WORKING PAPERS

EAST-WEST CENTER WORKING PAPERS

EAST-WEST CENTER

The U.S. Congress established the East-West Center in 1960 to foster mutual understanding and cooperation among the governments and peoples of the Asia Pacific region including the United States. Funding for the Center comes from the U.S. government with additional support provided by private agencies, individuals, corporations, and Asian and Pacific governments.

East-West Center Working Papers are circulated for comment and to inform interested colleagues about work in progress at the Center.

For more information about the Center or to order publications, contact:

Publication Sales Office
East-West Center
1601 East-West Road
Honolulu, Hawaii 96848-1601

Telephone: 808-944-7145
Facsimile: 808-944-7376
Email: ewcbooks@EastWestCenter.org
Website: www.EastWestCenter.org

EAST-WEST CENTER

Economics Series

No. 36, October 2001

From Digital Divides to Industrial Upgrading: Information and Communication Technology and Asian Economic Development

Dieter Ernst

Dieter Ernst is a Senior Fellow and Theme Leader for economic studies at the East-West Center. He is also a research professor at the Center for Technology and Innovation (TIK) at the University of Oslo. His previous affiliations include the OECD, Paris, as senior advisor; the Berkeley Roundtable on the International Economy; the University of California at Berkeley as senior fellow; and the Copenhagen Business School as professor of international management. He is coeditor of *International Production Networks in Asia: Rivalry or Riches?* (2000) and *Technological Capabilities and Export Success in Asia* (1998). He serves on the Committee on Information Technology and International Cooperation (ITIC) of the U.S. Social Science Research Council; as scientific advisor to the United Nations University's Institute for New Technologies (UNU-INTECH), Maastricht, Netherlands; and the Japan Foundation's Globalization Project.

Background study prepared for the Asia Development Bank report, *The Asian Development Experience: Overcoming Crises and Adjusting to Change,* by Seiji Naya in association with S. Mark and R. McCleery, Honolulu, Hawaii.

East-West Center Working Papers: Economics Series reports on research in progress. This paper has been peer-reviewed. The views expressed are those of the author and not necessarily those of the Center. Please direct orders and requests to the East-West Center's Publication Sales Office. The price for Working Papers is $3.00 each plus postage. For surface mail, add $3.00 for the first title plus $0.75 for each additional title or copy sent in the same shipment. For airmail within the U.S. and its territories, add $4.00 for the first title plus $0.75 for each additional title or copy in the same shipment. For airmail elsewhere, add $7.00 for the first title plus $4.00 for each additional title or copy in the same shipment.

FROM DIGITAL DIVIDES TO INDUSTRIAL UPGRADING:

INFORMATION AND COMMUNICATION TECHNOLOGY AND ASIAN ECONOMIC DEVELOPMENT

by

DIETER ERNST

INTRODUCTION

The paper explores how developing Asia can utilize the potential of information and communications technology (ICT) to foster economic growth and welfare. We ask what needs to be done to move from a plethora of "digital divides" that cut off a majority of Asian populations from potential benefits, to a long-term development strategy of upgrading the region`s economic structures and institutions.

Developing Asia`s success on the production side is common knowledge: the electronics industry is the most prominent example of rapid catching-up and the latest example of export-led growth. Especially for the standard bearers of the "East Asian Miracle" (South Korea, Taiwan, Singapore, Malaysia, Thailand, Philippines), as well as China/Hong Kong, electronic equipment and components dominate industrial manufacturing and exports. A central proposition of this paper is that a focus on export-led production of electronics goods can no longer guarantee sustained growth and welfare improvements. It only captures a small fraction of the potential benefits from ICT. Export-led production also faces serious external limitations from volatile global finance, currency and export markets. Three fundamental weaknesses characterize the region`s electronics industries: a sticky specialization on exportable "commodities", a narrow domestic knowledge base, and limited forward and backward linkages.

It is time to match a focus on production with the development of effective demand for ICT investment *within* the region. This is necessary to reduce multiple and persistent *digital divides*. These divides separate developing Asia from industrialized countries, and the poor countries in the region from the more developed ones. They also exclude rural areas, and lower income groups from access to information. These divides indicate a huge, underutilized potential to establish ICT as an engine of economic growth and welfare.

Enhancing the diffusion of ICT however does not imply a neglect of ICT production. Both hang together and need each other. A defining characteristic of developing Asia is a fundamental mismatch between the production and the limited and unequal diffusion of ICT. To reduce this mismatch, it is necessary to increase the use of ICT as a tool to boost productivity, speed and flexibility of the region´s production systems and economic institutions. Equally important is the potential of ICT to enhance learning efficiency and innovation, and to improve the transparency of governance structures. Threats to the region´s competitiveness provide a powerful rationale for such a shift in strategy. *Industrial upgrading* must complement the current emphasis on financial and corporate restructuring. It constitutes the medium-term challenge that Developing Asia must master in order to unleash new ICT-enabled sources of growth. Defined as a shift to higher value-added products and production stages through increasing specialization and forward and backward linkages, industrial upgrading necessitates a strong domestic knowledge base.

In section 1, we introduce a conceptual framework for analyzing the impact of ICT on economic development. Two inter-related concepts serve as a focusing device for the subsequent analysis and discussion: a focus on organizational innovation; and the concept of "industrial upgrading" (IU). In sections 2 and 3, we review achievements and limitations of export-led electronics production, and the resultant mismatch between the production and use of ICT. In section 4, we document the region´s multiple "digital divides", emphasizing the importance of intra-regional divides, and illustrate their constraining impact on IU. In the final section 5, we present suggestions for policy design and implementation and spell out priorities for future research. In a region as diverse as developing Asia, no "one-size-fits-all" approach will work. We first highlight the diversity of economic agents involved in the region´s production and use of ICT. Based on a taxonomy of "ICT for Development" strategies, we then assess alternative sequencing patterns of moving from partial to integrated strategies. We highlight unfulfilled promises of the "New Economy" model and the need to move from poverty alleviation to ICT - enabled industrial upgrading. We conclude with recommendations for funding priorities for international development agencies.

1. CONCEPTUAL FRAMEWORK

1.1. A Focus on Organizational Innovation

a) Impacts of ICT

Following Brynjolfsson and Hitt (2000), we argue that the impact of ICT on economic performance is mediated by a combination of intangible inputs and outputs that act as powerful catalysts for organizational innovation. “Intangible inputs” include, for instance, the development of new software and databases; the adjustment of existing business processes; the recruitment of specialized human resources and their continuous upgrading; and, induced by all of this, the transformation of existing economic structures, institutions and business strategies. Of equal importance are “intangible outputs” that would not exist without ICT, like new modes of communication and knowledge exchange, speed of delivery, flexibility of response to abrupt changes in demand and technologies, reduced energy and resource intensity of production, cost effective quality improvements, modular and manufacturing-friendly product design, and the spread of knowledge-intensive support services.

After a while, these induced organizational changes may lead to productivity growth, by reducing the cost of coordination, communications and information processing. Most importantly, these organizational changes enable economic agents “to increase output quality in the form of new products or in improvements in intangible aspects of existing products like convenience, timeliness, quality and variety.” (Brynjolfson and Hitt, 2000, p.4). In short, we are talking about a complex process that involves a set of inter-related (“systemic”) changes (Milgrom and Roberts, 1990): by combining ICT with changes in work practices, strategies, and products and services, a firm transforms its organization as well as its relations with suppliers, partners and customers.

Once we adapt such a framework, it becomes clear that benefits from an ICT-enabled transformation of business or public organizations can be enormous. A long-term process of “digital convergence” has enabled the same infrastructure to accommodate manipulation and transmission of voice, video, and data (Chandler and Cortada, 2000). The use of ICT as a management tool has experienced two important transformations (Nolan, 2000). From a machine to automate transaction processing, the focus has shifted to the extraction of value from information resources, and then further to the establishment of Internet-enabled flexible information infrastructures that can support the extraction and exchange of knowledge across firm boundaries and national borders. Compared to earlier generations of ICT, the Internet appears to provide much greater opportunities to share knowledge with a much greater number of people faster, more accurately, and in greater detail, even if they are not permanently co-located (Ernst, 2001a, 2001d). While such forms of interactive learning across borders are still exceptional, they illustrate nevertheless a huge potential for reorganizing the global chain of knowledge creation. Once these developments gather momentum, they will have dramatic implications for developing Asia´s long-term development. But when this happens, it may be too late to start research that could guide policy responses.

b) Drivers

These transformations in the use of ICT are driven by a combination of powerful technological and economic forces that have created an unequal distribution of benefits (Ernst, 2001b, 2001c). On the technology side, the move towards "open standards" in ICT architecture (UNIX, Linux, and HTML) and protocols (TCP/IP) enabled large global corporations (the "network flagships") to integrate their existing intranets and extranets[1] on the Internet. By reducing cost and by multiplying connectivity, the Internet dramatically extends the flagships` reach across firm boundaries and national borders[2]. By transmitting information in digital format instantly, and at much lower cost than earlier technology generations (like electronic data interchange, EDI), the Internet substantially broadens the scope for collaboration across organizational and national boundaries. A new generation of networking software provides flexible infrastructures that, computer scientists claim, "support not only information exchange, but also knowledge sharing, creation and utilization." (Jørgensen and Krogstie, 2000). The key is the open-ended structure of the Internet, which allows extra networks to be added at any point, creating almost unlimited opportunities for outsourcing and the diffusion of knowledge.

On the economic side, far-reaching changes in work organization have fundamentally increased the requirements for information management and for the exchange of knowledge (e.g., Ciborra et al, 2000). The transition from Fordist "mass production" to "mass customization" requires a capacity to constantly adapt products or services to changing customer requirements, "sensing and responding" to individual customer needs in real time (Bradley and Nolan, 1998)[3]. This necessitates dynamic, interactive information systems, and a capacity to rapidly adjust organizations to disruptive changes in markets and technology. Second, real-time resource allocation, performance monitoring and accounting became

---

[1] An "intranet" is defined as a private network contained within an organization (a firm) that consists of many inter-linked LANs (= local-area networks). Its main purpose is to share company information and computer resources among employees. An "extranet" in turn is a private network that links the flagship via conventional telecommunications networks with preferred suppliers, customers and strategic partners.

[2] These issues are addressed in an international policy-oriented research project, coordinated by the East-West Center (Honolulu, Hawaii) on "Global Corporate Networks, Digital Information Systems and the Mobility of Knowledge: Asian Experiences".

necessary, due to the short-term pressures of the financial system (quarterly reports) and due to the shortening life cycles of products and technologies.

Finally, globalization has acted as a third important driver of increasingly complex information requirements. The key is a fundamental transformation of production that affects manufacturing, finance and professional services. A transition is under way from “multinational corporations”, with their focus on stand-alone overseas investment projects, to “global network flagships” that integrate their geographically dispersed supply, knowledge and customer bases into global (and regional) production and knowledge networks (Ernst, 2001ed; Ernst, forthcoming). These networks help the global flagships to sustain their competitiveness, by providing them with access to specialized suppliers at lower-cost locations who excel in quick and flexible response to the flagships’ requirements. The coordination of these networks requires ICT-based flexible and adaptive information systems.

All of this is should remind us that the distribution of benefits from ICT is bound to be unequal. It would be misleading to deny that global corporations (the network flagships) are the primary beneficiaries. This raises the question, under what conditions economic agents in developing Asia can position themselves to reap a reasonable share of these benefits. To answer that question, we need to introduce an operational concept of economic development[4].

