lanka in building a garment industry on the basis of foreign investment and export-oriented trade in the 1980s aroused the attention of Africa. Subsequently, Kenya, Lesotho, Madagascar and Mauritius have all engaged in a parallel strategy with some success. Lesotho's ready-made garment industry currently employs more than 10,000 workers in foreign-owned factories operating in export processing zones. These factories are supported by a wide variety of the policy tools and incentives outlined in the report.

Given the recent success of Lesotho and other African countries that have successfully entered the global garment industry, it is not surprising that several West African countries have also targeted this industry for development. The focus on the garment industry in Africa is further encouraged by trade agreements that promote quota-free and tariff-free access to foreign markets. The most important Agreements are Africa Growth Opportunity Act (access to North American markets), the Cotonou Agreement (access to European markets), and Economic Community of West African States (West African trade pact). This has evoked UNIDO's active involvement in this area in several African countries, including Nigeria, to develop a national strategy for the textiles and garment industries (UNIDO [93]).

Ghana has targeted the garment industry for development under the President's special initiatives programme. The goal of this special initiative is to attract large-scale foreign garments

and textiles factories to locate in Ghana, build the capacity of medium-sized Ghanaian firms to meet international standards on export quality, price and on-time delivery, and create a large pool of local subcontractors. Specifically, the Government has set ambitious goals to attract at least 10 large-scale foreign textile and garment factories, to build the supply capacities of 100 medium-sized Ghanaian firms to meet international export standards for quality, price and on-time delivery, and to create a substantial pool of small-scale subcontractors. The cumulative target is to generate some 70,000 jobs in Ghana.

The Government identifies its role in this initiative as one of facilitating and supporting an effort led by the private sector. A number of specific policy initiatives are underway. Within the export processing zone in Tema, approximately a third of the land area has been assigned as a "garment village" with factories under construction for use by foreign firms. The Government has also established a training institute in an effort to build a supply of workers with basic training in garment manufacture. More generally, the garment industry is a focal point for other policy interventions, such as accelerated clearance customs, streamlined business start-up, tax incentives and export promotion.

Based on the diagnostic analysis presented in the report, Ghana meets many of the necessary conditions to pursue a strategy of technology upgrading either via joint ventures between domestic firms and multinational corporations, or through the participation of small and medium enterprises in global value chains. In the garment industry, it is linking to global value chains as suppliers to buyers in North America and Europe who offer the predominant market opportunity, supported by the Africa Growth Opportunity Act and Cotonou Agreements. The challenges Ghana faces in building this industry include attracting foreign investors and buyers, enhancing labour productivity, improving manufacturing performance to consistently meet international export expectations, ensuring reliable infrastructure support and continued improvement in the Government's technological infrastructure support.

What successes have been achieved to date? There are as yet no fully operational garment factories located in the garment village within the export processing zone in Tema. Ghana is experiencing difficulty attracting the required level of interest of foreign investors and buyers. While the Government's garment training institute is gradually building its labour supply, feedback from private sector garment factories suggests that the training received is quite basic and hence insufficient for workers to achieve international standards of labour productivity. Several garment factories have received allotted orders from international buyers, but it is not clear whether these factories are able to meet the recurring volume demand or whether the capacity to meet on-time volume delivery is available. While specific policy interventions are helpful, such as accelerated customs clearance, these interventions are not the core of industry competitive advantage, which is based on the ability to meet and exceed international standards with regard to price, quality and on-time delivery.

The experience of one garment factory in Ghana illustrates the advantage of a more demand-driven and internationally connected strategy for technological development in low-income countries. This particular firm has recently received extensive orders from a major retail chain for T-shirts in the United States of America. How was this achieved? The firm was established as a joint venture with investment from a Mauritian textile investment partner. The machinery was procured from Mauritius, including sewing machines and cutting equipment. The

managing director is a Mauritian national with extensive experience in that country's export-oriented garment industry. Together with four other Mauritian workers they make up the production floor management. Skilled workers have also been hired from India to help train Ghanaian workers to meet international productivity and quality standards. The firm has more than a thousand applications wait-listed for various worker positions. Approximately 40 per cent of the current workforce has received training from the Government-sponsored President's special initiative training institute. However, the firm notes that the emphasis at this training institute is on training in woven textiles, rather than in knitwear, which is the actual focus of their production.

Further international input has been received from international buyers and retailers. A major garment buyer in California serves as one of the links to retail customers in the United States. Contact with this particular garment buyer was made at an international trade fair. International buyers and retailers also have a direct impact on and provide inputs to many aspects of production, ranging from health and safety standards to qualification for ISO 14000 certification. The experience of this garment firm, in short, is to mobilize technology, know-how and market information emanating from connections in global arena. The positive contributing role of the Government has been in the area of demand-driven enabling support, such as accelerated customs clearance, rather than in the core area of building technological and production capability. Those initiatives that are directly supply linked, such as the effort to start a garment village in the export processing zone or train workers, have been less successful.

Ghana is at the early stages of building an internationally competitive garment industry. Garment firms remain concerned about the presence of stable enabling conditions, including macroeconomic stability, access to credit, infrastructure quality, stable water and electricity supply and Government transparency. Consistent with the framework and policy process laid out in the report, Ghana would do well if it continues to: *(a)* strengthen the enabling conditions for technology upgrading and poverty reducing growth; and *(b)* approach support for private firms within a demand-focused framework, rather than through supply push of policy support. These principles of demand-focus, international connection and context-specific policy should guide future efforts to support technology upgrading for low-income countries by UNIDO and other organizations.

C. Policy integration and supply chain management: the case of electronics in Penang

The third of these three empirical analyses focuses on ways in which technological development can be linked to industrial environmental management within a framework of policy integration. The analyses focus on the introduction of environmental requirements into supply chain management relations between multinational corporations and their suppliers in the electronics manufacturing industry in Penang, Malaysia.

There is a mass of literature, which demonstrates that firms in several East Asian newly industrializing countries acquired much of their marketing and technology know-how from buyers and suppliers in developed countries. For example, it is well known that international buyers—importers, wholesalers and retailers—from developed countries provided substantial technical

and marketing assistance to suppliers in developing countries on a wide range of simple consumer goods, particularly ready-made garments, footwear and leather goods and also in agro-processing activities. Those buyers were frequently one of the first points of contact between domestic producers and the international market.

As Mody and Egan [24] have demonstrated, international buyers of simple consumer goods were willing to invest in building long-term relationships with their suppliers from developing countries to reduce their risks and transactions costs. They did so by providing them with information on and access to international markets, product design and technology and by training them to meet their price, quality and on-time delivery specifications. Egan and Mody [24] also demonstrate that those long-term collaborative relationships often served as an essential source of information on markets and technology. Since the mid-1980s, firms in East Asian newly industrializing countries have been playing a similar role by mediating between buyers in developed countries and other suppliers in developing countries. The more recent shift by multinational corporations to global production networks as a vehicle for managing global production and distribution adds yet another element to the evolving relationships between suppliers in developing countries and their buyers and technology suppliers in developed countries. The voluminous empirical research undertaken demonstrates that governments and firms can build technological capabilities by "leveraging" technology support services provided by international markets, irrespective of which pathway to technological upgrading is followed. There is also a small but growing body of work (Rock [76]; Angel and Rock [9]) that suggests that "leveraging" the environmental support services provided by international markets also works. The strongest evidence of this can be found in Penang, Malaysia, where the State Government pursued technological development by ultimately, though somewhat belatedly, adopting policies that linked local small and medium enterprises to global value chains of multinational corporations.

The Government's most important small and medium enterprises–multinational corporations linkage programmes are the vendor development programme, the industrial linkage programme and the global supplier programme. The vendor development programme encourages multinational corporations and large local firms to provide procurement contracts and technical assistance to suppliers who then become eligible for subsidized finance.[9] The industrial linkage programme is a cluster-based industrial development programme designed to shift the industrial base towards high value-added activities, reduce both the import content and reliance on foreign-based research and development and technology service providers.[10] The global supplier programme invests in training personnel in small and medium enterprises in the important skills necessary for them to become first-tier global suppliers to multinationals.[11]

[9]Felker, [28]. Currently, 256 vendors participate in the vendor development programme of which 25 per cent are from the electronics and electrical goods sector. Some 82 anchor (multinational corporation) firms and 16 banks/financial institutions are also involved in the programme.

[10]Vendors under the industrial linkage programme supply parts, components and related services, along the value-added chain of leading firms. Priority sectors include transportation, electronics, machinery and equipment and resource-based industries. The industrial linkage programme is supported by programmes that emphasize technology development of small and medium enterprises, technology acquisition, skill enhancement and upgrading and export market development.

[11]The global supplier programme was launched in 1999 and was designed in response to the challenges and opportunities arising from globalization. The programme aims to enhance the capabilities of Malaysian firms so that they can become first tier global suppliers to multinational corporations in the global economy. It is the culmination of the Government's efforts to enhance industrial linkages in the development of small and medium enterprises. At end of 2002, a total of 1,392 employees from 357 small and medium enterprises received training under the global supplier programme while eight small and medium enterprises under the linkage initiative have been adopted by eight multinational corporations to be nurtured as first-tier global suppliers.

Interestingly enough, none of these linkage programmes are explicitly concerned with improving the environmental performance of affected small and medium enterprises. Despite this, there is substantial evidence that an increasing number of small and medium enterprises in Penang have been adopting industrial environmental management and best practice programmes to achieve Environment Management System certification and ISO 14001 certification. This raises the question about whether the small and medium enterprises in Penang were being driven by international market pressures to take advantage of "leveraging" the environmental support services provided by international markets. To test this hypothesis, structured survey questionnaires to a small sample of multinational corporations[12] and suppliers of small and medium enterprises[13] were administered. These surveys were followed up with in-depth interviews with several multinational corporations and small and medium enterprises.

From the results, it can be concluded that at least the first-tier small and medium enterprises suppliers in Penang established links to the global value chains of electronics multinationals and were in fact leveraging the environmental support services provided by international markets. They did so because both multinational corporations and markets required this of them. For their part, the multinational corporations that were surveyed, all were found to have written environmental policies that extend to their subsidiaries in Penang. These written policies are very often part of corporate-wide environment health and safety and sustainability policies that require affiliates all over the world to meet national environmental regulations, go beyond compliance, and seek continual industrial environmental management.

Moreover, these written policies tend to be backed up by corporate and Penang facility-specific quantitative environmental performance goals that range from explicit targets for reduction in usage of water and electricity, to restrictions on the use of particular hazardous substances, to recycling and reduction of wastes. As stated by those managers of multinational corporations that were interviewed, meeting these corporate-wide and their own facility-specific goals made it necessary for them to work with their suppliers, in particular on the phasing out of particular hazardous substances, such as the use of lead in solder paste used in printed wiring boards.

These corporate policies have been reinforced by two impending environmental market requirements for electronics and electrical products imported into the European Union:

- The European Union's Waste in Electrical and Electronics Initiative requires that 75 per cent of any electrical and electronic product must be recyclable, while 65 per cent of it must be recovered (information provided by Motorola-Penang);

[12]The multinational corporation questionnaires focused on environmental policies and practices and on multinational corporation environmental supply chain practices in Penang at headquarters of multinational corporations and Penang facilities. The objective of the survey was to develop an understanding of the extent to which environmental requirements were used to select suppliers and to ascertain whether the multinational corporations were assisting suppliers to improve their environmental performance.

[13]The suppliers' questionnaire was designed to assess the environmental commitments of small and medium enterprises and the extent to which they work with electronics multinationals to overcome particular environmental problems.

- The European Union's Reduction of Hazardous Substances Directive sets very stringent limits on the amount of hazardous wastes that can be embedded in electrical and electronics products.[14]

As the interviews and Lim [55] demonstrated, affiliates of multinational corporations in Penang, such as Motorola-Penang, draw on a range of environmental tools to assess the degree to which its current products and those under development meet those directives.

The managers of multinational corporations also recognized that they could not assess the degree to which their products complied with the environmental requirements of the European Union without extending their environmental practices to their global suppliers, including their global suppliers in Penang. Hence, multinational corporations in Penang demand that their first-tier suppliers develop their own written environmental policies with specific continuous industrial environmental management goals and require their suppliers to become ISO 14001 certified.[15]

In addition, multinational corporations require their suppliers to eliminate chlorofluorocarbons and other ozone-depleting substances from their production processes. They also require their suppliers to complete detailed materials disclosure sheets for all goods supplied. At one multinational corporation, Motorola-Penang, these sheets identify the use of specifically named materials, for example, lead and all heavy metals in components supplied, the amount of those materials embedded in each product supplied and, not surprisingly, the information provided in those data sheets are used to monitor the conformity of new products with the Reduction of Hazardous Wastes Directive of the European Union.

Working with local small and medium enterprise suppliers extends well beyond handling requests for additional information and testing of supplied parts or commodities. Increasingly, the multinational corporations in Penang have been forced to work closely with suppliers and dealers on numerous environmental problems related to increasing the compliance rate of their products with the Reduction of Hazardous Wastes Directive and the Waste in Electrical and Electronics Initiative. This is best demonstrated by the experience of Motorola-Penang, a wholly-owned subsidiary of Motorola, Inc. In one instance, Motorola-Penang worked very closely with several chemical suppliers,[16] other subsidiaries and corporate headquarters to develop a new no-clean flux tin/lead (essentially lead-free) solder paste. All the information developed as a result was shared with the suppliers of the new product.

[14]There is some disagreement about the Reduction of Hazardous Substances Directive. Engineers at Motorola-Penang believe that Reduction of Hazardous Substances bans the use of lead, cadmium, chromium oxide, mercury and polybrominated diphenyl ether, but has not yet set threshold limits which a product must meet to satisfy these restrictions (information provided by Motorola-Penang). The interviewees at Agilent Technologies in Penang said they believe the threshold limits will be as follows. The use of mercury will be restricted to 0.1 per cent by weight not to exceed 1,000 parts per million (ppm); cadmium to 0.01 per cent by weight not to exceed 100 ppm; lead to 0.01per cent by weight not to exceed 1,000 ppm, chromium 6 to 0.1 per cent by weight not to exceed 1,000 ppm and polybrominated diphenyl ethers by 0.1 per cent be weight not to exceed 1,000 ppm (information provided by Agilent Technologies in Penang). Because of these stringent requirements, Motorola-Penang has sent fully loaded (populated) printed wiring boards to the REAL laboratory in Germany for analysis. The REAL facilities have developed a non-destructive method of screening the PWB for hazardous materials using sophisticated X-ray machines (XRF).