1.2.Industrial Upgrading

An appropriate long-term development strategy must focus on improvements in specialization, productivity, and linkages (as defined by Hirschman, 1958, chapter 6), all of which necessitate local knowledge creation. All four elements are essential prerequisites for improving a country's capacity to raise long-term capital that is necessary for facility investment, R&D, human resource development and welfare expenditures. The concept of industrial upgrading (IU) ties these four elements together in a cohesive framework to serve as a focusing device for unlocking the economic growth potential of ICT[5].

---

3 For good reason, this has given rise to concern about invasion of data privacy.

4 As Heeks (1999: p.) correctly highlights, most research on ICT and economic development neglects this critical issue.

5 By focusing on knowledge and innovation as major sources of economic growth, our approach is consistent with leading-edge economic thinking, such as *endogenous growth* theories (Romer, 1990; Grossman and Helpman, 1991); Lipsey`s *structuralist* growth theory (e.g., Lipsey, 2001); evolutionary economics (e.g., Penrose, 1959/1995; Richardson, 1960/1990; Nelson and Winter, 1982); and attempts to reunite economic growth and innovation theory and business history (e.g., Lazonick, 2000). A focus on knowledge and innovation also reflects a recent shift in

The stylized framework of industrial upgrading used here is designed to explain how specialization affects market structure and upgrading potential. The framework also highlights the conditions that make it possible to move from partial to integrated strategies of "ICT for Development" (see section 5).

It is important to emphasize that "industrial upgrading" differs fundamentally from "import substitution" that has frustrated much of Latin America´s earlier development efforts (Ernst, 1973). In response to the external bottleneck problems created by Latin America´s traditional "export enclave" economies (Prebisch, 1962), import substitution was conceived as an "anti-trade bias strategy" (Balassa, 1970) that neglected the potential benefits of international trade and investment in manufactured products. Once the easy phase of import substitution was reached, that strategy stifled productivity and long-term economic growth (Bruton, 1967 and 1968).

We do not assume that IU ends at the national border, and that it occurs only if improved specialization generates pressures to create dense forward and backward linkages *within* the district or the national economy. A "closed economy" assumption is unrealistic, as globalization and ICT have drastically increased the international mobility of trade, investment, and even knowledge (Ernst, 2001d).This increases the scope for cross-border forward and backward linkages, in a similar manner that improved specialization generates pressures to create dense forward and backward linkages within the economy (Ernst, 2001f). Equally important, most countries are constrained by a narrow domestic knowledge base and limited linkages.

Both constraints are particularly important for developing economies. One of their primary features is a narrow and incomplete set of domestic linkages (e.g, Lall, 1997; Ernst, Ganiatsos, and Mytelka, 1998). The result is an "inverted production pyramid": a growing final product sector rests on a weak and much smaller domestic base of support industries (Ernst, 2001g). Rapid growth in the final products sector necessitates considerable imports of intermediates and production equipment (see section 3). In addition, highly heterogeneous economic structures constrain agglomeration economies; weak and unstable economic institutions obstruct learning efficiency; and a high vulnerability to volatile global currency and financial markets constrain patient capital that is necessary for the development of a broad domestic knowledge base. As a result of this "vicious circle", very limited sharing and pooling of

---

policy debates within important international institutions, such as the OECD, the World Bank, and the European resources and knowledge occurs *within* the country, and often even within the export-oriented cluster. This implies that our model of IU needs to integrate international knowledge linkages. To compensate for their narrow domestic knowledge base and limited linkages, Asian developing economies have to rely on foreign sources of knowledge to catalyze domestic capability formation. International linkages need to prepare the way for the development of integrated “ICT for Development” strategies.

We focus on two aspects of industrial upgrading found in the literature: "firm-level upgrading" from low-end to higher-end value chain stages, and "industry-level linkages" that provides the social capital that is the lifeblood for the individual upgrading firm.[6] We emphasize three additional features that distinguish our concept of IU. First, we use a broad definition of innovation that allows us to move beyond a narrow focus on R&D and patenting.[7] There is now a widespread consensus that a broad definition of “innovation efforts” is needed that includes engineering, technology purchases, expenditures on licensing and consultancy, and technology search, as well as the accumulation of tacit knowledge required to absorb imported technology (e.g., Nelson, 1990). That broader focus is necessary to capture the proliferation of knowledge-intensive professional services, made possible by ICT.

Second, we view industrial upgrading as a context-specific concept, with its characteristics differing across industrial sectors and countries. This is important, as ICT and globalization have substantially extended the geographic dispersion of economic transactions, involving diverse economic structures and institutions (Ernst, 1997b). Such diversity is a hallmark of developing Asia. Equally

---

Commission (e.g., World Bank and OECD, 2000; OECD, 2001).

[6] The other three forms of IU are: (i) inter-industry upgrading proceeding from low value-added industries (e.g. light industries) to higher value-added industries (e.g. heavy and higher-tech industries); (ii) inter-factor upgrading proceeding from endowed assets (i.e., natural resources and unskilled labor) to created assets (physical capital, skilled labor, social capital); and (iii) upgrading of demand within a hierarchy of consumption, proceeding from necessities to conveniences to luxury goods. See Ozawa (2000) for discussion of upgrading taxonomies. Most research has focused on a combination of the first two forms of IU, based on a distinction between low-wage, low-skill “sun-set” industries and high-wage, high-skill “sunrise” industries. Such simple dichotomies however have failed to produce convincing results, for two reasons: First, there are low-wage, low-skill value stages in even the most high-tech industry, and high-wage, high-skill activities exist even in so-called traditional industries like textiles. And second, both the capability requirements and the boundaries of a particular “industry” keep changing over time, which makes an analytical focus on the industry level even more problematic.

[7] Most empirical work on IU has explored the expansion of R&D-intensive industries. For most developing countries, that narrow focus is of very limited value.The (usually) implicit notion is that potential rates of productivity growth are higher in “emergent”, R&D-intensive industries (Globerman, 1997, pages 98 and 99). Hence, “… specializing in the “right” technological activities directly contributes to faster growth rates of real income”. A related notion is that, for R&D-intensive industries, economic rents can be extracted, in part, from

important are changes over time, that may not be linear, comprehensive, nor complete. Third, we include firm behavior as a key dimension, allowing for a co-evolution of industry structure and firm behavior in response to actions of key participants and also to the policy environment.

Specialization is an important indicator of the degree of industrial upgrading that a country has achieved. Specialization patterns reflect differences in product and production characteristics (homogeneous versus differentiated products), and in production characteristics (mass production versus flexible production) (see Table 1). The differences, in turn, are based on two criteria -- the complexity of technology, and uncertainty about demand. Differences in product and production characteristics also result in different market structures and account for different upgrading potential, i.e., augmenting the technological knowledge base and deepening Hirschman-type linkages.

Table 1. Specialization-Upgrading Matrix

The purpose of this exercise becomes clear when we look at the last row of the specialization matrix. While homogenous products have only a limited upgrading potential, in terms of technological learning requirements and linkages, the opposite is true for differentiated products. Similar distinctions can be made for production processes, with flexible production linked to premium pricing and significant profit margins that give rise to substantial upgrading potential. The downside to flexible production, of course, is the substantially higher upfront preparatory efforts that are necessary for successful entry. It is important to emphasize that causality works both ways -- while a narrow specialization on commodities fails to provide sufficient pressure to broaden the domestic knowledge base and to develop forward and backward linkages, it is also true that necessary improvements in specialization are constrained by a narrow domestic knowledge base and limited linkages, giving rise to a vicious cycle.

2. LIMITS TO EXPORT- LED PRODUCTION

Let us now use this framework to review achievements and limitations (both external and domestic ones) of Asia´s export-led electronics production, and to illustrate the resultant mismatch between the production and use of ICT.

2.1. Achievements

foreign consumers. A specialization in the “right” technological activities contributes to higher levels of national income by promoting more favourable international terms of trade.

Developing Asia has been highly successful in establishing itself as a major production base and export platform in the electronics industry. Compressed into a short period of time, there has been an extraordinarily rapid capacity and international market share expansion. The region's production of electronics equipment and components has increased tenfold since 1973, compared to a quadrupling of production in Japan. Five Asian countries (Korea, Taiwan, China/Hong Kong, Singapore, Malaysia) today belong to the group of the top ten world electronics producers[8].

Unsurprisingly, the region's strength is well-established for consumer electronics, which in volume terms contributed almost 50% of world production, up from 34% in 1993. This massive expansion of production capacity resulted from the relocation of Japanese consumer electronics production, first to Southeast Asia (primarily Malaysia and Thailand) and later to China (Ernst, 1997a). It also reflects the emergence of Korea as the second largest supplier, followed now by China (and Hong Kong). The really intriguing achievements however can be found in high-precision components and industrial electronics, such as computer memories (especially DRAM), motherboards, computer data storage and imaging products,[9] and advanced displays (like TFT-liquid crystal displays).

The semiconductor industry figures prominently in East Asian electronics exports (see **Table 4**). In terms of the geographic dispersion of its production sites and markets, the semiconductor industry is one of the most globalized industries. The industry has been characterized by a massive shift of production and assembly by US and Japanese firms outside of their respective countries, primarily to locations within Asia (e.g., Ernst, 2001e, and Ernst 1983). Until the financial crisis erupted in 1997, Asia had been the fastest growing supplier and consumer of semiconductors, not the U.S. or Japan[10]. Less

---

[8] India has not yet been able to leverage its success in software engineering exports to develop a reasonably integrated export production base.

[9] Data storage products include hard disk drives (HDD), tape drives, CD-ROM drives, disk media and their related components and subassemblies. Imaging output products include printers, facsimile machines and photocopiers, as well as multifunctional products with combined printing, facsimile and copier functions plus ink-jet color copiers and printers.

[10] Developing Asia´s leading position was briefly re-established during the short recovery from mid-1999 to the fall of 2000. Since then, semiconductor production and consumption has drastically declined almost everywhere, with China and Malaysia currently remaining the only significant exceptions. ("The Great Chip Glut", <u>The Economist</u>, August 11, 2001, pages 49-50)

well-known but of equal importance are achievements in other areas -- contract manufacturing,[11] especially for complex printed circuit board assembly, add-on and multimedia cards, embedded controllers, and a variety of specialized electric components (motors and compressors) both for computer and consumer products.

2.2. External Limitations

These impressive achievements are widely documented (e.g., Matthews and Cho, 2000; Hobday, 1995; Ernst, 2001g; Ernst and O'Connor, 1989 and 1992). Yet already since the late 1980s it had became clear that the more successful the catching-up, the more it would run into fundamental limitations (e.g., Kim Linsu, 1997; Ernst and O'Connor, 1992; Ernst, 1994). Let us first concentrate on external limitations. Best known are the external shocks that result from volatile global finance and currency markets. Yet, equally important are periodic constraints to exports. In 1997, for instance, the financial and currency crisis did not occur in a vacuum. It was preceded by a drastic fall in the production and export in electronics goods (Ernst, 2001g), as shown in **Table 2**.

Table 2. East Asian electronics exports growth, 1992 -1998, (y-o-y % change of US$ values)

As the "New Economy" has given way to a global recession, this has already terminated Asia´s recovery from the 1997 crisis. Economic growth rates have dropped alarmingly across Asia; many countries are lagging behind the US and Europe and the region is expected to grow at less than 2% during 2001 (Thornhill and Burton, 2001) The slow-down has been faster - and painful - than even the pessimists feared. Singapore is in recession[12]. Taiwan[13], South Korea, Malaysia, Thailand, Indonesia, and the Philippines have sharply slowing growth. Only China has maintained significant output growth because stronger investment (both domestic and foreign) and household spending have more than offset a slowdown in exports[14].

---

[11] Contract manufacturers are precision engineering firms that traditionally have focused on PCBA (printed circuit board assembly); recently, however they have expanded into the final assembly of PCs ("complete-box-build-and-ship").

[12] Singapore`s GDP fell by an annualised 10.1% in the second quarter of 2001 from the first quarter, when it had fallen by 11.3%. This meets the technical definition of recession of two successive quarters of contraction. This contrasts with a GDP growth of 9.9% in 2000. How unexpected this slide into recession has been, can be seen from the fact that the government, as late as April 2001, had forecast growth to be between 3.5-5.5%.

[13] The country´s second quarter GDP contracted by 2.35%, its worst fall in 25 years ("US Slowdown Buffets Taiwan", banner headline, Financial Times, August 18, 2001, p.1).

[14] For 2001, China is expected to sustain GDP growth of 7.5%.

The global electronics market which used to act as a major engine of Asia`s exports (Ernst, 2001g), is now in free fall. In July 2001, the world electronics industry was expected to shrink by up to 25% during the year, its worst performance ever (data are courtesy of Gartner`s Group Dataquest). During the first quarter of 2001, US ICT investment fell by 15% on a quarter-over-quarter annualised basis. This has let to a drastic fall in US exports and imports. April 2001 brought the biggest monthly fall in US exports and imports since 1992[15], which highlights how serious a threat Asia´s export-oriented economies are facing. This has resulted in a demand collapse for Asian electronics exports[16] (**Tables 3a,b,c,d)**.

Tables 3 a,b,c,d The Impact of Trade Recession

The big difference to 1997 is that all major economies (US, Japan and Europe) are now experiencing a simultaneous slow-down, if not recession. As a result, Asian currency depreciations that facilitated trade adjustment after the 1997 crisis, can no longer help to increase exports. As one analyst puts it: "No matter, how cheap you go, no demand is still no demand." [17]. A second important difference is that, ironically, it is the more sophisticated and open economies with a high exposure to the global ICT cycle that are most at risk. The higher the share of ICT in a country´s exports, the more vulnerable the country currently appears to trade recession. This is true for Taiwan, Singapore and Malaysia, countries with a high share of ICT in total merchandise exports. The region`s heavy reliance on ICT exports reflects a growing integration into the global production networks of leading electronics corporations, primarily from the US (Ernst and Guerrieri, 1998; Ernst and Ravenhill, 1999). It is thus no surprise that the global recession in electronics markets has hit especially hard those countries that are most integrated into these networks, i.e. Singapore, Malaysia, Taiwan, South Korea and China[18].

In both periods, the fall in Asian exports certainly reflect a substantially more adverse international environment. In 1996, the fall in world export growth from its cyclical peak in 1995 was the largest in the past 15 years -- from about 20% to about 4% in US dollars in just one year (World Bank,

---

[15] According to Department of Commerce data, US imports fell 2.2% to $119.1 bn in April 2001, while exports sank 2% to $ 86.9bn, the sharpest one-month fall in the volume of US trade since November 1992, when the country was struggling out of recession.

[16] As the Financial Times puts it (Jacob, Dickie and Leahy, 2001), "the slowdown in US information technology spending spreads at internet speeds to Asia.".

[17] Chang Weimin, head of research at ING Baring in Taipei, quoted in the Financial Times, July 12, 2001.

1998). Before the 1997 crisis, the region's currencies were pegged to the US dollar. Consequently, some Asian countries experienced an appreciation of the real effective exchange rate, due partly to the sharp depreciation of the yen vis-à-vis the US dollar, and partly to the renminbi devaluation in 1994 which hurt the region`s exports. The sharp depreciation of the yen in 1995 compounded the negative impact of the slowdown in world exports on many East Asian countries.[19] During the 2000/2001 recession, the US-dollar peg is no longer a concern, except for Hong Kong. The real threat is a disruptive and prolonged fall in the US -dollar. By increasing the price of US imports, this could severely hurt developing Asia´s export-oriented electronics industries

A hostile global competitive environment thus poses important constraints for export-led growth of Asia`s electronics industries. Equally important, however, are domestic constraints: fundamental drawbacks of East Asia's successful catching-up strategies have produced a mismatch between the production and use of ICT.

3. MISMATCH BETWEEN PRODUCTION AUND USE OF ICT: DRAW-BACKS OF CATCHING-UP STRATEGIES

Three fundamental drawbacks characterize developing Asia`s successful catching-up strategies in the electronics industry (Ernst, 2001g): a sticky specialization on exportable “commodities”, a narrow domestic knowledge base and limited forward and backward linkages. Together, these draw-backs have produced a fundamental mismatch between the production and use of ICT, giving rise to developing Asia`s multiple digital divides.

3.1. Sticky Specialization

The region`s successful entry into the electronics industry was based on a forced march to develop a “mass production” capacity that could serve high-growth export markets for homogeneous products. Very little upgrading occurred into higher-end and rapidly growing market segments for differentiated products and services that require flexible (or customized) production (such design-intensive ICs and computer products, software and Internet services).

---

[18] Outside of Asia, similar negative trade effects can be found for other major supply bases of US global networks, such as Mexico, Ireland, Israel, and Costa Rica.

[19] This is especially so for Korea whose export structure is similar to Japan´s: in 1996, Japan´s imports from Korea fell by 8.5%. Throughout the period 1990 to 1997, Korea´s real export growth mirrors changes in the yen-dollar

Korea pushed this strategy to the extreme (Kim Linsu, 2000; Ernst, 1994 and 1998). A handful of multi-sector, family-owned business groups (or *chaebol*) were given privileged access to large amounts of long-term debt capital. This shaped key features of the chaebol's strategy in terms of product specialization. Almost without exception, the chaebol have targeted those segments of the electronics industry that require huge investment outlays and sophisticated mass production techniques for fairly homogeneous products ("commodities") like microwave ovens, TV sets, VCRs, computer monitors, picture tubes and computer memories, especially DRAMs. Overwhelmingly, the focus has been on consumer electronics and components, with only limited inroads into industrial electronics. Burdened with unimpressive "me too" products, the chaebol have all failed to establish themselves as credible competitors in the more design-intensive sectors of the computer industry.

Trade data for the region`s leading electronics producers confirm a highly concentrated ("sticky") product specialization (**Table 4**). To start with, electronics dominates merchandise exports, ranging from almost 29% in Korea to more than 61% in Singapore. Moreover, product specialization is heavily concentrated *within* electronics. In Korea, three products dominate with a very high RCA: semiconductors (SC) with 3.6, components (Comp) with 2.7, and consumer electronics (CE), with 2.0. And, almost 61% of Korea's electronics exports consist of components, with semiconductors (SC) alone accounting for 40%. Other East Asian economies exhibited a similar pattern.

Table 4. Developing Asia´s Trade Specialization Profiles: RCA and Leading Export Products

A particularly disturbing feature of developing Asia`s specialization is a fundamental *mismatch* between the production and use of ICT. Take semiconductors. Korea, the region`s leading producer, exports more than 90% of its total semiconductor output, while at the same time **it** imports more than 87% of its domestic demand (Ernst, 2001, Doner book). While Korea´s exports focus on commodity devices like computer memories (especially DRAM, the industry`s "bleeding-edge"), the country`s semiconductor imports are dominated by differentiatetd, design-intensive products like microprocessors, ASIC, digital signal processors, and "systems-on-a-chip" devices. There is a long list of similar

exchange rate, rising with an appreciation of the yen, and falling with its depreciation (World Bank, 1998, figure mismatches for all major electronics producers in the region. Such an extreme imbalance between supply and demand makes it very difficult to broaden and deepen forward and backward linkages within the electronics industry and to place that industry onto a more viable basis. The supply-demand mismatch also obstructs attempts to reduce the region´s multiple “digital divides”.

In short, developing Asia's competitive position in electronics production remains highly fragile, despite impressive achievements. As long as the region's electronics industries continue to rely on commodity-type products like TV sets, monitors or DRAMs, this sticky specialization constrains limited possibilities for industrial upgrading. For such commodities, competition is of a fairly conventional nature, with size, economies of scale and first mover advantages being of primary importance rather than R&D or knowledge-intensive support services.

It is probably fair to say that much of developing Asia´s electronics industry represents a modern version of the classical “mono-product export enclave”, characterized by a minimum of linkages with the domestic economy. True, the dependence on traditional labor-intensive commodities (like toys and garments) or primary commodities has been reduced. Yet, a new and potentially quite destructive dependence on high-tech commodities has emerged. This reflects an important difference with the classical “export enclave” -- the cost of entering the electronics industry is horrendously high (especially for high-precision components like semiconductors), and certainly exceeds that of entering the plantation industry. And even higher is the cost of continuously upgrading the industry, and of maintaining the competitiveness of its exports.

3.2. Narrow Domestic Knowledge Base

A second important characteristic is the limited and achievable technological learning requirements.[20] A focus on mass-produced commodities (like DRAM) requires a narrow set of capabilities -- a capacity to absorb and upgrade imported foreign technology and to develop operational capabilities in production, investment and minor adaptations. The main objective has been to accumulate superior production capabilities and to become a quick, lower-cost follower for established product and

---

2.2., p.21)

[20] One needs to distinguish the increasing sophistication of the institutional arrangements for technological learning, especially for international technology sourcing, and the relatively mundane contents of the knowledge thus generated. In line with the theory of the path dependency of innovation, it is hardly surprising to find that most of

system designs and component technology, through reverse engineering and subcontracting (especially OEM).

This has resulted in three main weaknesses that characterize the region's knowledge base: (i) an insufficient critical mass of R&D and patenting; (ii) gross inefficiencies of corporate technology management; and (iii) equally important inefficiencies of its public innovation system. Take Korea, the region`s leader in per capita R&D expenditures. Korea's p.c. R&D expenditures of $176.2 (in 1993) lag well behind those of Japan ($762.9 in 1992) and the US ($540.9) (Lall, 1997). Korea still badly trails major OECD countries, with a patent intensity of 10 only a fraction of that reported for Germany (around 180), Japan (170), the US (140), and the UK and France (slightly below 100)[21] This gap is likely to increase, as the financial crisis has dried up funds available for this "patent portfolio race".

Inefficiencies of corporate knowledge management spillover into production inefficiencies, delaying product design cycles and speed-to-market. Feedback loops across the value chain thus remain weak and unreliable, and design, marketing and manufacturing often proceed in an asynchronous way. Finally, important inefficiencies in the public innovation system, like a lack of coordination among R&D programs of different ministries and inconsequential implementation, have given rise to a wastage of scarce financial and human resources. Fundamental weaknesses in the training- and education systems have led to a widespread brain drain. While examples of successful reverse brain drain exist (especially in the region`s NIEs), there is often limited scope for positive feedback effects from overseas expatriates.

What matters for our purposes is that a narrow domestic knowledge base has made it difficult to move up the ladder of specialization. It also erodes export competitiveness, and constrains the development of linkages, perpetuating a heavy dependence on input imports.

3.3. Limited Linkages

A third important structural weakness is a lack of forward and backward linkages, especially for materials and production equipment, that gives rise to a persistently high dependence on input imports. The result is an inverted production pyramid -- a huge and rapidly growing final product sector that rests

---

this knowledge has been confined to operational production capabilities of a fairly conventional mass production type, which after all has been the region´s original advantage.

[21] The measure of patent intensity for OECD countries, Triad patents, refers to high quality patents, i.e. world market-oriented patents registered in at least two overseas markets within the Triad region. In other words, the gap between G7 countries and Korea is even higher than shown by a mere quantitative comparison.

on a weak and much smaller domestic base of support industries. Rapid growth in the final products sector necessitates considerable imports of intermediates and production equipment.