[15]Motorola maintains a global preferred supplier list. Suppliers on this list are qualified to provide components to Motorola plants worldwide. Generally, a plant must source from a preferred supplier. This has important consequences for local suppliers to plants—the type of local firm-supplier linkages involving technological upgrading are becoming less prevalent as plants are required to use preferred suppliers.

[16]One supplier was based in the United States, while another was based in Malaysia.

A similar process was used for developing halogen-free printed wiring boards.[17] In this instance, Motorola, Inc. and its subsidiaries, including its subsidiary in Penang, worked with printed wiring boards manufacturers and their suppliers of raw materials to reduce the amount of halogen in printed wiring boards. Following the successful adoption of lead-free and halogen-free raw materials for manufacturing printed wiring boards, Motorola-Penang worked with key dealers and repair shops that questioned both the reliability and maintenance of the new products. Subsequently, multinational corporations produced a new internal technical manual for those new products and provided the new specifications and the problems associated with them.

Interviews with small and medium enterprise suppliers to major multinational corporations of electrical and electronic products in Penang revealed that managers of small and medium enterprises have begrudgingly come to recognize that their ability to meet the environmental requirements of their buyers is merely another requirement. Just as with the price, quality and on-time delivery requirements, they must meet these requirements if they are to remain or become first-tier suppliers to the multinational corporations. Accordingly, at least a few small and medium enterprises in Penang are learning how to "leverage" the environmental support services provided by global markets.

Owing to increased reliance of multinational corporations on global or international production networks, this trend is believed to provide important opportunities for governments to assist firms in this "leveraging" strategy. One way to do so would be to expand the availability of high quality ISO certification capabilities. Another way is to develop formal technological upgrading linkage programmes between multinational corporations and their small and medium enterprise suppliers in developing countries. A "leveraging" strategy, at least as practised in Penang, also suggests what government interventions might forgo. Chief among these appears to be pollution prevention or cleaner production programmes embedded in government agencies de-linked from small and medium enterprises–multinational corporation linkage programmes and the real world environmental problems faced by small and medium enterprises.

The Government of Malaysia, like numerous other governments in developing countries, has created multiple donor-funded cleaner production or pollution prevention programmes. There is no evidence that these programmes have been successful in Malaysia, or that they are linked to the "leveraging" of the environmental support services provided by global markets. "Leveraging" is important because it reduces the demands on governments in developing countries and because buyers are usually only willing to transfer the minimal amount of marketing and technical information needed by suppliers to meet their specifications. The former is a critical consideration when governments are weak, unstable and/or prone to corruption and rent-seeking, a general tendency in low-income countries. The latter is important because it suggests that unless governments and firms make a serious effort to maintain good relationships between international buyers and their suppliers in developing countries, the latter can become trapped in low value-added activities.

Governments in developing countries can adopt "leveraging" polices by assisting local firms through match-making services linking buyers to suppliers by helping local suppliers piece

[17] Flex refers to flexible wiring boards. Flex is used in numerous, in particular, small electronics, such as cellular phones.

together missing elements in international information channels and by assisting local suppliers through vehicles, such as formal linkage programmes between local firms and multinational corporations, in aggressively securing the most out of their long-term relationships with buyers.

The experiences of developing countries, especially those of the private sector, also confirm the importance of technological and environmental support institutions maintaining embedded autonomy with and from the private sector. In effect, embedded autonomy refers to the capacity of public sector institutions to work in collaboration with the private sector without being "captured" by the interests of private sector firms. This will be an especially challenging condition for low-income countries to meet owing to the weak levels of bureaucratic competency in many of these countries.

III. IMPLICATIONS FOR UNIDO

> "The past few years have witnessed a significant evolution of the international development agenda, driven in particular by the Millennium Declaration adopted by the Millennium Summit of world leaders held in September 2000, which has resulted in the identification of eight specific Millennium Development Goals. The time-bound and quantifiable nature of these goals underlines the growing emphasis placed by the international community on the need for conceptually well-founded and focused high-impact interventions by technical cooperation organizations such as UNIDO."
>
> Operationalizing UNIDO's Corporate Strategy (UNIDO [94]).

The final chapter reviews the implications of the conceptual policy framework together with the allied empirical analyses for UNIDO's operations. In this chapter, special reference is also made to UNIDO's corporate strategy. The corporate strategy rests on the premise that "productivity enhancement, driven by improved skills, increased knowledge and upgraded technology, plays a crucial role in promoting faster growth" (UNIDO [94]). There is little doubt that technological development is at the heart of productivity enhancement. For this reason, the conceptual framework articulated in the report bears relevance to much of UNIDO's strategy, both with respect to global forum activities and actual technical cooperation with low-income countries.

The implications of the report for UNIDO's operations can be organized in two broad categories. First, it is felt that the conceptual framework and associated empirical work has overarching implications for the process and approach that UNIDO adopts for promoting productivity enhancement. Here three elements are singled out for particular attention: policy process; diagnostics; and policy integration. Secondly, the report has specific implications for specific UNIDO service modules. The focus here is on the implications of the report for activities included under:

- Service Module 2: Investment Promotion and Technology Promotion;
- Service Module 8: Environmental Management (with a particular focus on national cleaner production centres);
- Service Module 3: Industrial Competitiveness and Trade (with a particular focus on standards and productivity centres);
- Service Module 4: Private Sector Development (with a particular focus on business development services).

A. Overarching implications

The conceptual policy framework developed in the report identifies the five core elements of an effective policy process for promoting technological development and industrial environmental management: *(a)* enabling conditions; *(b)* policy process; *(c)* technology infrastructure; *(d)* policy integration; and *(e)* technological development pathways. The empirical analysis in this chapter clearly demonstrates that one of the major challenges facing low-income countries is their weak position with respect to many of the basic enabling conditions necessary for successfully promoting technological upgrading by firms. While it is well understood, it is worth emphasizing that efforts of UNIDO to promote technological development need to be coordinated with broader development initiatives to strengthen the underlying enabling conditions for private sector development in low-income countries.

In addition to the emphasis on enabling conditions, the policy framework developed in the report identified five critical elements of the policy process that contribute to successful technological capability-building. The analysis suggests that successful technological development in low-income countries requires the adoption of a policy process marked by a national strategy of industrial development, centred round the principle of embedded autonomy between firms and governments. This principle must be market-building in its orientation, promote links to the global economy for services and technological know-how and, finally, engage in policy integration. This broad principle will guide the shape of policy advice and institutional development promoted by UNIDO. While UNIDO has made a strong commitment to shift toward a demand-oriented policy process, the assessment reveals a continuing legacy of supply-driven initiatives. Given UNIDO's expertise and strategic focus and the situation of most low-income countries with respect to enabling conditions and policy process, three areas are particularly advantageous to UNIDO, to the extent that it could provide important value-added to the industrial development process in low-income countries. These include strengthening the policy process, refining diagnostic tools and associated integrated country planning, and developing policy integration initiatives to promote environmentally sustainable industrialization in low-income countries.

1. Policy process

UNIDO is frequently requested to provide advice on the policy process. Given the range of needs of low-income countries, within the policy and institutional framework, what should countries focus on first? Are there particular policy tools that should be developed and deployed? Are there appropriate ways to identify priority industrial sectors for development? The analysis suggests that unless countries develop a policy process based on the principles articulated above, the returns on investment in particular institutions, tools or sectors are likely to be constrained. In other words, the first priority is to put in place the enabling conditions and policy process that are conducive to technological upgrading. Once such an institutional framework is in place, the relations of embedded autonomy between a competent government bureaucracy and firms secure the information flow needed to foster the demand for services that enhance technological capability-building.

This recommendation is similar to the conclusion drawn by Rodrik [82] who notes:

> "The critical institutional challenge therefore is to find an intermediate position between full autonomy and full embeddedness. Too much autonomy for the bureaucrats, and you have a system that minimizes corruption, but fails to provide the incentives that the private sector really needs. Too much embeddedness for the bureaucrats, and they end up in bed with (and in the pockets of) business interests. Moreover, we would like the process to be democratically accountable and to carry public legitimacy. Getting this balance right is so important that it overshadows, in my view, all other elements of policy design. In particular, once the institutional setting is 'right', we need to worry considerably less about appropriate policy choice. A first-best policy in the wrong institutional setting will do considerably less good than a second-best policy in an appropriate institutional setting."

The implication for UNIDO's technical services in low-income countries is the need to focus more on building an appropriate policy process, or institutional setting, for private sector technological development to take place.

2. Diagnostic tools and integrated country planning

The analysis indicated that opportunities for successful technological development in low-income countries are likely to be very limited. For this reason, effective diagnostic tools and an effective diagnostic process are particularly important. UNIDO is increasingly engaged in developing methodologies for industrial diagnosis and country planning. Within the Strategic Research and Economics Branch, an initiative is under way to provide a comprehensive "action and policy oriented" industrial diagnosis for developing countries. This initiative, like the current report, is linked to the *Industrial Development Report 2002/2003* and to the use of the competitive industrial performance as an aggregate performance index. Conceptually, this diagnostic tool builds on a concept of industry as an innovation and learning system that is supported by institutions, framework conditions and industrial governance.

The concept of an innovation and learning system is largely consistent with the framework presented in the report, though it is important to note that this particular system is a broader concept than the notion of a national technology and innovation system, and used in the report. The innovation and learning system is an approach applicable to countries at all stages of industrial development, irrespective of the pathway to technology upgrading used. In the report, the use of the term national technology and innovation system refers to a particular pathway to technology upgrading that is centred around public and private sector institutions of technological development and research and development.

The comprehensive industrial diagnostic tool under development by UNIDO contains both quantitative and qualitative indicators for industrial capabilities and support systems. As in other works that emphasize the use of published data, the comprehensive diagnostic tool is limited in the information available on institutions and policies (the report recommends primary surveys of individual institutions). It is, therefore, possible to make use of the rapid appraisal survey tool presented in the report as one part of the comprehensive diagnosis. The use of the survey tool, demonstrated and validated in the report, would enhance and build on

this effort to develop a comprehensive industrial diagnosis. It does so in three ways. It provides information on the soft institutional features on upgrading strategies, policies and institutions of countries. By focusing attention on alternative pathways to upgrading, it disaggregates the concept of industrial innovation and learning systems into one of three pathways, thereby enriching the concept. The survey tool will also enable UNIDO to undertake systematic gap analyses and will help to identify intervention opportunities.

In addition to efforts to develop a comprehensive diagnostic tool, various branches of UNIDO are, on a continuing basis, engaged in assessment activities in support of country planning. For example, a project to implement a technology needs assessment within low-income countries has recently been approved for the Investment Promotion and Technology Branch of the Programme Development and Technical Cooperation Division. The appraisal approach developed in the report can be an important tool for use in such a national technology needs assessment. In implementing this approach, the use of a modified version of the diagnostic survey tool presented in the report is recommended as the basis for facilitating stakeholders' discussion of strategies, policies and institutions—rather than as a direct assessment tool. In other words, the survey results are best used not as a free-standing assessment, but as the basis for a stakeholders' dialogue in which the effectiveness of strategies, policies and institutions are discussed and as a priority for future steps to strengthen effectiveness are identified.

UNIDO is encouraged to consider possible funding sources for such a policy dialogue among key stakeholders and to pilot test such an approach in Ghana and other low-income countries in Africa. The field analysis in Ghana confirmed that the availability of the rapid appraisal results provided a focus for stakeholder discussion that was not otherwise available. Facilitated discussion on opportunities to strengthen policy and institution intervention would definitely assist in promoting sustainable technology upgrading and poverty-reducing growth. If UNIDO could successfully link its strategic industrial diagnostic tools to the rapid appraisal survey and combine both with stakeholders' dialogues in assisted countries, it should be possible to link more systematically each of UNIDO's service modules and its overall assistance to a more strategic, demand-driven and internationally-focused assistance strategy.

3. Policy integration

The tools identified here—the policy framework, rapid appraisal survey and stakeholders' dialogues—can be extended to issues of environmentally sound industrial development. As argued in chapter I, ensuring environmentally sound industrial development requires building a competent, capable and well-financed environmental regulatory agency. It also requires the use of appropriate policy tools, a capacity in regulatory agencies to learn and adapt and the integration of industrial environmental management goals into more traditional industrial development agencies. How can UNIDO use what is learned in the report on the efficacy of policy integration to assist governments and private sectors in low-income countries to improve the environmental performance of those firms and industries engaged in long-term technological development strategies? There are numerous answers to this question. First, UNIDO could organize short-term training programmes and arrange specialized field visits for key government officials and private sector actors from low-income countries with less experience with

globalization. Such actions would provide exposure to concrete real life examples of how technological development in each of the three pathways identified in the report has moved hand in hand with industrial environmental management.

Visits, for example, could be made to one or more of Malaysia's palm oil processing facilities that are engaged in adding value, capturing export markets and cleaning up the environment. It could also include visits to first-tier and second-tier electronics suppliers in the Malaysian State of Penang to demonstrate how they are being assisted by their buyers in multinational corporations, who are developing firm-based environmental standards to increase their ability to recycle electronic parts they supply to multinational corporations while reducing the toxicity of those parts.

Visits to one or more multinational corporations, such as Holcim, Inc. and its large Thai subsidiary, Siam City Cement, could also be included to learn how Holcim's corporate and internal industrial environmental benchmarking programme is linked to technological upgrading in Holcim's subsidiaries. It could also include visits to the Industrial Development Bureau in the Ministry of Economic Affairs and the Industrial Technology Research Institute—two institutions in the national technology system in Taiwan Province of China—engaged in activities to help local Taiwan-based firms meet international best practice to reduce energy, materials and water pollution intensities.

Workshops and study trips could also be arranged to expose government officials and private sector actors to one or more examples of new governmental environmental initiatives, such as the Reduction of Hazardous Wastes Directive and its Waste Electrical and Electronic Equipment Initiative of the European Union, that are affecting the multinational corporations and their suppliers in developing countries who market electrical and electronic products in the European Union. Such workshops and study trips could be organized through the National Cleaner Production Centres or through one of the other networks that UNIDO has in developing countries. It would have the advantage of there being an institution in these countries through which UNIDO could promote a practical implementation of the lessons learned from workshops and study trips.