While import content ratios are not available,[22] it is possible to construct proxy indicators. **Table 5** documents the critical role played by electronic components, and especially semiconductors (SC) both for electronics imports and merchandise imports. It is important to emphasize that these shares are highest for the region's four leading electronics producers (Korea, Taiwan, Singapore and Malaysia). On the positive side, this of course reflects the more sophisticated product mix of these four industry leaders, with industrial electronics outweighing consumer products. It raises, however, an important consideration of why rapid capacity and international market share expansion for final products in developing Asia was not matched by a progressive reduction in input imports.

Table 5. Dependence on Input Imports

An important reason are peculiar features of the electronics industry that have intensified the *vicious circle*, discussed earlier, between sticky specialization, a narrow domestic knowledge base and limited linkages. I am referring to short product cycles, combined with rapid and often disruptive technological change (Christensen, 1997; Ernst, 2001e). The result is that a latecomer cannot count on a continuous decline of capital goods imports. Such imports, on the contrary, are likely to increase periodically, with each shift to a new product generation, with each extension of the product mix, and with each substantial change in technology. The same is true for the imports of those key components that are essential for the cost and performance features of a particular product.

Consider a simple model of the latecomer trajectory of input imports in the electronics industry. Input imports cover both key components and machinery. Suppose country K decides to establish local production for a certain key component Ct required for a particular product Pt. And suppose further that K has sufficiently strong companies that can cope with the substantial entry barriers that characterize the production of Ct - an assumption that surely cannot be taken for granted. Even then, catching-up requires a certain period of time. As a latecomer, country K may thus end up in a paradoxical situation, in that once it has finally succeeded in producing a substantial part of Ct required for Pt, the industry may

[22] Import content ratios differ from product to product, and even for a given product, they differ from company to company. This obviously poses severe methodological problems for the collection of such data. An important

already have moved on to the next product generation(s) Pt2 or Pt3, which require substantially more sophisticated key components Ct2 or Ct3. This does not imply that catching-up efforts have been in vain. Learning and capability formation has taken place, which country K can build upon. What it implies, however, is that country K will remain dependent on imported inputs of Ct2 and Ct3, until it has finally caught up to their more sophisticated requirements. At that stage, K's import dependence is likely to shift to Ct4, Ct5, and so on.

A high dependence on input imports thus constitutes the Achilles' heel of developing Asia's export-led catching-up in electronics. This explains why capacity and international market share expansion may well produce significant trade deficits and why exchange rates may come under downward pressure, even if economic growth rates rise. As long as this structure is preserved, this will constrain the scope for industrial upgrading. To break out of this vicious circle, it is necessary to reduce the mismatch between the production and use of ICT

4. ASIA´S MULTIPLE DIGITAL DIVIDES[23]

A key feature of that mismatch is that only limited linkages have been established between export-oriented supply clusters and the rest of the economy. Asia´s electronics exporters have used their prowess in electronics production to paper over the failings of inefficient traditional and service sectors[24] This lack of linkages explains the persistence of serious "digital divides". These divides separate developing Asia from industrialized countries, and the poor countries in the region from the more developed ones. They also exclude rural areas, and lower income groups from access to information.

4.1. What is at Stake?

Most research on the "digital divide" has focused on the exclusion, in the U.S. and other

objective for future research is to conduct a questionnaire survey to collect a representative set of product-specific import content ratios and to document how these ratios have developed over time.

[23] If not indicated otherwise, data in this section are taken from the following sources: Boston Consulting Group, 2001a and 2001b; ITU, Yearbook of Statistics, 1995 to 2001; ITU, 1999, "Internet for Development". Internet Software Consortium (isc.org), Nua Internet Surveys (nus.i.e), American Electronics Association (aea.org), Cybernation v.2.0; Internet Software Consortium (isc.org); www.netcraft.com; Dataquest (Gartner group); IDC; Yearbook of the Information Technology Industry Council (1998), Washington, D.C; Cheung, 2000; Oki, 2001; Cheskin Research, 2000;

[24] These weaknesses have been brutally exposed by external shocks, like the 1997 financial crisis and the 2001 trade recession. Take Taiwan where a drastic fall in electronics exports has forced a reconsideration of export-led growth, and a renewed urgency to search for broad-based IU options.

industrialized countries, of lower-tier income groups, women and ethnic minorities (e.g., NTIA, 1999). Of equal importance however is unequal geographic dispersion that indicates a *global* digital divide: Outside the industrial heartlands of the U.S., Japan and Europe, fundamental constraints exist to *access* (spread and capacity of information infrastructure), *connectivity* (variety of linkages) and *receptivity* (capacity to receive and absorb information). A few highly ICT-enabled lead regions are separated from the so-called RoW (= rest of the world) that lacks the capacity to benefit from ICT. Take Internet access: almost 90% is concentrated in North America, Western Europe and Japan. Developing Asia, despite its successful catching-up in industrial manufacturing, lags way behind: with almost two thirds of the world population, the region accounts for a meager 7% share of the total Internet population (Nua Internet Surveys).

The region´s limited access to the Internet is demonstrated by the fact that there is only one direct Internet link between two Asian cities, Tokyo and Seoul. More than 99% of the international Internet traffic in Asia is routed through the US (Chismar, 2000: p. 3). This will slow down access of Asian firms to broad bandwidth, which is essential for reaping the benefits of Internet-based information systems. A dependence on U.S. backbone networks constrains the region´s capacity to adjust the evolving Internet architecture to the specific needs and capabilities of its firms and public sectors. It will also make it more difficult to develop a strong regional pool of hardware and software companies that provide Internet infrastructure equipment.

Equally important are *intra-regional* divides: substantial disparities are also emerging *within* developing Asia itself. For instance, Hong Kong and Singapore have 57 fixed phone lines per 100 inhabitants, while India has three. Singapore and Australia have 56 and 54 PCs per 100 inhabitants respectively, while Indonesia and the Philippines have less than one. Wireless device penetration also varies greatly, with 68 and 67 wireless devices per 100 inhabitants in Taiwan and Hong Kong, respectively, and under one wireless devices per 100 inhabitants in India. Internet access costs also vary across the region. For example, in low-income countries, like India and Indonesia, Internet access costs[25] represent around 120% and 50%, respectively, of monthly GDP per capita. And the average Internet user in China has to spend around 20% of monthly income to get online for only one hour each day (Ernst and

[25] Internet access costs = ISP charges + call charges + PC amortisation cost.

Jiacheng, 2000, p.5). Compare this to the average Internet user in the U.S. who spends roughly 1-2% of monthly income for unlimited access to the Web and for monthly telephone charges.

There are also important intra-regional disparities in terms of Internet users. **Table 6** shows that China´s 16.9 million Internet users in mid 2000, while an impressive figure, was actually only 1.3% of the total population. To equal Taiwan´s 29% share of total population, the number of mainland Chinese online would have to rise to 377 million.

Table 6: Comparison of Internet users as a Percentage of Total Population

Intra-regional divides are especially pronounced for ICT business applications. For instance, Korea's e-business market is projected to be 2.5 times the size of China's by 2005, and larger than the combined markets of Singapore, the rest of Southeast Asia, India, and Hong Kong. This reflects Korea's higher stage of development, its broader knowledge base, and its more robust national information infrastructure.

Most importantly, such intra-regional digital divides are expected to grow rapidly. For instance, while Taiwan´s wireless device penetration is projected to grow from 68% in 2001 to 84% in 2004, that ration in India will increase from 0.3% to only 0.6%. However, given India´s enormous population, this small percentage increase translates into about three million new users. There seems to be a clear trend for intra-regional digital divides to increase with the sophistication and complexity of the ICT systems. For instance, attempts to push broadband in developed Asian economies like Korea, Japan, Singapore and Hong Kong will also widen inequality. By 2004, broadband penetration is forecast to reach 35% of the total population in Korea, 17% in Japan and Singapore, and 14% in Hong Kong. Broadband access however will remain off limits for the great majority of Asian populations.

4.2. Implications

These multiple digital divides indicate that countries and firms in developing Asia, on average, fail to use ICT effectively to upgrade production and economic institutions. There is a huge, underutilized potential to establish ICT as an engine of economic growth and welfare. Second, intra-regional divides are arguably more extreme than extra-regional divides. Highly ICT-enabled clusters in countries like Singapore, Korea and Taiwan contrast with ICT deserts in most of the Mekong Delta and South Asia. ICT has added yet another dimension to the deeply engrained regional disparities within the region. These disparities constitute the most demanding challenge for long-term economic development. As long as they exist, it will be difficult for the region´s leading economies to move away from a heavy reliance on extra-regional electronics exports. It is thus grossly misleading, as many observers do, to contrast and compare indicators for, one the one hand, Asian countries (including Japan), and, on the other hand, for non-Asian countries.

Third, Asian NIEs, with the exception of Singapore, lag substantially behind the U.S. and European leaders (especially the Nordic countries), in terms of Internet hosts, PCs and Internet users, as well as E-business readiness. Yet, NIEs are rapidly catching-up, having reached a level that is roughly comparable to that of Japan. A fourth important implication is that we need policies that address the huge regional disparities, in terms of ICT readiness, that exist, especially *within* large, quasi-continental economies like China and India[26]. For instance, within India, there is a huge gap in ICT readiness between the Southern belt (especially clusters around Bombay, Bangalore, Hyderabad, Trivandrum and Madras) and the rest of this sub-continent. Within China, equally extreme disparities are reported (e.g., Hachigian, 2001).

All of this implies that, fifth and most importantly, a majority of Asian populations remains cut off from access to ICT. That majority also lacks the appropriate knowledge to reap potential ICT benefits. For many of these people, the main challenge is day-to-day survival. Disposable income is simply too low to invest in even the most simple ICT device. Typically, this creates economic and social institutions that obstruct trust required for conducting ICT-based economic transactions. These findings raise important policy issues, to which we will turn in the concluding section of the paper.

4.3. Lack of Relevant Data: Priorities for Research

Before, however, we need to add an important caveat: there is a serious lack of relevant data that systematically analyze developmental impacts of ICT. To understand precisely how the above multiple digital divides affect developing Asia´s long-term economic growth and welfare, we have to move beyond the above rough indicators. Future research needs to develop a more systematic set of data needs that measure how different countries and micro-regions differ in their capacity to reap the benefits of ICT.

a) Classifying digital divides

We need to classify developing Asia`s diverse digital divides. Understanding this diversity matters. Most of the literature looks only at highly aggregated quantitative indicators that focus on the input side. This can be grossly misleading. Of primary importance are those divides that reduce or obstruct the appropriate choice of ICT applications and their effective implementation.

The key term is *readiness*, which consolidates three inter-related prerequisites for the effective use of ICT: access, knowledge, and trust[27]. "Access" includes both physical access (to telecommunications infrastructure and networks such as the Internet) and economic access (such as a non-prohibitive price structure for Internet use or low tariffs for ICT imports). "Knowledge" refers to the accumulated knowledge of ICT users and institutional arrangements for sharing such knowledge. Finally, "trust" is the most important element that defies however quantitative measurement. Trust encompasses all issues related to the security and confidentiality of transactions; authentication and encryption; intellectual property rights (especially the prevalence of "software piracy"); and, most importantly, the appropriateness of legal and regulatory frameworks.

b) Indicators

We suggest to distinguish three sets of indicators: ICT readiness; e-business readiness; and the match between production and use of ICT (see **table 7**). Under "ICT readiness", we measure five indicators of *physical access*, i.e. penetration ratios for fixed telephone lines, mobile phones, Internet hosts, PCs and Internet users; two indicators of *economic access*, i.e. monthly Internet access charges and per capita GDP; proxy indicators for the sophistication of accumulated user knowledge, i.e. combined first-, second, and third-level gross enrollment ratios; and, finally, a proxy indicator for trust, estimated software piracy rates. Under "E-business readiness", we collect data on four indicators: number of secure servers per 1,000; the size of combined ERP and ASP markets; the status of licenses for 2.5G and 3G systems; and estimates on investment in broadband infrastructure.

Table 7 Digital Divides - Indicators

[26] This points to an important priority for future research. We need to collect disaggregated data for individual Asian countries that highlight the digital divides that separate lead regions from the rest of these countries.

Finally, the last set of indicators measure whether there is a reasonable match between the use and the production of ICT. We suggest the following metrics: the share of ICT investment in GDP, as an overall measure of an economy`s degree of digitalization; sector distribution of ICT investment (comparing ICT producers and non-ICT producers); employment figures for the ICT producing sector; aggregated ICT employment (including ICT use and maintenance, and the outsourcing of ICT system management); and investment and R&D by ICT producers.

c) Coverage

We suggest that these data are collected for eight country groupings: I. Asian NIEs (Hong Kong, Singapore, Taiwan, and South Korea); II. China; III. ASEAN-4 (Malaysia, Thailand, Indonesia, and the Philippines); IV. India; V. Indochina (Vietnam, Laos, and Cambodia); VI. the U.S.; VII. The EU-12; and VIII. Japan. To get an idea of the underlying dynamics, this exercise should cover three distinct periods: I. pre-Financial crisis (1994 - 1997); II. Post- crisis recovery (1998- 1.Half of 2000); and III. The decline of the "New Economy" and trade recession (since 2.half of 2000). We need such time series to establish whether certain digital divides have been reduced over time, and which divides have kept growing.

5. POLICY SUGGESTIONS

We have documented that a focus on export-led production of electronics goods no longer guarantees sustained growth and welfare improvements. Fundamental changes are required in developing Asia`s "ICT for Development" strategies. It is time to match a focus on production with the development of effective demand for ICT investment *within* the region. Conscious efforts are required to reduce the region`s extreme reliance on electronics exports to the US, and to increase sales to Asian markets[28].

Equally important is the development and continuous upgrading of an ICT production sector. While manufacturing continues to matter, the focus of attention needs to shift gradually toward the development of high value-added, knowledge-intensive support services (KISS) (Ernst, 2001f). Such services encompass software engineering, product design and engineering, and organizational

[27] This conceptualization draws on the following sources: UNCTAD, 2000, chapter 3; OECD, 2000, chapter 3; OECD, 2001; and ITU, 1999.

innovations like quality control, inventory and supply chain management. The weak state of KISS in Asia reflects a bias of investment in plant and equipment relative to investment in intangible assets. The latter include the development of specialized skills and continuous higher education, and conscious efforts to develop patents and brand names as part of strategic marketing strategies (e.g., Dahlman and Andersson, 2000: chapters 6 and 7).

These elements define a new *integrated* "ICT for Development" strategy that is necessary to reduce the region`s multiple and persistent digital divides. The region`s diversity implies that this strategy comes in different shades and colors. Implementing such strategies poses daunting political and administrative challenges. Most importantly, hard choices are required about priorities, sequencing and opportunity costs. The following observations are meant to facilitate that task.

5.1. Diversity

In light of the diversity of Asian developing countries and their development experiences (Naya, Mark, McCleery, 2001), and in light of the region`s multiple digital divides, there is obviously no "one-size-fits-all" approach to ICT-enabled industrial upgrading. Instead, we need a flexible mix of diverse approaches. This reflects substantial differences that separate countries, for instance in terms of size, stage of development, industry structure, "openness" (exposure to trade and FDI), and knowledge base. These differences give rise to unequal capacities to reap the benefits of ICT. To capture these differences, it is useful to distinguish first- and second-tier newly-industrializing economies (South Korea, Taiwan, Singapore, Malaysia and Thailand), quasi-continental economies (China, including Hong Kong, and India), and poor economies (like Vietnam).

Equally important is a taxonomy of economic agents involved in the region`s production and use of ICT. We suggest to distinguish global corporations; large local conglomerates; small local firms; diverse government and public sector agencies; international development agencies; and operational NGOs with a specialized expertise. The taxonomy highlights some fundamental differences in terms of size, decision-making power, financial clout, technological capabilities and market access. Clearly some of these agents are "more equal than others", to paraphrase George Orwell, in terms of their capacity to shape and benefit from the use and production of ICT. We need empirical research that explores the

---

[28] Note however that, in Asia, a large share of intra-regional electronics trade should not be confused with a large

structural and contextual factors that shape the distribution of economic power among these agents, and how this distribution is changing over time[29]. This research will enable us to distinguish how key features of integrated strategies differ, depending on whether they are applied in poor countries or in mature economies.

5.2. ICT for Development - How to Move From Partial to Integrated Strategies?

A recent study, co-edited by the UNDP, Accenture (the global consulting firm), and the Markle Foundation, argues that an integrated "ICT for Development" strategy "is the most effective way to benefit from synergies and ensure the impact of ICT deployment is optimized." (UNDP, 2001, p.29). We agree with this statement, but contend that the key to such synergies is to reduce the mismatch between the production and use of ICT. This has important implications for strategy design and policy implementation. We argue that, while partial strategies may work for a while, they are insufficient to generate long-term economic growth and welfare improvements. A transition is necessary from partial to integrated strategies of "ICT for development". Such strategies should center on reducing the mismatch between the production and use of ICT within the region. To effectively implement such strategies, it is necessary to develop a broad set of knowledge-intensive support services (KISS), as described above. It is also necessary to link investments in ICT to the development of local capabilities and markets.

A taxonomy of "ICT for Development" strategies and sequencing patterns can help to clarify this issue (**Figure 1**).

Figure 1: ICT for Development: A Taxonomy of Strategies and Sequencing Patterns

The figure provides an important insight that should structure future research and policy design. While most countries initially pursued *partial* strategies, over time, the more successful countries have moved up to *integrated* strategies. It is also important to emphasize the *diversity* of possible sequencing and upgrading patterns. Important differences exist for instance between upgrading strategies pursued in Korea, Taiwan, Singapore and Malaysia[30].

share of final product sales to Asian markets. For evidence, see Ernst and Guerrieri, 1998.

[29] For a stylized taxonomy of Asia`s electronics firms, see Ernst, 2001g, Annex 2.

[30] See Kim 1997 and Ernst, 1994 and 2001h; Ernst, 2000, and Chen and Chen, 2001 (on Taiwan); Wong, 2000 (on Singapore); and Best, 2001 and Rasiah, 2000 (on Malaysia).

Yet, apart from these NIEs, very little is known about diverse upgrading options, and about the drivers and impacts of these processes. For instance, a review (Heeks, 2001) of the proceedings of the main "ICT for development " conferences (e.g., Odedra-Straub, 1996; Avgerou and Walsham, 2000) and relevant journals, like Information Technology for Development, and Electronic Journal on Information Systems in Developing Countries, shows that most contributions have been largely descriptive case studies of specific problems of ICT implementation. The remaining articles somewhat subserviently apply some of the currently fashionable grand social science theories, with little concern for policy implications.

Attempts to apply economic theory to these issues fare only slightly better. At least, they highlight some disturbing puzzles. For instance, Pohjola (2000) finds that, while ICT investment appears to boost growth in developed countries, the same is not necessarily true for developing countries. Other studies, like Quibria and Tschang (2001: p.27) emphasize the obvious: "… to reap the full benefits of the ICT revolution and reduce poverty, countries need to address the main impediments to economic development" , such as bottlenecks in infrastructure and education, and market intransparencies. But there is almost no attempt to trace the drivers and impacts of diverse "ICT for Development" strategies, and to assess their strengths and weaknesses[31].

In light of these limitations of our knowledge, let us look at three illustrative examples of possible sequencing approaches from partial to integrated strategies: attempts by Asian NIEs to move from export-led production to ICT-enabled upgrading of economic structures and institutions[32]; attempts to replicate the "New Economy" model; and attempts to move from poverty alleviation strategies to ICT-enabled industrial upgrading strategies. This exercise can help us to separate misguided illusions from feasible options.

5.3. From Export-Led Production to ICT-Enabled Upgrading

The transition from partial to integrated strategies is nicely illustrated by Asia´s first- and second-tier NIEs. A common feature of these countries is that they started out initially with a focus on developing

[31] Of greater relevance are earlier contributions on the role of technology for economic development that however do not address explicitly the specific ICT-related issues, such Bell and Pavitt (1993), Nelson and Pack (1995), and the contributions in Ernst, Ganiatsos and Mytelka, 1998. On ICT specifically, see various contributions to Bartzokas and Teubal, 2002, and a series of studies jointly published by the OEDCD and the World Bank on the transition to "knowledge-based economies (e.g., Dahlman and Andersson, 2001), and Ernst, 2001 c and d.

export-led clusters for ICT "commodities". This approach has been a major strength, as it established a *virtuous* circle between quick learning and late market entry. A narrow specialization on exportable ICT commodities combined with limited linkages and learning requirements, was necessary to overcome initial latecomer disadvantages. This was the only realistic entry possibility, as it guaranteed access to rapidly growing and relatively open export markets. It also helped to keep manageable the scope and depth of technological learning. For quite a while, this strategy has produced substantial benefits that were the envy of the rest of the developing world: new jobs and skills, rapid growth and improved balance of payments, in the context of reasonable macro-economic stability

That strategy however has now reached its limits. As documented in this report, a bias in favor of "commodity" manufacturing reduces the scope for value creation (or profit margins), due to an emerging "commodity trap" (Ernst, 2001g): ICT commodities like DRAM are prone to deflationary pricing pressures resulting from periodic over-capacity and price wars. This restricts the pool of financial and human resources available for continuous upgrading efforts. As a result, all of these mature economies now experiment with different approaches to use ICT as a catalyst for promoting the development of knowledge-intensive support services (KISS). For instance, Korea is trying to forge ahead with wireless Internet applications, based on broadband infrastructure. And Singapore and Taiwan are promoting Internet-enabled e-business applications.

5.4. Unfulfilled Promises of the "New Economy"

We also need to beware of "technological determinism" that makes ICT an "icon for modern development" (Heeks, 1999:15), neglecting opportunity costs, negative impacts and the potential for failure. There is still a widespread belief in developing Asia that copying the US-style "New Economy" model could do wonders for attempts to move beyond partial strategies (e.g., Sender, 2001). So deeply entrenched is that belief that it has survived the dramatic slow-down of key sectors of the "New Economy" (especially telecommunications and computers).

[32] For research on attempts by large, quasi-continental economies like China, India to move from domestic market and capability development, via the development of export-led clusters to more broad-based forms of ICT-enabled IU, see Lu Qiwen, 2000, Gu and Steinmueller, 1997, and D`Costa, forthcoming.

This is ironic in light of the fact that in the US, and especially on Wall Street and in Silicon Valley, the debate has moved on. The emerging consensus is that the concept of the "New Economy" is buried under a long list of unfulfilled promises **(table 8)**. Alice Rivlin, a former vice chair of the U.S. Federal Reserve, and a co-author of a major study of the productivity effects of the Internet (Litan and Rivlin, 2001), argues that much of the "New Economy" propositions are "hopes and hunches" (quoted in the Financial Times, September 3, 2001, p.2). And for Martin Bailey, former head of the White House Council of Economic Advisors, and an expert on productivity, the decline of U.S. productivity growth since late 2000 indicates that "the favourable performance of the 90`s could unravel, with higher inflation, higher unemployment, slower growth, stock market weakness and a dollar that could drop sharply." (quoted in the Financial Times, September 6, 2001, p.5).