In addition, the Strategic Research and Economics Branch and those technical cooperation branches involved in implementing the Sustainable Energy and Climate Change Service Module and the Environmental Management Service Module should consider developing a more refined rapid assessment survey instrument, similar to that developed in the report for technological upgrading, that focuses on industrial environmental management. As with the survey instrument developed for technological upgrading, this instrument should focus on alternative pathways to industrial environmental management that are linked to the three pathways to technological upgrading identified in the report. The survey instrument should be pilot tested in three or four countries, possibly using the network of National Cleaner Production Centres or other UNIDO-promoted support institutions, which could later be administered to approximately 25 low-income countries.

As with the rapid assessment instrument for technological upgrading, to ensure the success of any industrial environmental management strategy, the strategies, policies and institutions for industrial environmental management should be cross-mapped against the policy profiles and

initial conditions identified in the report. To integrate environmental considerations into the institutions of economic and industrial policy and into UNIDO's own thinking and actions, the mandate of the service module on Industrial Governance and Statistics should include the organization of workshops to encourage stakeholders' industrial–environmental dialogues in selected low-income countries to review the findings obtained from the industry and environment rapid appraisal. Individuals from prominent economic and industrial development agencies and institutions, along with representatives from environmental regulatory agencies and national cleaner production centres should be encouraged to attend such workshops. The outcome of such workshops involving stakeholders could result in an agreement on a strategy for improving industrial–environmental outcomes and contribute to strengthening a set of policies, institutions and initial conditions to ensure that the strategy works.

The major advantage of this approach is that it creates embedded autonomy by linking industrial plants and firms to technology upgrading institutions and industrial environmental management institutions and agencies. Assuming that the relevant branches participated in both the rapid appraisal survey and the stakeholders' dialogue, one or more of those branches could offer assistance for formulating an upgrading strategy that includes an important environmental dimension. This could provide an important opportunity for UNIDO to ensure the inclusion of policy integration in its service modules.

B. Implications for particular UNIDO service modules

Currently, UNIDO offers eight service modules that are linked through integrated programmes and/or country service frameworks. The recent shift to integrated programmes and country service frameworks as vehicles for providing UNIDO assistance marks an important step in linking UNIDO's service modules to an integrated country-level approach to assistance to each other and to the actual upgrading and environmental needs of governments and private sectors in low-income countries.

1. Service Module 2: Investment and Technology Promotion

The technical assistance programmes of Service Module 2 are central to initiatives to promote technological upgrading in low-income countries. The two primary areas of focus in this service module are investment promotion and technology promotion. In both areas, UNIDO identifies government and market failures and weaknesses in institutional capacity as the critical problems to be addressed. UNIDO's approach is appropriately sensitive to the development conditions of low-income countries, stressing the need for "technology-followers" to develop a technology management system that facilitates the capacity of industrial enterprises to adopt, adapt and diffuse technologies. The technical assistance programmes of UNIDO in this area include strategy and policy advice, a needs assessment, training in policy tools and approaches and institutional capacity-building. UNIDO also has a number of promising initiatives in technology foresight analysis and in assessing emerging technologies.

The programmes within this module reflect many elements of the policy framework outlined in the report. UNIDO has made the appropriate decision to expand the role of investment

promotion agencies to make them more development oriented—as opposed to purely promoting foreign direct investment. In addition, the investment promotion agencies place what is viewed as a correct strong emphasis on linking different industrial stakeholders. This approach is taken one step further in the work of Investment and Technology Promotion Offices to the extent that it stresses close interaction with domestic industry. All these initiatives are consistent with a shift toward a demand-driven and market-centred policy process that seeks to forge effective close ties between technology support institutions and domestic firms and multinational corporation investors.

Nevertheless, there are opportunities for UNIDO to take further steps along the path from supply-driven to market-centred policy intervention. Two specific recommendations are proposed. First, much of the analytical foundation of Service Module 2 continues to rest on a concept of market failure—of lack of information on the part of firms and government institutions on what technology to choose, which industries to target, and so forth. While the market failure approach has some merit, it has the tendency to lead to supply-driven initiatives that "fill the information gap". As indicated in the conceptual framework, once the analytical framework shifts from market failure to that of embedded autonomy, there is greater opportunity to shape a policy process that stimulates sustained demand for technological upgrading on the part of firms and institutions. Thus, the first recommendation is to focus greater attention on cultivating a policy process, rather than on responding to perceived need for technical assistance in countries. One way to do this is to take advantage of UNIDO's capability in industrial diagnosis and engage in industrial diagnosis as a participatory process that has as its goal the cultivation of relationships of embedded autonomy between domestic firms and institutions.

Secondly, Service Module 2 includes both investment promotion and technology promotion. The analysis suggests that the basic tools for investment promotion are far better understood in low-income countries than are approaches to technology promotion and technological capability-building. Low-income countries are fairly familiar with the "tool kit" of investment promotion—especially approaches used to promote foreign direct investment, including "one-stop" regulatory approvals, tax-free zones, export processing zones and the like. The importance of, and the pathways toward, technological upgrading are less well understood. Indeed in many cases, the expectations of low-income countries stop at promoting investment (especially foreign direct investment) and do not extend in practical terms to technological upgrading and capability-building. UNIDO is perhaps uniquely positioned to focus on technology upgrading. Productivity improvement is at the core of UNIDO's corporate strategy. For this reason, it is recommended that UNIDO consider concentrating more of the programme emphasis on Service Module 2, or technological upgrading and capability-building.

2. Service Module 8: Environmental Management

Service Module 8 links issues of technological upgrading to environmentally sound industrial development. Here three major focal areas are identified, namely, cleaner production, water management, and treatment of persistent organic pollutants and persistent toxic substances. In the overarching recommendations, some of the implications of policy integration for UNIDO's

operations have been spelled out. The focus here is more specifically on the work of the National Cleaner Production Centres, which have been an important part of UNIDO's environmental management technical assistance programmes. Indeed, it is fair to say that UNIDO has played a leading role in the international community in promoting cleaner production initiatives. Technical assistance programmes focus on the transfer and adoption of environmentally sound technology, eco-efficiency, environmental impact assessment and others. Clients include both domestic firms and institutions, especially environmental regulatory institutions.

Most government-led initiatives that seek to promote cleaner production are supply driven. The typical profile of a cleaner production initiative is one in which firms engage in recommended activities while the programme is in place (as long as the programmes are consistent with cost reduction and industrial environmental management). There is, however, little diffusion of best practice beyond the participating firms, and only modest commitments to continuation on the part of participating firms once the programme has ended. While these cleaner production programmes can be justified in terms of their immediate impact, they rarely have the downstream multiplier effects that policymakers desire. UNIDO's own assessment of the National Cleaner Production Centres is consistent with this pattern.

Cleaner production initiatives are, in short, a classic example of the limits to supply-driven initiatives. The UNIDO network of National Cleaner Production Centres is an important development resource. It is recommended, however, that the programme focus of the National Cleaner Production Centres shift more toward interventions that promote the demand for cleaner production. In addition, it is recommended that UNIDO continue to look to private firms and to market processes to provide the technical and market know-how needed to engage in cleaner production (as opposed to developing further in-house technical capability). In practical terms, this means that National Cleaner Production Centres should work closely with environmental regulatory institutions to create the demand for cleaner production, and less with firms and firm-networks for providing cleaner production services. Finally, in line with the analysis of supply chain management in chapter II, it is recommended that the National Cleaner Production Centres link up to the growing importance of firm-based standards and supply chain requirements as a driver of cleaner production.

3. Service Module 3: Industrial Competitiveness and Trade

Service Module 3 supports technical assistance projects in the area of standards, metrology and accreditation and in the area of supply chain development through networks and partnerships. Both these areas are likely to be crucial to technological upgrading and capability-building in low-income countries. The first area of standards, metrology and accreditation is a critical "market-building" resource in the sense that these services create a framework within which the market for product and services are created and "trading" can take place. Standards are alsó a contested topic among countries—with developing countries fearing the presence of exclusionary tendencies in some market standard regulations. Because of its status as a credible international industrial development organization, UNIDO is well placed to launch initiatives to promote the adoption of standards as an economic development initiative. There is little doubt that there is a great need for institutional capacity-building in this area and that UNIDO is

well placed to provide such support. The only concern is that the need is so great that it is difficult to expect a realistic response from UNIDO. For this reason, UNIDO's interventions should primarily act as a facilitator rather than as a direct supplier of services to building capability—and should look to other institutions, including universities and firms, to help build capacity in low-income countries.

In the second area of supply chain assistance, UNIDO supports a network of Subcontracting and Partnership Exchanges. These Subcontracting and Partnership Exchanges serve, in part, as a clearing house that helps to link small and medium enterprises to global value chains. The key characteristic of these Subcontracting and Partnership Exchanges, from the perspective of the policy framework, is that they are self-financing. The principal of self-financing of technical assistance services is fully consistent with the concept of embedded autonomy—the value of these Subcontracting and Partnership Exchange services is determined in the marketplace. The absence of such a self-financing requirement would raise fears that these facilitator and brokerage services are unable to serve the particular needs of firms and industries.

4. Service Module 4: Private Sector Development

The final service module commented on is Private Sector Development. This service module covers a variety of technical assistance programmes designed to promote private sector development, especially the development of the small and medium enterprise sector. Specific programme focuses include access to information technology, promoting sector-based business partnerships, small and medium enterprise cluster and networking development, as well as the role of women in entrepreneurship. The activities of this service module are discussed extensively in another COMPID project that focuses on small and medium enterprise development. A simple point is accordingly made here. UNIDO views itself as playing a catalyst role in private sector development, including small and medium enterprises, which is the appropriate position for UNIDO. The tendency to be resisted is engaging in direct technical assistance to small and medium enterprises. UNIDO can best make a catalytic contribution to small and medium enterprise development by creating an overall policy process within which small and medium enterprises can grow and develop in low-income countries—instead of attempting to build the small and medium enterprise sector by one group or network of firms at a time.

C. Conclusions

For the past several years, UNIDO has been undertaking a strategic review of its mission and of the adequacy and efficacy of the services it provides its client countries relative to that mission. Taken together, the activities that have comprised this multi-year strategic review have sharpened their focus—on technological and industrial environmental management in the low-income countries—and emphasized the need to build demand for upgrading those services that UNIDO provides in the context of a rapidly globalizing environment. This strategic effort has also led to the development of an impressive array of tools that enable UNIDO to assess the real needs of its clients and to develop an integrated country-level approach to assistance.

The findings in the report build on these efforts in several ways. To begin with, by drawing on published data, UNIDO's own strategic research and the experiences of the East Asian newly industrializing countries, the report develops a policy framework that includes consideration of enabling conditions for three technological upgrading pathways, that is, through the development of national technology and innovation systems, linking of large local firms with multinational corporations, and linking small and medium local firms to global value chains. These policy profiles move UNIDO a step closer to developing highly targeted, demand-driven, externally-based and integrated assistance strategies. They also enable UNIDO to undertake a capabilities assessment of where particular countries stand relative to the policy profiles and initial conditions. Since the policy profiles and the associated empirical work presented in the report demonstrate that enabling conditions matter, taken together they suggest a logical sequence for policy interventions or for the policy process.

An upgrading strategy will never work unless the macroeconomic environment is stable, physical infrastructure is efficiently priced and reliable, and the labour force is sufficiently educated so that it can productively engage in factory work. Implementing any upgrading strategy, when one or more of these conditions are not fulfilled, is unlikely to meet with much success. Focusing on getting these conditions above the critical threshold values is essential. Once the enabling conditions are in place, governments and international development organizations will be faced with other tough choices. Chief among these is which upgrading strategy to adopt. To answer this question a close examination of the policy profiles and the conditions required for successfully implementing each upgrading strategy is necessary.

While the empirical work in the report suggests that upgrading by linking small and medium enterprises to global value chains holds greatest promise for low-income countries, governments might want to at least consider one or more pathways to upgrading. Successfully doing so requires a cross-mapping of the conditions associated with each pathway with initial conditions prevalent in low-income countries. It must be stated here that the conceptual framework with its emphasis on pathways should be seen as one concrete demonstration of a particularly fruitful approach—an approach to specifying a framework, which can be used as a diagnostic tool for policy formulation.

Aspects of the conceptual framework matrix, such as pathways and enabling conditions, were found to be helpful in empirically conducting a gap analysis in Ghana and assessing the adequacy of the Government of Ghana's upgrading strategy, policies and institutions in the ready-made garment sector. However, the use of pathways, enabling conditions, policy process, technological infrastructure and policy integration as a diagnostic tool will, no doubt, need to be refined in the course of its practical implementation by UNIDO. Hence, the present specification should be considered a guide, and not a blueprint, and should be used with necessary flexibility.

The rapid appraisal instrument developed and pilot tested in the report for more than 20 countries, has been shown to provide the specific type of information on strategy, policy and institutions, as part of its strategic industrial diagnosis, which published data do not include. This suggests that the next step in the policy process would be to carry out a rapid assessment of strategies, policies and institutions associated with upgrading. In so doing, governments and UNIDO would be in a position to raise questions such as whether country X has a strategy

for upgrading. Is that strategy understood and agreed to by key government officials, private sector actors and donors? Are the relevant institutions needed to meet the strategy in place and are they effective? Are the relevant policies in place and are they effective? The rapid appraisal tool enables governments and UNIDO to cross-map the conditions associated with particular upgrading pathways in the policy profiles with the actual state of development of existing strategies, policies and institutions associated with particular pathways in particular countries.