This new consensus culminates in three questions that should inform policy debates in developing Asia: How long will it take to correct the previous over-investment in ICT? Will productivity gains survive, as we move into a global recession? Or does the productivity decline during the first half of 2001 signal a reversal to a downward spiral?[33]

Table 8: Unfulfilled Promises

A widely known example of Asia´s attempts to copy the "New Economy" model is Malaysia`s attempt to establish a $40 billion Multimedia Super Corridor (MSC) that was supposed to transform major sectors of the economy. In 1996, the government had hired McKinsey, the global consulting firm, to draft a blueprint for a 15-kilometer-by-50-kilometer strip intended to be Malaysia`s answer to Silicon Valley. $3.7bn have been consumed thus far, but results are disappointing. To the embarrassment of the Malaysian government, a leaked confidential report by the very same company that designed the project (McKinsey) concluded that the Multimedia Super Corridor " had not attracted much interest from global investors, nor made an impact on the domestic economy." (Prystay, 2001)

Even more influential has been the idea that, by establishing Nasdaq-type second boards to foster innovative start-up companies, Asia could catch up in reaping "New Economy" benefits. Especially after the financial crisis, Asian firms have increasingly relied on stock to finance capacity and upgrading

[33] Many financial analysts now argue that U.S. productivity growth will subside to the lower levels that existed before the "New Economy" boom. For instance, Stephen Roach, chief economist at Morgan Stanley in New York,

investments. Even more important, there was a rush into IPO and venture capital-funded business start-ups. Since Nasdaq began to crash, however, these attempts to copy the US system of stock market-based innovation finance are in shambles. As long as Nasdaq boomed, Asian technology stocks followed suit. But once prices of US technology stocks fell, the market capitalization of Asian electronics firms fell a lot harder than their US counterparts. This has drastically changed the composition of Asian stock markets: technology stocks now make up a much smaller percentage of market capitalization. Take Korea. In July 2001, the share of technology stocks in MSCI`s Korea Free Index has fallen to 32%, down from 44% in July 2000. This raises an important question: How will the breakdown of the "New Economy"-type system of finance, centered on IPO, VC and Nasdaq-type boards, affect innovation and industrial upgrading in the region? Will this drain available scarce resources even further? And what options exist for Asian firms to circumvent these constraints?

In short, attempts to replicate the US-style "New Economy" are unlikely to provide a short-cut to a sustainable integrated strategy. As the current downturn of the US ICT sector demonstrates, it may be an advantage that Asian countries and firms have not blindly followed the US over- investment in ICT. Maybe being one or two steps behind in certain areas, like highly sophisticated and capital-intensive ERP (enterprise resource planning) systems, may not hurt. Maybe, moving ahead at a slower pace than dictated by the US "New Economy" model may provide opportunities for Asian firms to learn from the mistakes committed by the early users of these systems (Strassman, 2001; Ciborra et al, 2000; Hagstrøm, 2000).

5.5. From Poverty Alleviation Strategies to ICT-Enabled Industrial Upgrading Strategies

Finally, everybody agrees that the most serious challenge for "ICT for Development" strategies in the region is to find ways that would enable poor countries and regions to move from poverty alleviation strategies to ICT-enabled industrial upgrading strategies. Sadly, very little is known about the drivers, realistic options and possible impacts of such transition strategies. While there are plenty of normative statements (e.g., Mansell and When, 1998), and long laundry list of micro-projects ('e.g., appendices in UNDP, 2001) we lack relevant data that could guide policy implementation.

---

argues that much of the earlier productivity boom was simply a reflection of the stock market boom, which was based on excessive optimism about the effects of ICT (quoted in: Luce and Kehoe, 2001).

One of the best studies in this field (Heeks, 1999), exploring the scope for ICT in small and micro-enterprises, documents serious inequalities, in terms of finance, skills and knowledge, that constrain the use of ICT-based information by poor entrepreneurs. The study argues that “ICTs currently have a far greater enabling value in building capacity within intermediary institutions - in “helping the helpers” - than in directly affecting the poor” (ibid: p.18)[34] Most of these very partial strategies, that are currently subsumed under the label of “poverty alleviation”, unfortunately fail to address the real issue of enhancing long-term economic growth and welfare in Asia´s poorest societies. History tells us that no country ever got rich through poverty alleviation (e.g., Rosenberg and Birdzell, 1986; Braudel, 1992). History also demonstrates that development is a chain of disequilibria (Schumpeter, 1961; Hirschman, 1958) where certain activities and sectors move ahead, at least temporarily, while others decline, uprooting whole regions and social classes.

This clearly indicates that searching for specific ICT applications to alleviate poverty is important in the vast poor and rural areas of developing Asia. However, such partial strategies need to be gradually transformed into broader, increasingly integrated strategies that also emphasize the development of local intangible assets, like skills, finance, and knowledge-intensive support services (KISS). Of equal importance over time are complementary capabilities required for the production and design of ICT hardware and software. We need to move beyond a too narrow version of “poverty alleviation” that tends to see ICT production and design “as too far removed from the lives of the poor to warrant donor agency attention” (Heeks, 2000, p.2).

Table 9 Recommendations for Funding Priorities

Table 9 summarizes our recommendations for funding priorities that could facilitate a transition from poverty alleviation to ICT-enabled industrial upgrading. we highlight five key components of an integrated strategy of “ICT for development”. First, to reap the benefits of participation in global production networks, established by major global electronics corporations (Ernst, 2001d and 2001f), it is necessary to promote local supplier development programs, like the ones developed in Singapore and Malaysia. Equally important are co-funding schemes of Skill Development Programs, where seed money

[34] Specifically, ICT have enabled NGOs to share experiences about - and thereby improve - their microcredit programs and have assisted those campaigning for greater democracy, social equality and protection of the

from international development agencies would be complemented by funds from global corporations, and local companies, induced to do so by tax incentives. An equally important part of the first component are schemes to develop standards & ISO qualifications, and the capacity to register patents and trademarks.

A second priority for funding is infrastructure development. It is important to emphasize that there is little need for funding of hardware investments. This reflects the current market situation, where global equipment vendors of telecommunications and networking equipment are eager to expand sales in Asia at almost any cost, and where the bargaining power has shifted from sellers to buyers. Financial support however is required for the development of a vast array of knowledge-intensive support services that encompass web design, outsourcing and application service providers (ASP).

Market development, both within individual countries and across the region, is a third element of an integrated strategy that qualifies as a funding priority. Examples include training schemes for potential sophisticated users , like banks and other financial institutions, and local suppliers. Especially in poorer countries, priority should first be given to micro-finance schemes for weaker/backward users, as described in Heeks, 1999. Fourth, effective reforms of educational and training systems require substantial funding. A key criterion for dispersal of funds should be an emphasis on strengthening the exposure of local agents to international linkages and procedures, including informal international knowledge communities (Ernst, 2001f). Last but not least, a fifth element of an integrated strategy involves the creation of robust sources of investment and innovation finance. It has become standard to propose a replication of US-style venture capital. Reflecting the vast differences in economic institutions, that approach however has produced only minor results. This raises a number of issues that need to be addressed by policy-oriented research. For instance, there is now evidence that corporate stock and venture capital have become critical sources of innovation finance worldwide. What changes does this require in Asian financial systems that were traditionally focused on directed credit? And how could international development agencies help poorer countries that try to build on their existing micro-finance systems?

---

environment (World bank, 1998). There are also individual examples of ICT assisting government agencies,

REFERENCES

Avgerou,C. and G. Walsham (eds), 2000, Information Technology in Context, Ashgate, Aldershot, UK

Balassa, B., 1970, “Growth Strategies in Semi-Industrial Countries”, The Quarterly Journal of Economics, Vol.84 #1

Bartzokas,A. and M. Teubal (eds), 2002, special issue of the Journal of the Economics of Innovation and New Technologies, on “Integrating Policy Perspectives in Research on Technology and Economic Growth”

Bell, Martin and Keith Pavitt [1993], "Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries", Industrial and Corporate Change, Vol.2, No.2

Best, M., 2001, “Globalization and Localization of Value Networks”, East-West Center Working Paper, Economics Series, # 35

Boston Consulting Group, 2001a, Digital Dragons. How Asia-Pacific`s Large Companies can Generate Real Value from Consumer E-Business, Bostong Consulting Group, July

Boston Consulting Group, 2001a and 2001b

Bradley, S P. and R.L. Nolan (eds.),1998, Sense and Respond: Capturing Value in the Network Era, Harvard Business School Press, Boston

Braudel, F., 1992, The Perspective of the World, Civilization and Capitalism. 15^{th} -18^{th} Centuries, Volume 3, University of California Press, Berkeley

Bruton, H.J., 1968, “Import Substitution and Productivity Growth”, The Journal of Development Studies, April

Bruton, H.J., 1967, “Productivity Growth in Latin America”, American Economic Review , December

Brynjolfson, E. and L.M. Hitt, 2000, “Beyond Computation: Information Technology, Organizational Transformations and Business Performance”, manuscript, Sloan School of Management, MIT, July

---

universities, and hospitals, some of which can serve the poor (UNDP, 2001).

Chandler, A. D. and J.W. Cortada, 2000, " The Information Age: Continuities and Differences", chapter 9 in: Chandler, A. D. and J.W. Cortada (eds.), A Nation Transformed by Information, Oxford University Press, Oxford and New York

Chen, Tain-Jy and Shin-Horng Chen, 2001, "Global Production Networks and Local Capabilities: New Opportunities and Challenges for Taiwan", East-West Center Working Paper, Economics Series, #15

Cheskin Research, 2000, Greater e-China Insights. Online Behaviors and Attitudes in Greater China, study prepared in cooperation with chinadotcom corporation, Redwood Shores, California, October

Cheung, Kei, 2000, Telecommunication Access and E-Commerce Prospects in Asia, paper presented at the Second Asia Academy of Management Conference, December 15-18, 2000, Shangri-La Hotel, Singapore

Chismar, W.G., 2000, "Developing Cooperation for Regional Information Infrastructure", manuscript, Business School, University of Hawaii at Manoa, June 27, 16 pages

Christensen, C. M., 1997, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Boston: Harvard Business School Press.

Ciborra, C.U. et al, 2000, From Control to Drift. The Dynamics of Corporate Information Infrastructures, Oxford University Press, Oxford etc.

D`Costa, A.P., forthcoming, "Software Outsouricng and Policy Implications: An Indian Perspective", International Journal of Technology Management

Dahlman,C. and T. Andersson, 2000, Korea and the Knowledge-Based Economy. Making the Transition, a joint OECD and World Bank Institute study, Paris

Ernst, D., 2001a, "The Internet, Global Production Networks and Knowledge Diffusion. Challenges and Opportunities for Developing Asia", in: Pacific Telecommunications Council, PTC2001: From Convergence to Emergence: Will the User Rule?, proceedings of the 2001 Annual Pacific Telecommunications Council Conference, January 14-18, 2001, Honolulu, Hawaii

Ernst, D., 2001b,"The Internet`s Effects on Business Organization: Bane or Boon for Developing Asia?, Asia Pacific Issues No. 48, January 2001, East-West Center. Honolulu, Hawaii

Ernst, D., 2001c, “The Internet`s Effects on Global Production Networks: Challenges and Opportunities for managing in Developing Asia”, East-West Center Working Paper, Economics Series, # 33

Ernst, D., 2001 d, “The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks”, in: Latham, R. and S. Sassen (eds.), Cooperation and Conflict in a Connected World, Social Science Research Council, New York

Ernst, D., 2001e, “The Economics of Electronics Industry: Competitive Dynamics and Industrial Organization”, in: The International Encyclopedia of Business and Management (IEBM), editors: Malcolm Warner and William Lazonick, International Thomson Business Press, London

Ernst, D., 2001f, “Global Production Networks and the Changing Geography of Innovation Systems. Implications for Developing Countries”, special issue of the Journal of the Economics of Innovation and New Technologies , on “Integrating Policy Perspectives in Research on Technology and Economic Growth”, edited by Anthony Bartzokas and Morris Teubal.

Ernst, D., 2001g, “Moving Beyond the Commodity Trap? Trade Adjustment and Industrial Upgrading in East Asia´s Electronics Industry”, in: R.S. Newfarmer and C.A. Wood, eds, East Asia: From Recovery to Sustainable Development, World Bank, Washington, D.C.

Ernst, D., 2001, “Catching-Up and Post-Crisis Industrial Upgrading. Searching for New Sources of Growth in Korea’s Electronics Industry”, in: Deyo, F., R. Doner and E. Hershberg (editors), Economic Governance and the Challenge of Flexibility in East Asia, Rowman and Littlefield Publishers

Ernst, Dieter, 2000, “Inter-Organizational Knowledge Outsourcing: What Permits Small Taiwanese Firms to Compete in the Computer Industry? Asia Pacific Journal of Management, 17, 2, 223-255

Ernst, D., 1998, “Catching-Up, Crisis and Industrial Upgrading. Evolutionary Aspects of Technological Learning in Korea`s Electronics Industry “, in: Asia Pacific Journal of Management, Volume 15, #2

Ernst, D., 1997 a, “Partners in the China Circle? The Asian Production Networks of Japanese Electronics Firms”, in: Barry Naughton (ed.), The China Circle, The Brookings Institution Press, Washington, D.C.

Ernst, D., 1997b, From Partial to Systemic Globalization. International Production Networks in the Electronics Industry, report prepared for the Sloan Foundation project on the Globalization in the Data Storage Industry, The Data Storage Industry Globalization Project Report 97-02, Graduate School of International Relations and Pacific Studies, University of California at San Diego (94 pages)

Ernst, D., 1994, What are the Limits to the Korean Model? The Korean Electronics Industry Under Pressure, A BRIE Research Monograph, The Berkeley Roundtable on the International Economy, University of California at Berkeley, Berkeley, 129 pages

Ernst, Dieter, 1983, The Global Race in Microelectronics, with a foreword by Prof. David Noble, Massachusetts Institute of Technology (MIT), Campus Publishers, Frankfurt and New York, 290 pages

Ernst, D., 1973, "Economic Development Through Import -Substituting Industrialization? The Case of Latin America" (in German), in: Das Argument, Vol.15, # 4-6, pages 332- 403, July

Ernst, D. and He Jiacheng, 2000, "The Future of E-Commerce in China", AsiaPacific Issues, No.46, East-West Center, Honolulu, October

Ernst, D. and J. Ravenhill, 1999, "Globalization, Convergence, and the Transformation of International Production Networks in Electronics in East Asia", Business & Politics, Vol I#1

Ernst, Dieter and Paolo Guerrieri, 1998, "International Production Networks and Changing Trade Patterns in East Asia. The Case of the Electronics Industry", Oxford Development Studies, Vol.26, No.2, June

Ernst, D, T. Ganiatsos and L. Mytelka (eds.), 1998, Technological Capabilities and Export Success - Lessons from East Asia, Routledge Press, London etc.

Ernst, D. and O'Connor, D. [1992], Competing in the Electronics Industry. The Experience of Newly Industrialising Economies, Development Centre Studies, OECD, Paris, 303 pages

Ernst, Dieter and David O'Connor [1989], Technology and Global Competition. The Challenge for Newly Industrialising Economies, OECD Development Centre Studies, Paris, 149 pages

Globerman, S., 1997, " Transnational Corporations and International Technological Specialization", Transnational Corporations, vol6., #2, August

Grossman, G.M., and E. Helpman, 1991, Innovation and Growth in the Global Economy, MIT Press, Camb ridge/Mass.

Gu, Shulin and W.E. Steinmueller, 1997, China´s National Innovation System Approach to Participating in Information Technology, Institute for new Technologies (INTECH), The United Nations University (UNU), Discussion Paper 9701, Maastricht

Hachigian, N., 2001, "China`s Cyber Strategy", Foreign Affairs, March/April

Hagstrøm, P. (2000), "New Wine in Old Bottles: Information Technology Evolution in Firm Strategy and Structure", in: Birkinshaw, J. and P. Hagstrøm, eds., The Flexible Firm. Capability Management in Network Organizations, Oxford University Press, Oxford etc.

Heeks, R., 2001, " Academic Writings on Information Systems and Development", Short Papers on Development Informatics, Institute for Development Policy and Management, University of Manchester

Heeks, R., 2000, " Lessons for Development from the `New Economy`", Short Papers on Development Informatics, Institute for Development Policy and Management, University of Manchester

Heeks, R., 1999, "Information and Communication Technologies, Poverty and Development", Working Paper Series on Development Informatics, #5, Institute for Development Policy and Management, University of Manchester

Hirschman, A.O., 1958, Strategy of Economic Development, Yale University Press, New Haven

Hobday, M., 1995, Innovation in East Asia: The Challenge to Japan, Edward Elgar, Aldershot

ITU, 1999, "Internet for Development", International Telecommunications Union (ITU), Geneva

ITU, Yearbook of Statistics, 1995 to 2001;

Jacob, R., M. Dickie, J. Leahy, 2001, "Collapse in Demand. Asia reaps Whirlwind of Over-Reliance on Exports", Financial Times, July 12, p. 4

Jørgensen, H.D. and J. Krogstie, 2000, "Active Models for Dynamic Networked Organisations", Working Paper #, Institute of Computer & Information Sciences, Norwegian University of Science and Technology, available from hdj.jok@ informatics.sintef.no

Kim Linsu, 2000, "Crisis and National Innovation System: Its Renegineering in Korea", paper prepared for International Workshop on `Åinnovation and Crisis: Asian technology after the Millenium", MIT, Cambridge, Mass., September 15-16

Kim, Linsu, 1997, Imitation to Innovation. The Dynamics of Korea´s Technological Learning, Harvard Business School Press, Boston, Mass.

Lall, S., 1997, “Technological Change and Industrialization in the Asian NIEs: Achievements and Challenges”, paper presented at international symposium on “Innovation and Competitiveness in Newly Industrializing Economies”, Science & Technology Policy Institute, Seoul, Korea, May 26-27.

Lazonick, W. (2000), Understanding Innovative Enterprise: Toward the Integration of Economic Theory and Business History, manuscript, University of Masachusetss Lowell and The European Institute of Business Administration (INSEAD), Fontainebleau, May

Lipsey, R., 2001, “Understanding Technological Change”, East-West Center Working Papers: Economics Series, No.13, February

Litan, R.E., and A.M. Rivlin, eds., 2001, The Economic Payoff from the Internet Revolution, Internet Policy Institute, Brookings Institution Press

Lu, Qiwen, 2000, China`s Leap into the Information Age: Organization and Innovation in the Computer Industry, Oxford University Press

Luce, E. and L. Kehoe, 2001, “A Dip in Silicon Valley.”, Financial Times, April 19, 2001

Mansell, R. and U. When (eds), 1998, Knowledge Societies, Oxford University Press

Mathews,J.A. and Dong-Sung Cho, 2000, Tiger Technology. The Creation of a Semiconductor Industry in East Asia, Cambridge University Press, Cambridge

Milgrom, P. and J. Roberts (1990), “The Economics of Modern Manufacturing: Technology, Strategy, and Organization”,The American Economic Review, Vol. 80,no.3: 511- 528

Naya, S., S. Mark, and R. McCleery, 2001, The Asian Development Experience: Overcoming Crises and Adjusting to Change, paper prepared for the CAPID (= Center for Asia-Pacific Infrastructure Development) conference, Hilton Hawaiian Village, Honolulu, August 23-25

Nelson, R. and H. Pack, 1995, “The Asian growth miracle and modern growth theory”, manuscript, School of International and Public Affairs, Columbia University, December

Nelson, R. R. and S. G. Winter, 1982, An Evolutionary Theory of Economic Change, Bellknap Press, Cambridge:Mass

Nelson, R.R. (1990), "Acquiring Technological Capabilities", in: H. Soesastro and M. Pangestu (eds.), Technological Change in the Asia-Pacific Economy, Allen and Unwin, Sydney

Nolan, R.L. (2000), “Information Technology Management since 1960”, in: Chandler, A. D. and J.W. Cortada (eds.), A Nation Transformed by Information, Oxford University Press, Oxford and New York

NTIA, 1999, Falling Through the Net: Defining the Digital Divide, National Telecommunications and Information Administration, U.S. Department of Commerce, Wahsington, D.C.

Odedra-Straub, M. (ed.), 1996, Global Information Technology and Socio-Economic Development, Ivy League Publishing, Nashua, NH

OECD, 2001, Knowledge-Based Industries in Asia, Directorate for Science, technology & Industry (DSTI), OECD, Paris

OECD, Information Technology Outlook . ICTs, E-Commerce and the Information Economy, 2000, Paris

Oki, T., 2001, “ICT Infrastructure Development and the Growth of E-Commerce in Asia”, RIM. Pacific Business and Industries, Vol. I, # 50, pages 68-80

Ozawa, T. (2000), “The ‘Flying-Geese´Paradigm: Toward a Co-evolutionary Theory of MNC-Assisted Growth”, in: K. Fatemi (ed.), The New World Order: Internationalism, Regionalism and the Multinational Corporationjs, Pergamon, Amsterdam and New York

Penrose, Edith, T. 1959/1995. The Theory of the Growth of the Firm. Oxford: Oxford University Press

Pohjola, M., 2000, “Information technology and Economic Growth: A Cross-Country Analysis”, UNU World Institute for Development Economics (WIDER) Working Paper, # 173, Helsinki

Prebisch, R., 1962, “The Economic Development of Latin America and its Principal Problems”, Economic Bulletin for Latin America, United Nations Economic Commission on Latin America, New York, Vol VII/1, February

Prystay, C., 2001, “Malaysia Seeks to Lift Super Corridor”, Asian Wall Street Journal, August 24

Quibria, M.G. and T. Tschang, 2001, “Information and Communication Technology and Poverty: An Asian Perspective”, Asian Development Bank Institute Working paper # 12, Tokyo, January

Rasiah, R., 2001, “Politics, Institutions and Flexibility: Microelectronics Transnationals and Machine Tool Linkages in Malaysia”, in: Deyo, F., R. Doner and E. Hershberg (editors), Economic Governance and the Challenge of Flexibility in East Asia, Rowman and Littlefield Publishers

Richardson, G.B. 1960/1990. Information and Investment. Oxford: Oxford University Press

Romer, P.M., 1990, “Endogenous Technological Change”, Journal of Political Economy, 98: S71-S102

Rosenberg, N. and L.E. Birdzell, 1986, How the West Grew Rich. The Economic Transformation of the Industrial World, Basic Books, New York

Schumpeter, 1961, The Theory of Economic Development, Harvard University Press, Cambridge, Mass

Sender, H., 2001, “Asian Tech Companies Study Silicon Valley”, Asian Wall Street Journal, August 8,2001