As the Ghana case study demonstrated, the findings from the rapid appraisal survey instrument provide a basis for developing a dialogue with relevant Government officials, private sector actors and donors, in particular client countries, on upgrading strategies, policies and institutions. This could well provide the basis for engaging in a stakeholders' dialogue on upgrading strategy, policies and institutions that will lead to an agreement on the strategy to be adopted and for identifying gaps in policies and institutions that need to be filled for the strategy to be effective. *This stakeholders' dialogue constitutes the most important next step in the policy process. Proceeding to adopt a strategy and policies and institutions without such a policy process would be futile.*

Once agreement is reached on a vision and overall strategy for upgrading, the next step in the policy process involves the identification and assessment of the policies and institutions needed to make a strategy successful. If the relevant Branches of UNIDO as well as other development partners could be drawn into such a stakeholders' dialogue, it might be possible to better integrate UNIDO's service modules into a more effective and shared upgrading assistance strategy. Finally, it might also be possible to achieve more donor coordination in this area. The conceptual work as well as the range of diagnostic tools developed in this respect should bring UNIDO an important step closer to being able to provide its clients in low-income countries with a needs-based and integrated assistance package that recognizes alternative pathways to upgrading, taking full account of the gaps in actual upgrading strategies, policies and institutions.

ANNEX I. DATABASE OF POLICIES AND INSTITUTIONS DRAWN FROM INTERNATIONAL EXPERIENCE

Demand-increasing industrial policies	*Rationale and objectives for policy*	*Where used*	*Permitted by the WTO*
Board of Investment Promotional privileges sometimes targeted to promoted firms in promoted industries	Assumes that tax holidays and accelerated depreciation are required to get firms to invest in capital equipment and new technology. Sometimes used to encourage promoted firms (local and foreign) in promoted industries to invest in new capital equipment and sometimes to undertake research and development Over-riding objective is to increase productive investment in promoted firms and industries	Thought to be successful in the Republic of Korea (Rhee and others [68]), Taiwan Province of China (Wade [98]), Indonesia (Rock [73]), Malaysia (Felker [28]), Thailand (Rock [71]), Singapore (Huff [37]), Ireland (Arnold and others [10]) and elsewhere. Seen as successful in the Republic of Korea (Jones and Sakong [41]) and Taiwan Province of China (Wade [98]) in creating indigenous export-oriented firms. Seen as successful in Indonesia (Rock [73]), Malaysia (Felker [30]) and Thailand (Rock [71]) in creating large indigenous conglomerates serving the local market. Some evidence suggests that promotional privileges have been successful in encouraging these conglomerates to increase exports (Rock [71, 73]). Has been seen as successful in Singapore (Huff [37]) and Ireland (Arnold and others [10]) in attracting multinationals in increasingly technologically-sophisticated activities, including research and development activities	Yes, if not industry or firm specific, does not discriminate between domestic and foreign firms and is not linked to performance requirements that distort trade
Infrastructure provision sometimes for promoted firms in promoted industries, particularly in industrial estates, export processing zones and licensed manufacturing warehouses. Often linked to export performance requirements	Reliable infrastructure—power, water, wastewater treatment, roads, ports and airport facilities—are typically lacking or are of poor quality in many developing countries. Provision of high quality infrastructure reduces the cost of business and can be used to attract foreign direct investment and increase profitability of investments made by local firms. Is often used to promote the exports of promoted firms in promoted industries. Objective is to enhance quality of infrastructure	Used extensively and thought to be successfully in the Republic of Korea (Rhee and others [68]), Taiwan Province of China (Wade [98]), Indonesia (Rock [73]), Thailand (Rock [71]), Malaysia (Felker [28]), Singapore (Huff [37]) and many other countries. Has been generally seen as somewhat less successful elsewhere	Yes, if not industry or firm specific; does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade

Public investment in education (primary, secondary and tertiary) and training initially imparting basic skills for low-skilled workers, but focusing over time on skilled workers. Sometimes (Ireland) after formal schooling, workers are trained in a national training agency. Other times, Government support is used to fund in-company training. In several countries (Malaysia, Republic of Korea and Singapore) in-company training funded by a levy on firms that is reimbursable for in-company training expenses	Ensures a sufficient supply of increasingly skilled workers that meets the needs of industrial firms at acceptable wages to foreign and local firms. Objective is to enhance the quality and quantity of educated labour for use in manufacturing	Viewed as most successful in the Republic of Korea (Haggard [32]), Taiwan Province of China (Haggard [32]), Singapore (Haggard [32]) and Ireland (Arnold and others [10]) where it emphasized craft, technical and engineering skills tied to the needs of industrial firms as opposed to education in the arts and humanities. Viewed as less successful in Indonesia, Malaysia (Mani [59]), Thailand (Arnold and others [10]) and elsewhere. Also seen as successful in software development in India (Evans [26])	Yes, if does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade
Regulating and limiting new firm entry into a promoted industry. Promoting formation of Government sanctioned cartels	Enables promoted firms in a promoted industry to capture rents. Also justified as necessary to thwart "excess competition"	Viewed as successful in the Republic of Korea (Jones and Sakong [41]) and Taiwan Province of China (Wade [98]) in promoting the development of indigenous export-oriented firms. In the Republic of Korea has been used to enable promoted firms to earn near monopoly profits on local sales to cover losses on export sales (often referred to in the Republic of Korea as "bleeding exports"). Viewed as successful in Indonesia (Rock [73]), Thailand (Rock [73]) and Malaysia (Searle [83]) in creating large indigenous conglomerates serving the local market facilitating primitive accumulation. Used in many other countries with varying success	No
Government procurement of the output of promoted firms in promoted industries	Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Used in the Republic of Korea (Amsden [5]) and Taiwan Province of China (Wade [98]). No evidence of effectiveness	No

Demand-increasing industrial policies	*Rationale and objectives for policy*	*Where used*	*Permitted by the WTO*
Creation of State-owned enterprises in new industries where risks are assumed to be too large for private sector firms to undertake	**Enables entry into an industry where capital investments and risks are high**	Generally considered successful in the Republic of Korea in steel and shipbuilding (Amsden [5]), in Taiwan Province of China in plastics and other upstream industries (Wade [98]), and somewhat less successful in Indonesia in aircraft (McKendrick [61]) and automobiles (Aswicahyono, Basri and Bird [11]; Doner [23]) and in Malaysia and Thailand (Doner [23]) in automobiles. *Used in a number of other countries with what is* thought to be very limited to no success	Yes, if is not linked to performance requirements that distort trade
Directed and subsidized credit	Enables promoted firms in promoted sectors to expand production capacity and technological capabilities	Thought to be successful when used to promote exports in the Republic of Korea (Amsden [5]; Rhee and others [68]) and Taiwan Province of China (Wade [98]) of promoted firms in promoted industries. Also thought to be successful in promotion of promoted local firms in promoted import substitution industries by encouraging primitive accumulation in Indonesia (Rock [73]), Malaysia (Searle [83]) and Thailand (Rock [71]). In Thailand, directed and subsidized credit based on limiting entry into commercial banking (Rock [71]). As a consequence, Sino-Thai conglomerates that dominate the manufacturing sector are affiliated usually with a Thai commercial bank	No
Heavy restrictions on FDI from outright bans in certain sectors to explicit joint-venture and local content requirements	To increase the demand in local firms for technological development by limiting access of foreign firms in certain sectors (both import substituting and export-oriented) and/or requiring foreign firms to transfer explicit technologies and/or develop a local (indigenous) supplier base	Most extensive prohibitions on FDI in the Republic of Korea (Mardon [60]). Less extensive prohibitions in Taiwan Province of China (Wade [98]). Generally thought that programmes in Korea and Taiwan Province of China were successful. Also generally thought that these programs have been somewhat successful in Brazil (Evans [26]), Indonesia (Doner [23]; Rock [73]), Malaysia (Doner [23]), Thailand (Doner [23]; Rock [71]) where focus has been on joint-venture/local content requirements	No

Labour market regulations that limit coverage of minimum wage legislation, restrict efforts to unionize, and ban or limit the right to strike, particularly in export processing zones and licensed manufacturing warehouses	Keeps manufacturing wages nearer to market levels and limits disruption to production by union activity and strikes. Helps keep labour costs down thereby enhancing corporate profits	Thought to be successful in the Republic of Korea (Haggard [32]), Taiwan Province of China (Haggard [32]), Indonesia (Rock [81]), Malaysia (Jomo and Todd [40]), Thailand (Rock [71]), Singapore (Huff [37]) and off and on again in a number of countries in Latin America	Yes, but workers rights are on the agenda
Joint public-private sector deliberation councils	**Assumption is that public sector needs close relationships with the private sector to devise and monitor policies and institutions designed to promote technological development within firms. Objective is to use JPPDCs to develop embedded autonomy**	Successful in the Republic of Korea (Amsden [5]; Rhee and others [68]), Taiwan Province of China (Wade [98]) and Singapore (Huff [37]), successful in Thailand in the mid-to-late 1980s (Rock [71])	**Yes**
Venture capital development programmes	**Assumption is that market failures high-tech industries limit emergence of domestic high-tech entrepreneurs. Subsidies and low interest loans plus incentives to get high-tech personnel to move from public sector high-tech R&D agencies to start own venture capital firms. Objective is to stimulate investment and risk taking in high-tech industries.**	Used most effectively in Singapore after 1991 (Mani [59]) and in Ireland (Arnold and others [10])	**Yes**
Indicative planning, sometimes (as in the Republic of Korea and Taiwan Province of China) used to monitor and reward/punish firms for meeting or failing to meet quantitative export targets	Indicative planning when tied to performance monitoring of firm-level performance and subsequent allocation of learning rents based on performance relevant to target can be a powerful way for the State to hold firms accountable for technological learning. Objective used to hold firms accountable for performance	Best successful example is thought to be the Republic of Korea's export targeting programme linked to Monthly Export Promotion Meetings in Blue House (Rhee and others [68]). Learning rents (particularly directed and subsidized credit) allocated on the basis of a firm's performance relative to target	No, distorts trade
Import protection provided to promoted industry via import bans, import quotas, and high and variable effective rates of protection	Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Thought successful in the Republic of Korea (Amsden [5]) and Taiwan Province of China (Wade [98]) in promoting development of indigenous export-oriented firms. Thought successful in Indonesia (Rock [73]), Thailand (Rock [71]) and Malaysia (Searle [83]) in creating large indigenous conglomerates serving the local market where this facilitated primitive accumulation. Used elsewhere with varying success	No, except for use of tariffs in the lowest-income countries for limited and specified time periods

Demand-increasing industrial policies	*Rationale and objectives for policy*	*Where used*	*Permitted by the WTO*
Export subsidies provided to promoted firms in promoted industries	**Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems**	Thought to be somewhat successful in the Republic of Korea (Amsden [5]) and Taiwan Province of China (Wade [98])	No, except for the lowest-income countries for limited and specified time periods
Preferential access to foreign exchange, sometimes at preferential rates, particularly for exports	Increases the demand for exports of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Thought to be successful in Taiwan Province of China (Wade [98]) during the early days of its export drive	No
Duty drawback privileges on tariffs and taxes on imported inputs for exports of promoted firms in promoted industries	Used to overcome the import bias in the trade regime	Thought to be most successful in the Republic of Korea (Westphal [100]; Rhee and others [68]), Taiwan Province of China (Wade [98]), Indonesia (Rock [73]) and Thailand (Rock [71]). Is now a standard part of recommendation from aid agencies, including the World Bank	Yes, if not industry or firm-specific, does not discriminate between domestic and foreign firms and is not linked to performance requirements that distort trade
Control over access to imported raw materials and spare parts used to produce exports	Given foreign exchange constraints, allocating imported raw material and spare parts to those who use these inputs to export makes it possible for exporters to meet export demand	Practised most extensively in the Republic of Korea (Amsden [5]) and Taiwan Province of China (Wade [98]). In the Republic of Korea, the Government allocated access to these imported inputs on the basis of a firm's export performance sometimes allocating more inputs than a firm could use. Sometimes firms sold these excesses, referred to as wastage allowance, on the local market at near monopoly prices	No, distorts trade
Widely publicized national annual export award programmes administered by the highest level of political authority	National publicity and high-level political support for firm-specific export performance increases the demand for technological capability needed to increase exports	Generally thought to have been used effectively in the Republic of Korea (Rhee and others [68]) and Taiwan Province of China (Wade [98])	Unknown, but probably not if it distorts trade

Joint public-private local industry upgrading programmes linking foreign and export-oriented multinational corporations or large/medium-sized export-oriented domestic firms with local small and medium enterprises	**Local small and medium enterprises lack the technological and managerial capabilities to meet the price, quality and on-time delivery needs of foreign export-oriented multinationals and large export-oriented local companies. Objective of local industry upgrading programmes is to overcome these problems**	Successful local industry upgrading programmes thought to be in Singapore (Battat and others [12]), Taiwan Province of China (Battat and others [12]), and Malaysia, (Churchill [20]; Rasiah [67]) and Ireland (Arnold and others [10]) also has been considered successful in its local supplier development programmes	Yes, if not industry or firm-specific, does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade
Creation of a public sector export-marketing agency	Assumption is that local firms have difficulty identifying potential export markets. This limits demand for their exports Objective is to use a public sector export-marketing agency to help local firms identify foreign market demands	Generally thought that most successful examples are in the Republic of Korea, Taiwan Province of China, Hong Kong (Keesing [46]), and to a lesser degree in Thailand. Many other countries have created a public sector export-marketing agency. Most of these agencies are generally thought to be ineffective (Keesing [46])	Yes
Public sector export quality testing institutes	**In the Republic of Korea and Taiwan Province of China, there was a fear in the public sector that local firms would not be able to meet buyers' quality requirements. This fear was stoked by Japan's early experience as an exporter of low-quality toys and trinkets. Objective was to enhance the quality of exports**	Generally thought to be successful in the Republic of Korea (Rhee and others [68]) where the Government worked closely with local firms/industry associations in commodity-specific working groups to overcome quality problems. Generally thought to be successful in Taiwan Province of China (Wade [98]) where the Government developed a multi-tiered export-quality testing system exempting foreign firms, testing the quality control system of large indigenous firms, and testing the quality of exports from smaller firms. Firms failing to pass inspections were exposed to frequent inspections and sometimes prohibited from exporting	Yes

Technology supply-enchancing institutions	*Rationale and objectives for policy*	*Where used*	*Permitted by the WTO*
Ministries of Science Technology and the Environment, National Science and Technology Agencies/Boards	**Charged with spearheading and coordinating national policies with regard to science and technology and research and development. Objective is to identify science and technology needs of industrial firms and find ways to meet these needs by engaging, among other things, in scientific and technological research**	Most developing countries have such ministries/agencies/boards. Generally thought that all too often they are disconnected from both the private industrial sector and the economic/industrial development agencies charged with promoting industrial development (Arnold and others [10]). When this happens, these agencies appear prone to disarticulated supply push strategies of scientists that tend to fail (Arnold and others [10])	Yes
Premier National Science and Technology Agencies	**Assumption is that indigenous firms are not likely to be innovators. Proposed solution is to have innovation and research and development undertaken by a public sector science and technology or research and development agency**	Many developed/developing countries (or regions) have such agencies. Even under the best of circumstances (Taiwan Province of China and the Republic of Korea), these premier science and technology and research and development agencies are generally seen as too disconnected from the private sector, too focused on basic research, or too academic-oriented to be of much assistance to the private sector. Evidence from Taiwan Province of China (the Industrial Technology Research Institute in Wade [98]; Hobday [34]) and the Republic of Korea (Korea Institute for Science and Technology and the Republic of Korea Advanced Institute for Science and Technology in Rock [70]) suggests these agencies' most important contribution was in supplying highly skilled personnel to the private sector (Arnold and others [10]). As with productivity centres and SME technology assistance agencies, these agencies are thought to be more effective when they are required to fund a significant part of their budget by selling services to the private sector (Arnold and others [10])	**Yes**

Industry (sector) specific technology support institutions	**Assumption is that sectors differ quite substantially from each other. Some have mature technologies (foundries and textiles), others have more science-based technologies (bio-technology, advanced materials). Because of this industry-specific technology, support institutions are needed to cater to the specific demands of specific industries**	The Republic of Korea (Amsden [5]), Taiwan Province of China (Wade [98]), Malaysia (Mani [59]), Singapore (Mani [59]), and Thailand (Rock [75]). When linked closely to the private sector by exchanges of personnel and contract work can be highly successful, otherwise major contribution appears to be providing highly trained personnel to the private sector (Arnold and others [10]). Services most likely to be used, if used at all, by larger firms and firms with science-based technologies (Arnold and others [10]). Evidence appears to suggest that these institutes have been successful in Singapore after 1991 after a large pooled of highly-trained science and technology personnel was available to man these institutions (Mani [59]). Success also appears linked to movement of trained personnel out of these specialized institutions to become venture capitalists in high-tech industries (Mani [59]). Evidence from Malaysia (Mani [59]) also suggests that these institutions and the personnel in them flounder when the country lacks either a sufficient number of trained personnel or policies to promote venture capitalists in high-tech industries	**Yes**
Joint university-private industry linkage programmes	**Assumption is that these can be used to overcome market failures in the development of new products and processes**	Used with some success in Singapore (Mani [59]) and Ireland (Arnold and others [10]). Much less successful elsewhere. Sometimes (Thailand and Malaysia) these programmes flounder because skill levels in universities are insufficient to meet the needs of industry (Arnold and others [10] and Mani [59]). Evidence from the United States, Europe, Singapore and Ireland suggests that universities rarely transfer inventions (Arnold and others [10]). Can be used, if appropriately designed, for problem solving, for providing basic research, and for providing industry with highly skilled workers (Arnold and others [10])	**Yes**

Technology supply-enchancing institutions	*Rationale and objectives for policy*	*Where used*	*Permitted by the WTO*
National standards and metrology agencies	**For manufacturing firms to successfully compete in local and global markets they must be able to meet national and international standards, such as ISO 9000 quality standards. Objective of national standards and testing agencies is to help local firms meet international standards required for exporting**	Very common in all developing countries. There is very little systematic evidence on the effectiveness of these agencies. There is some evidence that they have been of some help to SMEs in Ireland (Arnold and others [10]) and Singapore (Mani [59])	Yes
Productivity centres and small and medium enterprise technology support institutions	**Small and medium enterprises assumed to have substantial difficulty assimilating new technologies. These support institutions have been designed to help small and medium enterprises overcome these problems**	Many developed/developing countries (or regions) have one or more institutions designed to help small and medium enterprises assimilate new technologies. Taiwan Province of China's Productivity Center (Wade [98]; Arnold and others [10]) is thought to be among the more successful of these kinds of agencies. Similar agencies in Thailand (Rock [69]) and Indonesia (Berry and Levy [15]), and to a lesser degree, in Malaysia (Mani [59]) are thought to be less successful. Generally these agencies are thought to be more successful if agency funding is tied to contracts with the private sector (Arnold and others [10])	Yes
Special purpose funds (subsidized credit, tax incentives or grants) for special purposes such as saving water (Singapore), saving labour (Taiwan Province of China), or purchasing locally-made capital equipment (Republic of Korea and Taiwan Province of China)	These special purpose funds are used to increase incentives to meet these very particular objectives	Very common in Taiwan Province of China (Wade [98]), a bit less common elsewhere in the East Asian newly industrializing economies. No evidence exists on the effectiveness of these programmes	Yes, if not industry or firm-specific; does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade

Tax incentives for research and development expenditure of private sector firms. Often focused on promoted industries. Often applied to the research and development expenditure of foreign as well as local firms	By increasing the incentives for firm-level research and development in promoted industries, tax incentives can stimulate the demand for research and development by making it more attractive	Used by the Republic of Korea (Teubal [88]), Taiwan Province of China (Wade [98]), Malaysia (Mani [59]), Thailand (Arnold and others [10]), Singapore (Mani [59]), and many other countries, including a large number of OECD countries. Limited evidence suggests these schemes produce highly variable outcomes, generate substantial redundancy, break even, depend on careful design, monitoring and adaptation for success, while not radically changing firm behaviour (Arnold and others [10])	Yes, if not industry or firm-specific; does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade
Grants for the research and development expenditures. Often focused on promoted industries. Often applied to the research and development expenditures of foreign as well as local firms	By increasing the incentives for firm-level research and development in promoted industries, tax incentives can stimulate the demand for research and development by making it more attractive	Used by the Republic of Korea (Teubal [88]), Taiwan Province of China (Wade [98]), Malaysia (Mani [59]), Thailand (Arnold and others [10]), Singapore (Mani [59]), and many other countries, including a large number of OECD countries (Arnold and others [10]). Limited evidence suggests these schemes produce highly variable outcomes, generate substantial redundancy, break even, depend on careful design, monitoring and adaptation for success, while not radically changing firm behaviour (Arnold and others [10])	Yes, if not industry or firm-specific; does not discriminate between domestic and foreign firms; and is not linked to performance requirements that distort trade

Industrial-environmental policies and institutions	*Rationale for institution*	*Where used*	*Permitted by WTO*
Command and control environmental regulatory agencies set ambient and emissions standards and they monitor and enforce compliance with these standards	These agencies correct market failures associated with pollution. Objective is to get firms to internalize environmental costs into their decision-making	Have been used extensively in the OECD (Lovie and Weiss [56]) and with increasing effectiveness in China (including Taiwan Province of China), the Republic of Korea, Singapore and Malaysia (Rock [79])	Yes
Pollution charge systems most often used for wastewater emissions	If set high enough, pollution charges can change behaviour, that is, get firms to internalize environmental costs. If not set high enough to change behaviour, pollution changes can be used to raise revenues	Used most extensively in Western Europe, thought to be particularly effective in the Netherlands (Bressers [16]). Used effectively in China (Wang and Wheeler [99]). Used elsewhere, including in East Asia (Thailand and the Republic of Korea), but no evidence of effectiveness (Stavins [84])	Yes
Emissions trading systems most often for pollution from a relatively small number of large stationary sources	Is more cost-effective than command and control. Objective is to help firms meet emissions standards at least cost	Used most effectively in the United States for SOx emissions from power plants (Burtaw [17])	Yes
Informal regulation based on community pressure	Communities most affected by regulation can use this as a vehicle for getting polluters to change behaviour. Objective is to use public disclosure to empower communities to put pressures on polluters to change their behaviour	Used effectively in Japan (MEIP [62]) and to a lesser extent in Indonesia (Aden and Rock [1])	Yes
Public disclosure	Assumption is that public disclosure of poor environmental performance undermines a firm's reputation affecting demand for its products and its stock price. Objective is to use public disclosure to get firms to change their behaviour	Best examples are the United States Environmental Protection Agency's Toxics Release Inventory programme (Konar and Cohen [51]), Indonesia's Programme for pollution control evaluation and rating: PROPER (Afsah and Vincent [4]) and China's sustainable cities programme (Rock [77])	Yes

Integration of command and control regulatory agency with industrial policy agencies	Linking of promotional privileges offered by industrial policy agency and access to superior infrastructure offered by infrastructure agency to promoted firms meeting environmental requirements can get firms to comply	Used most effectively in Singapore (Rock, 2002)	Yes
Integration of command and control regulatory agency with industry association and a quasi public-private, industry-specific research institutes	Linking of command and control regulatory agency, industry association and industry -specific research institute can lead to cost-effective solutions to pollution that do not undermine firm profits or exports	Used most effectively in palm oil industry in Malaysia (Vincent and others [97])	Yes
Industrial policy agency assumes responsibility for pollution prevention and state-of-the-art work in industrial ecology	Because industrial policy agencies have embedded autonomy with private sector firms, they can find less costly solutions to pollution	Used most effectively in pollution prevention/waste minimization and in state-of-the-art benchmarking work on the energy, materials, water and pollution intensities of firms in Taiwan Province of China compared with international best practices (Rock [76])	Yes
Environmental supply chain activities of large firms	**Large firms are under pressure to improve their environmental performance and to reduce their environmental liabilities. Since these liabilities may extend to the environmental activities of these firms' suppliers, large firms have introduced corporate codes of environmental conduct that extend to suppliers**	Most extensively in the United States and Western Europe (King Lenox [50]) Currently being studied in Malaysia (Lim [55])	**Yes**

ANNEX II. DATABASE OF POLICIES AND INSTITUTIONS USED FOR DIFFERENT PATHWAYS TO TECHNOLOGICAL AND ENVIRONMENTAL UPGRADING

Policy/institution	*Pathway to technological upgrading*		
Demand increasing industrial policies	**Building large-scale domestic conglomerates**	**Building a national technology system linked to local SMEs and technological changes in the global economy**	**Linking local SMEs to the global value chains of OECD-based multinational corporations**
Board of Investment Promotional privileges sometimes targeted at promoted firms in promoted industries	Used by the Republic of Korea (Rhee and others [68]; Jones and Sakong [41]) to build export-oriented firms and by Indonesia (Rock [73]), Malaysia (Felker [30]) and Thailand (Rock [71]) to build large local import substitution firms that ultimately became export-oriented	Used by Taiwan Province of China (Wade [98]) to build export-oriented small and medium enterprises	Used by Singapore and Malaysia to attract OECD-based multinational corporations (Mani [59])
Infrastructure provision sometimes for promoted firms in promoted industries, particularly in industrial estates, export processing zones, and licensed manufacturing warehouses. Often linked to export performance requirements	Used by the Republic of Korea (Rhee and others [68])	Used by Taiwan Province of China (Wade [98])	Used by Singapore (Huff [37]) and Malaysia (Churchill [20]) to attract OECD-based multinational corporations
Public investment in education (primary, secondary and tertiary) and training initially imparting basic skills for low-skilled workers, but focusing over time on skilled workers. Sometimes (Ireland) after formal schooling, workers are trained in a national training agency. Other times, *Government support* is used to fund in-company training. In several countries (Malaysia, Republic of Korea and Singapore) in-company training funded by a levy on firms that is reimbursable for in-company training expenses	Used in the Republic of Korea (Haggard [32]) and to a lesser extent in Malaysia (Mani [59]) and Thailand (Arnold and others [10])	Used by Taiwan Province of China (Haggard [32])	Used by Singapore (Huff [36] and Mani [59]) and Malaysia (Mani [59]) to attract OECD-based multinational corporations
Regulating and limiting new firm entry into a promoted industry. Promoting formation of Government-sanctioned cartels	Used in the Republic of Korea (Jones and Sakong [41]), Indonesia (Rock [73]) and Thailand (Rock [71])	Used in Taiwan Province of China (Wade [98])	Not used

Policy/institution		*Pathway to technological upgrading*	
Government procurement of the output of promoted firms in promoted industries	Used in the Republic of Korea (Amsden [5])	Used in Taiwan Province of China (Wade [98])	Not used
Creation of State-owned enterprises in new industries where risks are assumed to be too large for private sector firms to undertake	**Used in the Republic of Korea (Amsden [5]), Indonesia (McKendrik [61]) and Malaysia (Felker and Jomo [29])**	Used in Taiwan Province of China in upstream industries (Wade [98])	Not used
Demand increasing industrial policies	**Building large-scale domestic conglomerates**	**Building a national technology system linked to local small and medium enterprises and technological changes in the global economy**	**Linking local small and medium enterprises to the global value chains of OECD-based multinational corporations**
Directed and subsidized credit	Used in Indonesia (Rock [73]) and the Republic of Korea (Rhee and others [68])	Used in Taiwan Province of China (Wade [98])	Not used
Labour market regulations that limit coverage of minimum wage legislation, restrict efforts to unionize, and ban or limit the right to strike, particularly in export processing zones and licensed manufacturing warehouses	Used in Indonesia (Rock, 2002), Malaysia (Jomo and Todd [40]) Republic of Korea (Haggard [32]) and Thailand (Rock [71])	Used in Taiwan Province of China (Haggard [32])	Used in Singapore (Huff [37]) and Malaysia (Jomo and Todd [40])
Joint public-private sector deliberation councils	**Used most extensively in the Republic of Korea (Rhee and others [68]; World Bank [105]), less so in Malaysia (Felker [28]) and Thailand (Rock [71])**	Used extensively in Taiwan Province of China (Wade [98])	**Used extensively in Singapore (Huff [37]; Mani [59]; Battat and others [12]) and in Malaysia, particularly in Penang (Churchill [20])**
Venture capital development programmes	**Used in the Republic of Korea (Teubal [88])**	Used in Taiwan Province of China (Wade [98]).	**Used in Singapore after 1991 (Mani [59]).**
Demand-increasing trade policies	**Building large-scale domestic conglomerates**	**Building a national innovation system linked to local SMEs and technological changes in the global economy**	**Linking local SMEs to the global value chains of OECD-based multinational corporations**
Indicative planning, sometimes (as in the Republic of Korea and Taiwan Province of China) used to monitor and reward/punish firms for meeting or failing to meet quantitative export targets	Used in the Republic of Korea (Rhee and others [68])	Used in Taiwan Province of China (Wade [98])	Not used
Import protection provided to promote industry via import bans, import quotas, and high and variable effective rates of protection	Used in Indonesia (Rock [73]), Republic of Korea (Jones and Sakong [41]; Rhee and others [68]) and Thailand (Rock [71])	Used in Taiwan Province of China (Wade [98])	Not used in Singapore or in export activities in Malaysia
Export subsidies provided to promoted firms in promoted industries	**Not used**	Used some in Taiwan Province of China (Wade [98])	Not used

Policy/institution		*Pathway to technological upgrading*	
Demand-increasing trade policies	**Building large-scale domestic conglomerates**	**Building a national technology system linked to local small and medium enterprises and technological changes in the global economy**	**Linking local small and medium enterprises to the global value chains of OECD-based multinational corporations**
Preferential access to foreign exchange, sometimes at preferential *rates particularly for* exports	Used in the Republic of Korea (Rhee and others [68])	Used in Taiwan Province of China during the early days of its export *drive (Wade [98])*	Not used
Duty drawback privileges on tariffs and *taxes on imported* inputs for exports of promoted firms in promoted industries	Used in Indonesia (Rock [73]), Republic of Korea (*Rhee and others* [68]; Westphal [101]) and Thailand (Rock [71])	Used in Taiwan Province of China (Wade [98])	Used in export activity in Malaysia, not used in *Singapore*
Control over access to imported raw materials and spare parts used to produce exports	Used most extensively in the Republic of Korea (Rhee and others [68])	Used in Taiwan Province of China (Wade [98])	Not used
Widely-publicized national annual export award programmes administered by the highest level of political authority	Used in the Republic of Korea (Rhee and others [68])	Used in Taiwan Province of China (Wade [98])	Not used
Joint public-private local industry upgrading programmes linking foreign and-export-oriented multinational corporations or large/medium-sized export-oriented domestic firms with local small and medium enterprises	**Not used in the Republic of Korea or Indonesia, used but believed not to be successful in Thailand (World Bank [104])**	Used in Taiwan Province of China, particularly for larger local firms and local SMEs in industrial parks in centre-satellite systems (Battat and others [12])	Used in Singapore (Battat and others [12]) and in Malaysia (Churchill [20]) in export activity
Creation of a public sector export-marketing agency	Used in the Republic of Korea (Keesing [46]) and Thailand	Used in Taiwan Province of China (Keesing [46])	Not used
Public sector export-quality testing institutes	**Used in the Republic of Korea (Rhee, and others [68])**	Used in Taiwan Province of China (Wade [98])	Not used
*Technology supply-*enhancing institutions/incentive policies	**Building large-scale domestic conglomerates**	**Building a *national* technology system linked to local small and medium enterprises and technological changes in the global economy**	**Linking local small *and medium* enterprises to the global value chains of OECD-based multinationals corporation**
Ministries of Science Technology and the Environment, National Science and Technology Agencies/Boards	**Used in Malaysia (Mani [59]) and Thailand (World Bank [104])**	Used in Taiwan Province of China (Wade [98])	Used in Singapore (Mani [59]) and Malaysia (Mani [59])
Technology supply-enhancing institutions/incentive policies	**Building large-scale domestic conglomerates**	**Building a national technology system linked to local small and medium enterprises and technological changes in the global economy**	**Linking local small and medium enterprises to the global value chains of OECD-based multinationals corporation**

Policy/institution	*Pathway to technological upgrading*		
Premier national science and technology agencies	**Used in Indonesia (McKendrik [61]) Malaysia (Mani [59]) Republic of Korea (Lee [53]) and Thailand (World Bank [104])**	Used in Taiwan Province of China (Wade [98])	**Used in Singapore (Mani [59]) and Malaysia (Mani [59])**
Industry (sector) specific technology support institutions	**Used in Malaysia (Felker [28]) and Thailand (Arnold and others [10])**	Used in Taiwan Province of China (Wade [98])	**Used in Singapore (Mani [59]) and Malaysia (Mani [59])**
Joint university-private industry linkage programs	**Used in Malaysia (Mani [59]) and Thailand (Arnold and others [10])**	Used in Taiwan Province of China (Wade [98])	**Used in Singapore (Mani [59]) and Malaysia (Mani [59])**
National standards and metrology agencies	**Used in Malaysia (Mani [59]), Republic of Korea (Rock [70]) and Thailand (Arnold and others [10])**	Used in Taiwan Province of China (Wade [98])	Used in Singapore (Mani [59]) and Malaysia (Mani [59])
Productivity centres and small and medium enterprise technology support institutions	**Used in the Republic of Korea after democratization and less successfully in Indonesia (Berry and Levy [15]); Thailand (Rock [69])**	Used in Taiwan Province of China (Wade [98])	Used in Singapore (Mani [59]) and Malaysia (Mani [59])
Special purpose funds (subsidized credit, tax incentives or grants) for special purposes such as saving water (Singapore), saving labour (Taiwan Province of China), or purchasing locally-made capital equipment (Republic of Korea and Taiwan Province of China)	Used in Republic of Korea (Rhee and others [68]) and to a lesser degree in Malaysia (Mani [59]) and Thailand (Arnold and others [10])	Used extensively in Taiwan Province of China (Wade [98])	Used in Singapore (Mani [59])
Tax incentives for research and development expenditures of private sector firms. Often focused on promoted industries and applied to the research and development expenditures of firms	Used in the Republic of Korea (Kim [47, 48]; Rhee, and others [68]) and to a lesser degree in Malaysia (Mani [59]) and Thailand (Arnold and others [10])	Used extensively in Taiwan Province of China (Wade [98])	Used in Singapore (Mani [59])
Grants for the research and development expenditures. Often focused on promoted industries. Often applied to the research and development expenditures of foreign as well as local firms	Used in the Republic of Korea (Kim [47, 48]) and to a lesser degree in Malaysia (Mani [59]) and Thailand (Arnold and others [10])	Used extensively in Taiwan Province of China (Wade [98]).	Used in Singapore (Mani [59])
Industrial–environmental policies and institutions			
Command and control environmental regulatory agencies set ambient and emissions standards and they monitor and enforce compliance with these standards	Used in the Republic of Korea (Aden, Kyu-Hong and Rock [2])	Used in Taiwan Province of China (Rock [76])	Used in Singapore (Rock [76])

Policy/institution		*Pathway to technological upgrading*	
Pollution charge systems most often used for wastewater emissions.	Used in China (Wang and Wheeler [99])		
Emissions trading systems most often for pollution from a relatively small number of large stationary sources			
Informal regulation based on community pressure	Used in Japan (MEIP [62]) and Indonesia (Rock and Aden [1])	Used in Taiwan Province of China (Rock [76])	
Public disclosure	Used in Indonesia (Afsah and Vincent [4]) and China (Rock, 2002)		
Integration of command and control regulatory agency with industrial policy agencies			Used in Singapore (Rock [76])
Integration of command and control regulatory agency with industry association and a quasi public-private industry-specific research institute	Used in Malaysia (Vincent [97])		
Industrial policy agency assumes responsibility for pollution prevention and state-of-the-art work in industrial ecology		Used in Taiwan Province of China (Rock [76])	
Environmental supply chain			Being studied in Malaysia (Lim [55])

ANNEX III. UNIDO LOW-INCOME COUNTRIES SURVEY INSTRUMENT

The purpose of the survey is to assess the degree to which industry and environmental policies and institutions in this country promote and/or impede technological learning and environmental improvement by manufacturing firms. The survey instrument is divided into three parts. The first part deals with the vision and strategy for industrial development. The second part focuses on policies and institutions. The third part looks at institutional capability—of Government, of industrial support institutions and at the technological capability of firms.

In the survey, the following terms are used:

Industrial development: economic growth based on the improved economic performance of industry;

Industrial support institutions: organizations charged with enhancing the financial, managerial and technological capabilities of firms and industries. These could be Government organizations (such as Board of Investment) or private organizations (such as an industrial association);

Technological capability: the skills (technical, managerial, organizational) that allow firms to utilize equipment and information efficiently;

Technological learning: the capability of firms to enhance their use of technology to enhance competitiveness (also known as technology upgrading).

Instructions for completing the survey instrument

Respondents should complete the questionnaire as fully and as accurately as possible based on their experience and understanding. If a respondent does not know the answer to a particular question, please select the "Do not know" option.

A. Vision and Strategy for Industrial Development

1. In your assessment, is there a clear and agreed upon vision among key Government officials and private sector actors regarding industrial development in this country?

Not at all _____

Somewhat _____

Very much so _____

Do not know: _____

2. If there *is* a clear and agreed upon vision, please describe in 4 or 5 sentences the main elements of this vision:

3. Which of the following *strategies* are *currently used* in this country to promote industrial development?

	Not part of strategy	Part of strategy but *not* successful	Part of strategy and partially successful	Part of strategy and very successful	Do not know
The Government identifies priority industries based on an analysis of market opportunity					
The Government identifies priority industries based on development impact such as forward and backward linkages					
The Government targets technological upgrading as the key to successful industrial development					
The Government targets *exports of manufactures* as a way to promote technological upgrading					
Government trade, industrial and exchange rate policies promote the competitiveness of export manufacturers					
The Government targets for support a small number of leading firms within an industrial sector					
The Government seeks to attract foreign investment					
The Government promotes joint ventures between multinational firms and large local firms					
The Government actively promotes small local firms as suppliers to major multinational firms					
The Government promotes the development of a national technology system					

B. Institutions and Policies

In answering the questions in this section, an institution should be judged effective if it has both the policies and the minimum resources to meet its objectives and successfully delivers on its objectives.

1. Please comment on the following types of industry support institutions (ISIs) in this country.

	Industry Support Institution (ISI) does not exist	ISI not effective	ISI somewhat effective	ISI very effective	Do not know
Government agency charged with promoting private investment in industry					
Government agency charged with promoting exports by industry					
Government productivity centres					
Industry research and development centres					
Government agency dedicated to supporting small and medium-sized firms with management, technical information and technology extension services					
Government agency that supports small and medium-sized firms in location-specific industrial clusters (such as a textile dyeing cluster)					
Public or private agency providing low interest loans or financing to small and medium-sized firms					
Public or private industrial estates that provide reliable electricity, water and infrastructure					
Export processing zones or industrial estates providing tax incentives to firms locating there					

	Industry Support Institution (ISI) does not exist	ISI not effective	ISI somewhat effective	ISI very effective	Do not know
Joint public-private industry councils in priority industries working to promote competitiveness and industry growth					
Private industry associations working to strengthen industry					

2. Please comment on the following types of industry support policies in this country.

	Policy does not exist	Policy not effective	Policy somewhat effective	Policy very effective	Do not know
Tax incentives for firms investing in capital equipment and new technology					
Tax incentives for firms investing in research and development					
Government subsidized loans for new business development					
Import duty rebates for high priority industries					
Government training programmes for workers in high priority industries					
Industry upgrading programmes for export-oriented firms					
University–industry linkage programmes to help industries become internationally competitive					
Policies to support technological upgrading by small and medium-sized enterprises					

	Policy does not exist	Policy not effective	Policy somewhat effective	Policy very effective	Do not know
Programmes to support one or more location-specific industrial clusters					
Streamlined licensing process for new business start-up					
Technical assistance programme to help firms improve their environmenal performance (through an agency such as a national centre for cleaner production)					
Technical assistance programme to help firms qualify for ISO 9000 certification					
Technical assistance programme to help firms qualify for ISO 14000 certification					
Technical assistance programme to help firms meet export quality standards					

3. Please comment on whether Government policies promote private sector provision of:

	Not part of policy	Part of policy but not successful	Part of policy and partially successful	Part of policy and very successful	Do not know
ISO 9000 certification					
ISO 14000 certification					
Worker training					
Export-marketing assistance					
Technical extension services to SMEs					
R&D laboratories					

C. I Institutional Capability—General

1. To what extent do the following statements accurately describe the capability of industry support system* or particular industry support institutions in this country?

Key capability	Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly	Do not know
Our Government industry support system can rapidly assess technological threats and opportunities					
Our industry support system is responsive to the industrial needs of firms and industrial clusters of firms					
Our Government regularly evaluates the effectiveness of our industry support system by, among other things, surveying clients in the private sector					
There are important gaps in our industry support system					
The gaps in our industry support system are due to the lack of industrial firm-level demand for support services					
The gaps in our industry support system are due to deficiencies in the supply of support services					
Our industry support system lacks coordination and is subject to overlapping responsibilities and mandates					
Our national standards and metrology agency provides useful information and services to the private sector, such as ISO 9000 certification. In fact, demand for these services outstrips supply**					

Key capability	Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly	Do not know
Our small and medium enterprise technology support agency links local SMEs, through local industry upgrading programmes, to the global value chains of MNCs**					
Our national science and technology agency works closely with economic agencies to ensure that technology upgrading is part of industrial policies**					
We can point to numerous successful Government-supported technology achievements in the private sector					
Government industry support institutions routinely charge private sector firms for using the services provided by our technology support institutions					
The Government makes it easy to start a new business by simplifying licence procedures					
Our Government makes it easy to import and export goods by ensuring efficient and timely clearance at the port					

*The industry support system includes all of those Government or private sector agencies listed under B.1 and B.3.

**If such an agency is not present in this country, then please write in "not applicable" as the answer.

2. To what extent do the following statements accurately describe the capability of industry-environment support institutions in this country?

Key capability	Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly	Do not know
We have a tough, competent but fair environmental regulatory agency that monitors and enforces the country's emissions standards					
Our environmental regulators work closely with private sector firms and industry associations to find solutions to pollution that do not undermine the viability of private sector manufacturing firms					
Our industry support agencies cooperate effectively with environment regulatory agencies					
Industry support institutions play an important part in improving the environmental performance of our industry					
Our Government agencies are familiar with the environmental requirements of export markets such as ISO 14000					
Our Government's environmental technology institutes provide useful assistance to firms					
Our Government routinely evaluates the effectiveness of technological environmental support institutions for industry by surveying private sector clients					
Industrialists see Government environmental technology representatives as highly skilled and knowledgeable					

Key capability	Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly	Do not know
We can point to several successful Government-supported efforts to help industry meet the environmental requirements of foreign markets					
Government agencies are able to charge firms for participation in environmental improvement programmes					

C.II. Institutional Capability—of Government Industrial Support *Institutions*

(A list of these institutions appears in the table under B.1)

1. Approximately what per cent of the higher ranking officers (office directors and above) in industrial support institutions enter Government employment via a formal examination system?

   a. _____Less than 30 per cent

   b. _____Between 30 per cent and 60 per cent

   c. _____Between 60 per cent and 90 per cent

   d. _____More than 90 per cent

2. What is the roughly modal number of years spent by a typical higher level official in one of these institutions during his career?

   a. _____1-5 years

   b. _____2-10 years

   c. _____10-20 years

   d. _____entire career

3. What prospects for promotion can someone who enters one of these institutions through an examination early in his career reasonably expect? Assuming that there are at least six steps or levels between an entry-level position and the head of the agency, how would you characterize the possibilities for moving up in the agency? (N.B. more than one answer may apply.)

   a. _____In most cases will move up one or two levels

   b. _____In most cases will move up three or four levels

   c. _____Will move up several levels to the level just below top political appointees

   d. _____In at least a few cases, will move up to the very top

4. How common is it for high-level officials in these agencies to spend a substantial part of their careers in the private sector, interspersing private and public sector activity?

   a. _____Almost never

   b. _____Unusual

   c. _____Frequent but not modal

   d. _____Normal

5. How would you estimate the salaries and perquisites, not including bribes or other extra legal income, of higher officials in these industry support institutions relative to those of private sector managers with comparable training and responsibilities?

   a. _____Less than 50 per cent

   b. _____Between 50 per cent and 80 per cent

   c. _____Between 80 per cent and 90 per cent

   d. _____Comparable

   e. _____Higher

6. How important are civil service exams for entry into these agencies?

   a. _____No civil service exams, or exams are of trivial importance

   b. _____Ambiguous

   c. _____Civil service exams are an important component of entry into the bureaucracy

7. Among graduates of the country's most elite universities, is a public sector career in one of these institutions considered?

   a. _____A second best option

   b. _____It depends on circumstances

   c. _____The best possible option

C.III. Technological Capability—within Firms and Industries

1. In your assessment, which industrial sectors in this country should be prioritized for further development? (please list two)

   Industry 1_____

   Industry 2_____

2. Within these industries, do the most advanced local firms have the capability to successfully engage in building their technological capabilities by successfully installing, setting up and operating imported capital equipment, adapting it to local conditions, making minor and then major process modifications to it, and using it to modify products?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

3. Within these industries, do the most advanced local firms have the capability to engage in reverse engineering to figure out how a product is made?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

4. Within these industries, can the most advanced local firms successfully engage in research and development related to new production processes and products?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

5. Within these industries, can the most advanced local firms typically meet the quality expectations of foreign customers?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know:_____

6. Within these industries, can the most advanced local firms typically meet the expectations of foreign customers for on-time delivery?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

7. Within these industries, can the most advanced local firms typically meet the price expectations of foreign customers?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

8. Within these industries, can the most advanced local firms typically meet the environmental expectations of foreign customers?

   Not at all_____

   Somewhat_____

   A great deal_____

   Do not know_____

Annex IV. Interviews conducted during survey validation in Ghana

1. UNIDO Director and staff (A. Akpa, M. Groenbech, S. Boateng, F. Owusu-Bonsu, D. Baffour-Awuah, J. Ainoo-Ansah)
2. Ministry of Trade and Industry, the Honourable Minister I. Ashitey and staff
3. Coordinator, President's Special Initiative Garments and Textiles (Nana Tweneboa-Boateng)
4. Ghana Standards Board (N. Ahinkorah and staff)
5. Environmental Protection Agency (J. Allotey, D. Amlalo and staff)
6. ISSER, Peter Quartey
7. Ghana Free Zones Board (K. Agyepong and staff)
8. Belin Textiles (R. Dadson)
9. USAID (A. Newton)
10. AMEX International (D. Esch)
11. World Bank (P. Mensah)
12. Ministry for Private Sector Development, the Honorable Minister Kwamena Bartels and staff
13. Ghana Investment Promotion Center (Ruth Nyakotey)
14. Association of Ghana Industries (A. Lawson)
15. GRATIS (K. Dankyi Darfoor and staff)

ANNEX V. LIST OF VARIABLES

Variable	*Definition*	*Source*
Competitive Industrial Performance Index (CIP)	Competitive industrial performance index	UNIDO, 1992
Political stability	Principle components measure of political stability	Kaufmann and others [44]
Inflation	Annual change in GDP deflator	World Bank [107]
Dollar index	Exchange rate measure of a country's trade orientation	Dollar [22]
Human skills index	Harbison-Meyers Skills index	UNIDO [90]
Telecommunication infrastructure	Number of the main phone lines per 1,000 population	World Bank [107]
Weberian scale	Bureaucratic capability of Government	Evans and Rauch [27]
TRDY	(Exports + imports)/GDP	World Bank [107]
FDIY	Foreign direct investment inflows/GDP	World Bank [107]
GPER	Gross primary school enrolment rate	World Bank [107]
GSER	Gross secondary enrolment rate	World Bank [107]
NAT-Tech	Percentage of respondents in low-income survey (LIS) who indicated country is pursuing a national technology approach to upgrading (Response to question A-3-j in LIS)	Low-income survey
INST-Tech	Composite index of institutional effectiveness (sum of responses C-I-1 on LIS)	Low-income survey
JV-Policy	Per cent of respondents in LIS who indicated country is pursuing upgrading by promoting JV between local and foreign firms (Response to question A-3-h in LIS)	Low-income survey
Lead-firms	Per cent of respondents in LIS who indicated country is pursuing upgrading by promoting large lead firms (Response to question A-3-f in LIS)	Low-income survey
SME-MNCs	Per cent of respondents in LIS who indicated country is pursuing upgrading by promoting SME-MNC linkages (Response to question A-3-i in LIS)	Low-income survey
SME-effect	Composite index of effectiveness of SME support institutions (sum of responses to B-1-f, B-1-j, B-2-h, B-2, l, B-3-e, and C-I-1-b, i in LIS)	Low-income survey
Firm-capacity	Composite index of local firm-level capabilities (sum of responses to C-III-2-7)	Low-income survey
Industrial estates	Effectiveness of industrial estates (Response to question B-1-i in LIS-)	Low-income survey

BIBLIOGRAPHY

1. Aden, J. and Rock, M. T. (1999), "Initiating Environmental Behavior in Manufacturing Plants in Indonesia", *The Journal of Environment and Development*, 6 (4), pp. 357-375.
2. Aden, J., Ahn, K. H. and Rock, M. T. (1999), "What is Driving the Pollution Abatement Expenditure Behavior of Manufacturing Plants in Korea?" *World Development*, 27 (7) July, pp. 1203-1214.
3. Afsah, S. and Vincent, J. (1997), "Putting Pressure on Polluters: Indonesia's PROPER Program", Cambridge, MA: Harvard Institute for International Development.
4. Afsah, S. and Vincent, J. (2000), "Putting Pressure on Polluters: Indonesia's PROPER Programme", Angel, D. and Rock, M. T. (eds), *Asia's Clean Revolution: Industry Growth, and the Environment*, Sheffield, U.K.: Greenleaf Publishing, pp. 175-172.
5. Amsden, A. (1989), *Asia's Next Giant*, New York: Oxford University Press.
6. Amsden, A. (2001), *The Rise of the Rest*, New York: Oxford University Press.
7. Angel, D. P. and Rock, M. T. (eds) (2000), *Asia's Clean Revolution: Industry, Growth and the Environment*, 2000, Sheffield, U.K.: Greenleaf Publishing.
8. Angel, D. P. and Rock, M. T. (2001), "Policy Integration: Environment and Development in Asia, with David Angel", Paper prepared for the Asian Environmental Outlook Series of the Asian Development Bank, Manila: Asian Development Bank.
9. Angel, D. P. and Rock, M. T. (2003), "Engaging Economic Development Agencies in Environmental Protection: The Case for Embedded Autonomy", *Local Environment*, 8 (1): 45-59.
10. Arnold, E., Bell, M., Bessant, J. and Brimble, P. (2000), "Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand", December, mimeo.
11. Aswicahyono, H., Basri, M. C. and Hill, H. (2000), "How Not to Industrialize? Indonesia's Automotive Industry", *Bulletin of Indonesian Economic Studies*, 36 (1), pp. 209-41.
12. Battat, J., Frank, I. and Shen, X. (1996), "Suppliers to MNCs: Linkage Programs to Strengthen Local Companies in Developing Countries", Foreign Investment Advisory Service, Occasional Paper No. 6, Washington, D.C.: World Bank.
13. Bell, M. and Pavitt, K. (1992), "Accumulating technological capability in developing countries, in *Proceedings of the World Bank Annual Conference on Development Economics*, Washington, D.C.: World Bank, pp. 257-281.
14. Bennett, D. (2002), *Innovative Technology Transfer Framework Linked to Trade for UNIDO Action*, Vienna: United Nations Industrial Development Organization.
15. Berry, A. and Levy, B. (1994), "Indonesia's Small and Medium-Size Exporters and Their Support Systems", Policy Research Working Paper 1402, Washington, D.C.: World Bank.
16. Bressers, H. (1988), "The Impact of Effluent Charges: A Dutch Success Story", *Policy Studies Review*, 7 (3), pp. 500-518.

17. Burtaw, D. (2000), "Innovation Under the Tradable Sulfur Dioxides Emissions Permits Program in the U.S. Electricity Sector", Discussion Paper 00-38, Washington, D.C.: Resources for the Future.

18. Campos, J. E. and Root, H. L. (1996), *The Key to the Asian Miracle*, Washington, D.C.: Brookings Institution.

19. Chang, Ha-Joon (2002), *Kicking Away the Ladder: Development Strategy in Historical Perspective*, London: Anthem.

20. Churchill, P. R. (1995), "Local Government Initiative in Southeast Asia: Toward a New Growth Model", *Journal of Asian Business*, 11 (1), pp. 40-76.

21. Dahlman, C., Ross Larson, B. and Westphal, L. (1987), "Managing Technological Development: Lessons from the Newly Industrializing Economies", *World Development*, 15 (6), pp. 759-775.

22. Dollar, D. (1992), "Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs: 1976-85", *Economic Development and Culture Change*, vol. 40 (April), pp. 523-44.

23. Doner, R. F. (1991), *Driving a Bargain: Automobile Industrialization and Japanese Firms in Southeast Asia*, Berkeley: University of California Press.

24. Egan, M. L. and Mody, A. (1992), "Buyer-Seller Links in Export Development", *World Development*, 20 (3), pp. 321-334.

25. Erh-Cheng, Hwa (1988), "The Contribution of Agriculture to Economic Growth: Some Empirical Evidence", *World Development*, 16 (11), pp. 1329-1339.

26. Evans, P. (1995), *Embedded Autonomy: States and Industrial Transformation*, Princeton: Princeton University Press.

27. Evans, P. and Rauch, J. E. (1999), "Bureaucracy and Growth: A Cross National Analysis of the Effects of 'Weberain' State Structures on Economic Growth", *American Sociological Review*, October 64, pp. 748-765.

28. Felker, G. (1999), "Malaysia's Innovation System: Actors, Interests and Government", Jomo, K. S. and Felker, G. (eds), *Technology, Competitiveness and the State*, New York: Routledge, pp. 98-147.

29. Felker, G. and Jomo, K. S. (1999), "Introduction" in Jomo, K. S. and Felker, G. (eds), *Technology, Competitiveness and the State*, New York: Routledge, pp. 1-37.

30. Felker, G. (2001), "The Politics of Industrial Investment Policy Reform in Malaysia and Thailand", in Jomo, K. S. (ed.) *Southeast Asia's Industrialization: Industrial Policy, Capabilities and Sustainability*, London: Palgrave, pp. 129-182.

31. Grabowski, R. (1994), "The Successful Developmental State: Where Did It Come From?", *World Development*, 23 (3), pp. 413-422.

32. Haggard, S. (1990), *Pathways from the Periphery*, Ithaca: Cornell University Press.

33. Hobday, M. (1995), *Innovation in East Asia: The Challenge to Japan*, Edward Elgar Publishers.

34. Hobday, M. (2001), "The Electronics Industries of the Asia-Pacific: Exploiting IPNs for Economic Benefit", *Asia-Pacific Economic Literature*, 15, pp. 13-29.

35. Hobday, M. (2002), *Technology Needs Assessment for Developing Countries*, Vienna: United Nations Industrial Development Organization.

36. Huff, W. G. (1995), "The development state, Government, and Singapore's economic development since 1960", *World Development*, 23 (8), pp. 1421-1438.

37. Huff, W. G. (1999), "Singapore's Economic Development: Four Lessons and Some Doubts", Oxford Development Studies, 21 (1), pp. 33-55.

38. Johnston, B. F. and Kilby, P. (1975), *Agriculture and Structural Transformation*, New York: Oxford University Press.

39. Johnston, B. F. and Mellor, J. (1961), "The Role of Agriculture in Economic Development", *The American Economic Review*, September, pp. 566-591.

40. Jomo, K. S. and Todd, P. (1994), *Trade Unions and the State in Peninsular Malaysia*, Kuala Lumpur: Oxford University Press.

41. Jones, L. and Sakong, I. (1980), *Government, Business and Entrepreneurship: The Korean Case*, Cambridge, MA: Harvard University Press.

42. Justman, M. and Teubal, M. (1995), "Technology Infrastructure Policy (TIP): Creating Capabilities and Building Markets", *Research Policy*, 24, pp. 259-281.

43. Kang, D. (2002), *Crony Capitalism: Corruption and Development in South Korea and the Philippines*, Cambridge, UK: Cambridge University Press.

44. Kaufmann, D., Kraay, A. and Zodio-Lobaton, P. (2002), *Governance Matters II—Updated Indicators for 2000/01*, Policy Research Working Paper No. 2772, Washington, D.C.: World Bank.

45. Kay, C. (2002), "Why East Asia Overtook Latin America: Agrarian Reform, Industrialization and Development", *Third World Quarterly*, 23 (6), pp. 1073-1102.

46. Keesing, D. (1988), "The Four Exceptions", UNDP-World Bank Trade Expansion Programme, Occasional Paper No. 2, New York: United Nations.

47. Kim, L. (1993), "National System of Innovation: Dynamics of Capability Building in Korea", Nelson, R. R. (ed.), *National Innovation Systems: a Comparative Analysis*, New York: Oxford University Press, pp. 357-383.

48. Kim, L. (1997), *From Imitation to Innovation*, Boston: Harvard Business School Press.

49. Kim, L. and Nelson, R. R. (2000), *Technology, Innovation, and Learning*, Cambridge: Cambridge University Press.

50. King, A. A. and Lenox, M. J. (2000), "Industry Self-Regulation without Sanctions: The Chemical Industry's Responsible Care Program", *Academy of Management Journal*, 43 (4), pp. 696-716.

51. Konar, S. and Cohen, M. A. (1997), "Information as Regulation: The Effect of Community Right to Know Laws on Toxics Emissions", *Journal of Environmental Economics and Management*, vol. 32, pp. 109-124.

52. Lall, S. (1992), "Technological Capabilities and Industrialization", *World Development*, 22 (4), pp. 645-654.

53. Lee, D. H. and others (1991), "Performance and Adaptive Roles of the Government Supported Research Institute in South Korea", *World Development*, 19 (10).

54. Lee, K. Y. (2000), *From Third World to First: The Singapore Story: 1965-2000*, New York: Harper Collins.

55. Lim, P. L. (2004), Policy Integration Environmental Supply Chain: A Malaysian Case Study, Kuala Lumpur: PE Research Sdn. Bhd.

56. Lovie, M. and Weiss, C. (1998), *Environmental Management and Institutions in OECD Countries*, Washington, D.C.: World Bank.

57. MacIntyre, A. (1994), "Power, Prosperity, and Patrimonialism: Business and Government in Indonesia", MacIntyre, A. (ed.), *Business and Government in Industrializing Asia*, Ithaca: Cornell University Press, pp. 244-267.

58. MacIntyre, A. (2000), "Funny Money: Fiscal Policy, Rent-Seeking and Economic Performance in Indonesia", Khan, M. H. and Jomo, K. S. (eds), *Rents, Rent-Seeking and Economic Development: Theory and Evidence from Asia*, Cambridge: Cambridge University Press, pp. 248-273.

59. Mani, S. (2000), "Policy Instruments for Stimulating R&D in the Enterprise Sector: The Contrasting Experiences of Two MNC Dominated Economies from Southeast Asia", UNU INTECH Discussion Paper 2000-9, Maastricht, The Netherlands: UNU INTECH.

60. Mardon, R. (1990), "The State and the Effective Control of Foreign Capital", *World Politics*, October, pp. 111-138.

61. McKendrick, D. (1992), "Obstacles to 'Catch Up': The Case of the Indonesian Aircraft Industry", *Bulletin of Indonesian Economic Studies*, 28 (1), pp. 39-66.

62. MEIP (1999), *Japan's Experience in Urban Environmental Management*, Washington, D.C.: World Bank.

63. Mellor, J. W. and Johnston, B. F. (1984), "The World Food Equation: Interrelations Among Development, Employment and Food Consumption", *Journal of Economic Literature*, 22 June, pp. 531-574.

64. Murphy, K., Schleifer, A. and Vishny, R. (1989), "Income Distribution, Market Size and Industrialization", *Quarterly Journal of Economics*, 104 (3), pp. 537-564.

65. Nelson, R. R. (1993), *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press.

66. Rasiah, R. (1995), *Foreign Capital and Industrialization in Malaysia*, Basingstoke: MacMillan.

67. Rasiah, R. (2001), "Politics, Institutions, and Flexibility: Microelectronics Transnationals and Machine Tool Linkages in Malaysia", Deyo, F. C., Doner, R. F. and Hershberg, E. (eds), *Economic Governance and the Challenge of Flexibility in East Asia*, New York: Rowman and Littlefield, pp. 165-190.

68. Rhee, Y. H., Ross-Larson, B. and Westphal, L. (1984), *Korea's Competitive Edge: Managing Entry into World Markets*, Baltimore: Johns Hopkins University Press.

69. Rock, M. T. (1984), "Rural (Provincial) Industry and Thai Development: A Policy Framework", Bangkok: USAID/Thailand.

70. Rock, M. T. (1992), "Public Sector Marketing and Production Assistance to South Korea's Manufacturing Exporters: Did It Make a Difference?", *Development Policy Review*, 10 December, pp. 339-357.

71. Rock, M. T. (1995), "Thai Industrial Policy: How Irrelevant was It to Export Success?", *Journal of International Development*, 7 (5), pp. 745-757.

72. Rock, M. T. (1996), "Toward More Sustainable Development: The Environment and Industrial Policy in Taiwan", *Development Policy Review*, 14 (3), pp. 255-272.

73. Rock, M. T. (1999), "Reassessing the Effectiveness of Industrial Policy in Indonesia: Can the Neo-liberals be Wrong?", *World Development*, 27 (4) April, pp. 691-704.

74. Rock, M. T. (2000), "Thailand's Old Bureaucratic Polity and Its New Semi-Democracy", Khan, M. H. and Jomo, K. S. (eds), *Rents, Rent-Seeking and Economic Development: Theory and Evidence from Asia*, Cambridge: Cambridge University Press, pp. 182-206.

75. Rock, M. T. (2001), "Pathways to Industrial Improvement in the East Asian Newly Industrializing Economies", Paper prepared for Ninth International Greening of Industry Conference, 21-25 January 2001, Bangkok, Thailand, *Business Strategy * the Environment*, 11 (2), March-April 2002, pp. 99-102.

76. Rock, M. T. (2002a), *Pollution Control in East Asia: Lessons from the Newly Industrializing Economies*, Washington, D.C.: Resources for the Future and Singapore: Institute for Southeast Asian Studies.

77. Rock, M. T. (2002b), "Integrating Environmental and Economic Policy-Making in China and Taiwan", Paper prepared for MacArthur Foundation Workshop on Globalization, Governance and the Environment, Institute for International Studies, University of California, Berkeley, CA, April 14-15, 2000, *American Behavioral Scientist*, 45 (9) May 2002, pp. 1435-1455.

78. Rock, M. T. (2002c), "Exploring the Impact of Selective Interventions in Agriculture on the Growth of Manufactures in Indonesia, Malaysia, and Thailand", *Journal of International Development*, 14, 2002, pp. 485-510.

79. Rock, M. T. (2002d), "Pollution and Development: Lessons from the Latin American and East Asian Newly Industrializing Economies", Issue Brief No. 02-13, The RFF Issue Brief Series on Sustainable Development, Washington, D.C: Resources for the Future, August, available at http://www.rff.org/sustainabledevelopment/Issuebriefs/joburg6.pdf.

80. Rock, M. T. and Kim, S. (2003), "Globalization, Policy Integration and Capturing Win-Win Opportunities for Reducing Greenhouse Gas Emissions in Asia", Paper under review at *Ecological Economics*, Paper prepared for the U.S. Asia Environmental Partnership.

81. Rock, M. T. (2003), "The Politics of Development Policy-Making in New Order Indonesia", Paper presented at seminar on Economic Policy Reform in Asia at the Department of Political Science and the William Davidson Institute, University of Michigan, Ann Arbor, 12 September 2002.

82. Rodrik, D. (2004), "Industrial policy for the 21st Century", Working Paper RWP04-047. JFK School of Government, Harvard University.

83. Searle, P. (1999), *The Riddle of Malay Capitalism*, St. Leonards, NSW, Australia: Allen and Unwin.

84. Stavins, R. N. (2000), "Experiments with Market-Based Environmental Policy Instruments", Discussion Paper 00-09, Washington, D.C.: Resources for the Future.

85. Times Academic Press (1993), *Challenge and Response: Thirty Years of the Economic Development Board*, Singapore: Times Academic Press.

86. Timmer, C. P. (1993), "Rural Bias in the East and Southeast Asian Rice Economy", *Journal of Development Studies*, vol. 30, No. 2, pp. 149-176.

87. Teubal, M. (1996), "R&D and Technology Policy in NICs as a Learning Process", *World Development*, 24 (3), pp. 449-460.

88. Teubal, M. (2002), "What is the Systems Perspective to Innovation and Technology Policy (TIP) and How Can We Apply It to Developing and Newly Industrialized Economies?" Jerusalem, Israel: Hebrew University, mimeo.

89. Tybout, J. R. (1996), "Heterogeneity and Productivity Growth: Assessing the Evidence" in Roberts, M. J. and Tybout, J. R. (eds), *Industrial Evolution in Developing Countries*, New York: Oxford University Press, pp. 43-72.

90. UNIDO (2002a), *Industrial Development Report, 2002/2003: Competing through Innovation and Learning*, Vienna: United Nations Industrial Development Organization.

91. UNIDO (2003a), *Annual Report 2002*, Vienna: United Nations Industrial Development Organization.

92. UNIDO (2003b), *Methodological Guide: Restructuring, Upgrading and Industrial Competitiveness*, Vienna: United Nations Industrial Development Organization.

93. UNIDO (2003c), *Sector Wide Assessment Study to Develop a 'Blue Print' for the Improvement of the Textile and Clothing Industry in Nigeria*, Vienna: United Nations Industrial Development Organization.

94. UNIDO (2004), *Operationalizing UNIDO's Corporate Strategy*, Vienna: United Nations Industrial Development Organization.

95. UNIDO (2004), *Industrial Development Report, 2004: Industrialization, Environment, and the MDG in sub-Saharan Africa*, Vienna: United Nations Industrial Development Organization.

96. UNIDO (2005), *Industrial Development Report, 2005*, Vienna: United Nations Industrial Development Organization.

97. Vincent, et al. (2000), "Water Pollution Abatement in Malaysia", Angel, D. P. and Rock, M. T. (eds), *Asia's Clean Revolution*, Sheffield, U.K.: Greenleaf Publishing, pp. 173-193.

98. Wade, R. H. (1990), *Governing the Market*, Princeton: Princeton University Press.

99. Wang, H. and Wheeler, D. (1996), "Pricing Industrial Pollution in China: An Econometric Analysis of the Levy System", World Bank Policy Research Department Working Paper No. 1644, Washington, D.C.: World Bank.

100. Westphal, L. (1978), "The Republic of Korea's Experience with Export-Led Industrial Development", *World Development*, 6 (3).

101. Westphal, L. (1981), "Korea's Industrial Competence: Where It Came From", World Bank Staff Working Paper No. 469, Washington, D.C.: World Bank.

102. Westphal, L. (2001), "Technology Strategies for Economic Development in a Fast-Changing Global Economy", Swarthmore College, mimeo.

103. Williamson, J. (1990), *The Progress of Policy Reform in Latin America*, Washington, D.C., Institute for International Economics.

104. World Bank (1990), *Technology Strategy and Policy for Industrial Competitiveness: A Case Study of Thailand*, Industries and Energy Department Working Paper, Industries Series Paper No. 24, Washington, D.C.: World Bank.

105. World Bank (1993), *The East Asian Miracle*, New York: Oxford University Press.

106. World Bank (2000b), *Greening Industry*, Washington, D.C.: World Bank.

107. World Bank (2004), *World Development Indicators 2004*, Washington, D.C.: World Bank, on CD-ROM.

GLOSSARY

Ambient standards	"Ambient standards" refer to air or water quality standards.
Autonomy	"Autonomy" refers to the independence government has from the private sector. Autonomy is important because it enables the Government to protect itself from capture, rent-seeking and corruption while holding the private sector accountable for its performance.
East Asian newly industrializing countries (or regions)	The East Asian newly industrializing countries (or regions) referred to in the report include Indonesia, Malaysia, the Republic of Korea, Singapore, Taiwan Province of China and Thailand.
Embeddedness	"Embeddedness" refers to the institutionalized links of communication with the private sector and is essential to Government understanding of the real constraints firms face as they attempt to upgrade their technological capabilities.
Emissions standards	"Emissions standards" refers to pollutant loads in water or air emitted by firms.
Enabling conditions	"Enabling conditions" refer to political stability, macroeconomic stability (a competitive exchange rate, low inflation, and minimizing fiscal and current account deficits), physical infrastructure (roads, ports, railways, airports, communications and power), openness to trade and investment, and the human capital base.
Institutions	Two definitions are used in the report: on the one hand, the term "institutions" is used to refer to a set of formal and informal rules of conduct that facilitate coordination or govern relationships between individ ual actors. Under this definition, embedded autonomy can be considered as an institution. On the other hand, it is common to refer to particular private or public sector agencies as institutions. Under this definition of institutions, a Government standards and metrology agency can be referred to as an institution.

Market-building technology policies	"Market-building technology policies" refers to policies which aim at stimulating the supply of technological services while promoting the articulation of their demand.
National technology and innovation system	A "national technology and innovation system", as used in the report, refers to the public sector and quasi-public sector institutions that support technology and innovation—institutions which, importantly, are linked through embedded autonomy, to the real needs of firms.
Policy integration	"Policy integration" refers to a policy process that seeks to manage levels of industrial pollution and environmental intensities (such as the energy intensity of value-added) by linking environmental regulatory agencies to the core agencies responsible for industrial development, i.e. those responsible for policy design and implementation, including technological support institutions.
Policy process	"Policy process", as discussed in the report, refers to the institutional setting for policy formulation and implementation. Embedded autonomy is a key element of this process.
Technological capability	"Technological capability" comprises the ability to operate productive facilities competitively, raise quality, introduce new products, upgrade productive and environmental practices, diversify into higher value-added activities and, more broadly, develop the skills, knowledge and institutions required for economic development.
Technological capability-building	"Technological capability-building" is the activity of allocating resources to create and develop such capability. This definition is intended, mutatis mutandis, as much for firms as for more aggregate levels.
Technological development	"Technological development" is the improvement in productive practices that results from engaging technological capability in innovative activity which translates into enhanced productivity and social welfare (technological development and technological upgrading are used interchangeably in the report).

Pathways to technological development	"Pathways to technological development" refers to the concrete and specific pathways used by Governments in the East Asian newly industrializing countries to link Governments and firms in a policy process designed to strengthen the technological capabilities of firms. These pathways—building of a national technology and innovation system linked to small and medium firms, promoting the development of a small number of large firms linked to the international
Technology strategy	"Technology strategy" refers to the outlines of a Government's approach to fostering technological development.

Printed in Austria
V.05-90438—September 2006—600

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: http://www.unido.org