Strassman, P., 2001, The Economics Of Information, Butler Group,

Thornhill, J. and J. Burton, 2001, “Asia Falling”, Financial Times, August 10,2001

UNCTAD, 2000, chapter 3

UNDP, 2001, Creating a Development Dynamic. Final Report of the Digital Opportunity Initiative, jointly published with Accenture and Markle Foundation, United Nations, New York

Wong, Poh Kam, 2000, “Riding the Waves: Technological Change, Competing US-Japanese Production Networks, and the Growth of Singapore`s Electronics Industry, in: Borrus, M., D. Ernst and S. Haggard (eds.), International Production Networks in Asia. Rivalry or Riches?, Routledge, London

World Bank, 1998, East Asia: The Road to Recovery, The World Bank, Washington, D.C., September

Table 1. Specialization-Upgrading Matrix

Variables	Complexity/Uncertainty	
	Low	High
Product Specialization	**Homogeneous (commodities)** • Mature technology • Established design • Easy to replicate • Predictable changes in demand & technology • Limited interactions w/customers	**Differentiated** • New technology • Fluid design • Difficult to replicate • Unpredictable changes • Close interaction with customers
Process Specialization	**Mass Production** • Economies of scale & scope	**Flexible Specialization** •Speed of response
Market Structure	•Low entry barriers • Price competition • Limited value generation: periodic over-capacity & price wars ⇒⇒ deflationary pricing pressures	• High entry barriers • Premium pricing • Significant value generation
Upgrading	• Limited technological learning requirements • Limited pressure to develop forward & backward linkages	• Substantial pressure to broaden & deepen local knowledge base • Ditto for linkages

Table 2. Developing Asia's Electronics Exports Growth

	1992	1993	1994	1995	1996	1997	1998
Korea	5.8	6.7	23.7	35.5	-3.3	6.5	-6.7
Taiwan	10.3	10.9	15.4	32.4	8.5	10.5	1.4
Singapore	16.9	25.1	45.0	26.2	5.6	0.0	-10.9
Malaysia	24.4	30.4	37.8	31.2	5.7	2.6	-4.1
Thailand	25.7	16.1	40.3	29.3	12.6	8.9	
Philippines						29.2	31.7
China		21.5	49.6	36.0	9.1	23.6	13.6

Source: UN Trade Data Base Comtrade

Table 3 Impact of Trade Recession

Table 3a: Korea

Indicator/Year	1996	1998	1999	2000	2001
Merchandise Exports (% growth)			+19	+20	-14 (June, yoy) -17 (July, yoy)
SC exports (% growth) In 2000 =12% of merchandise exports; =5.7% of GDP		-6.7 (total electronics exports)		+32 (1. half)	-26 (1. half) -14.4 (1. half, total electronics exports)
Computers			≥6 times		-19 (1. half)
Export dependence (exports/GDP,%)	25			40	

Sources: Computed, based on EIAK data

Table 3b. Taiwan

Growth of merchandise exports (yoy,%)	-17 (June 2001) > - 20 (projection for 3.q. 2001)
Output growth of electronics industry (yoy, %)	> - 15 (projection for 2001)
Share of electronics exports to US in Taiwan´s total electronics exports (%)	40
Exports of Hsinchu Science Park/ total exports of Hsinchu Science Park (%)	> 90

Table 3c. Southeast Asia

Decline of June 2001 merchandise exports, yoy,%	Malaysia: -14 Indonesia: -10
Malaysia (%)	• Electronics exports, growth (2.q, yoy): -18.4 • Electronics production, growth (2.q, yoy): -25.2 • Electronics exports/total exports: 59 • Exports to the US/GDP: 24
Singapore (%)	• Electronics exports, growth (2.q, yoy): >-20 • Electronics exports/total exports: 64 • Exports to the US/GDP: 26

Table 3d. China

Growth of electronics exports, July 2001 (yoy, %)	-8
Electronics exports/total exports (%)	30

Table 4. Asian Trade Specialization Profiles: RCA and Leading Export Products

Country	Product	RCA '93	RCA '94	RCA '95	RCA '96	RCA '97	RCA '98	Share in Electronics exports (%) '93	'94	'95	'96	'97	'98
Korea	Computers	0.9	0.8	0.8	0.9	0.9	0.7	14.4	11.9	12.2	14.5	15.5	13.9
	o/w storage	0.2	0.3	0.4	0.7	1.3	1.1	0.5	0.8	1.0	1.8	4.1	4.1
	Components	2.4	2.7	2.8	2.7	2.8	2.7	50.1	56.2	62.4	60.8	62.3	63.4
	o/w semiconductors	3.3	3.8	4.1	3.6	4.0	3.8	30.4	37.2	45.7	40.3	42.9	45.3
	Consumer electronics	2.3	2.4	2.0	2.0	1.7	1.5	22.5	20.5	16.1	15.6	12.8	12.7
	Telecommunications	0.9	0.9	0.8	0.8	0.6	0.5	3.0	2.7	2.4	2.4	2.1	1.9
	Memo: Share of Electronics in Merchandise exports (%)	28.0	29.7	30.9	28.8	29.2	28.3						
Taiwan	Computers	2.5	2.7	3.0	3.4			39.4	39.0	41.6	45.0	44.62	45.29
	o/w storage	0.3	0.3	0.5	0.6			0.8	0.6	1.0	1.3	2.10	1.97
	Components	1.9	2.0	2.1	2.2			37.2	39.3	41.6	40.2	41.93	40.86
	o/w semiconductors	1.6	1.8	2.0	2.2			13.7	16.8	20.4	19.6	22.05	21.77
	Consumer electronics	1.4	1.5	1.2	1.1			12.9	12.0	8.5	6.8	6.42	5.98
	Telecommunications	1.7	1.7	1.6	1.6			4.9	4.8	4.1	4.0	3.59	4.20
	Memo: Share of Electronics in Merchandise exports (%)	29.5	31.0	34.3	35.8								
Singapore	Computers	4.6	5.1	5.1	5.4	5.5	5.2	40.7	38.6	39.4	42.8	44.1	44.6
	o/w storage	12.9	13.4	12.8	15.3	12.4	11.4	17.6	15.7	16.0	18.8	19.3	19.8
	Components	2.7	3.4	3.4	3.6	3.7	3.7	29.4	35.4	38.5	38.0	38.9	40.7
	o/w semiconductors	3.2	4.0	4.2	4.5	4.8	5.0	15.7	19.4	23.8	23.9	25.0	27.4
	Consumer electronics	3.1	3.2	2.9	2.9	2.3	1.7	15.9	13.7	11.6	10.4	8.7	6.8
	Telecommunications	1.1	1.2	1.1	0.8	0.7	0.6	1.9	1.9	1.6	1.3	1.1	1.1
	Memo: Share of Electronics in Merchandise exports (%)	53.0	58.8	60.7	60.7	60.6	61.4						
Malaysia	Computers	1.4	1.8	2.0	2.3	2.9	3.0	13.8	15.6	17.1	20.5	25.3	27.4
	o/w storage	0.0	0.1	0.8	0.2	3.7	4.1	0.0	0.2	1.1	0.3	6.3	7.6
	Components	3.7	3.7	3.6	3.8	3.9	3.9	44.6	42.6	43.9	44.6	45.1	45.7
	o/w semiconductors	5.6	5.2	4.7	4.9	5.3	5.2	30.5	28.3	29.8	29.3	30.1	30.7
	Consumer electronics	4.2	5.0	5.1	5.0	4.1	3.5	24.2	24.2	22.6	20.1	16.5	15.1
	Telecommunications	2.1	2.4	2.0	2.0	1.7	1.5	3.8	4.0	3.2	3.3	3.1	2.8
	Memo: Share of Electronics in Merchandise exports (%)	47.6	52.5	54.9	54.7	55.8	57.5						
Thailand	Computers	1.4	1.8	1.9	2.4	2.5		32.2	34.0	36.8	41.4	40.9	
	o/w storage	2.8	5.4	4.6	4.5	2.0		9.8	15.5	14.0	11.9	6.2	
	Components	1.4	1.5	1.5	1.6	1.6		38.4	38.8	39.9	36.5	35.8	
	o/w semiconductors	1.7	1.6	1.4	1.6	1.7		20.8	19.3	19.5	18.8	18.3	
	Consumer electronics	1.3	1.6	1.4	1.5	1.7		16.7	16.4	13.3	12.0	13.1	
	Telecommunications	1.2	1.1	1.0	1.2	1.2		5.2	3.9	3.7	4.1	3.9	
	Memo: Share of Electronics in Merchandise exports (%)	20.8	24.0	24.9	28.4	29.6							

Source: UN Trade Data Base Comtrade

Table 5. Dependence on Input Imports

		In Electronics Imports (%)						In Merchandise Imports (%)					
		1993	1994	1995	1996	1997	1998	1993	1994	1995	1996	1997	1998
Korea	Components	57.0	53.2	54.1	55.3	60.2	71.6	9.5	9.5	9.7	10.0	12.0	16.6
	o/w Semiconductors	34.8	34.0	35.7	36.8	43.0	54.7	5.8	6.0	6.4	6.7	8.6	12.7
Taiwan	Components	66.3	67.5	70.0	65.3			13.7	14.8	16.9	16.7		
	o/w Semiconductors	41.2	43.9	46.5	43.1			8.5	9.7	11.2	11.0		
Singapore	Components	48.0	52.9	56.9	55.4	53.4	56.4	18.6	23.2	26.0	24.3	23.8	26.5
	o/w Semiconductors	25.0	30.5	35.6	33.9	33.6	37.3	9.7	13.4	16.2	14.9	15.0	17.5
Malaysia	Components	76.5	78.7	78.1	76.7	72.8	78.5	25.3	28.3	28.8	29.6	28.3	36.7
	o/w Semiconductors	42.9	45.9	49.7	49.6	49.2	56.5	14.2	16.5	18.3	19.1	19.1	26.4
Thailand	Components	55.1	55.9	59.1	60.0	58.7		9.6	11.6	12.4	12.6	14.1	
	o/w Semiconductors	26.4	26.8	28.7	30.2	29.9		4.6	5.6	6.0	6.4	7.2	
Philippines	Components	37.8	40.3	43.7	54.7	34.9		5.8	6.6	7.7	20.7	9.4	
	o/w Semiconductors	28.0	28.8	30.3	46.6	27.0		4.3	4.7	5.4	17.7	7.3	
Indonesia	Components	46.4	48.6	46.3	37.5	33.8	33.9	4.4	3.5	3.3	3.2	3.0	2.0
	o/w Semiconductors	4.5	4.0	3.8	2.9	2.1	2.4	0.4	0.3	0.3	0.2	0.2	0.1
Hong Kong	Components	38.0	38.1	39.7	39.6	40.5	40.1	9.8	10.4	11.6	11.6	12.5	12.8
	o/w Semiconductors	18.8	18.7	20.7	20.2	20.3	19.6	4.8	5.1	6.0	5.9	6.3	6.2
China	Components	40.9	43.1	44.3	49.6	55.0	53.1	5.3	6.3	6.9	7.4	9.2	11.4
	o/w Semiconductors	11.0	12.5	14.7	17.7	21.4	22.3	1.4	1.8	2.3	2.6	3.6	4.8

Table 6. Comparison of Internet Users as a Percentage of Total Population

	Total Population	Internet Users	Internet Users as % of Total Population
Mainland China	1.3 billion	16.9 million	1.3
Hong Kong	7 million	1.9 million	27
Taiwan	22 million	6.4 million	29
Chinese in the U.S.	3 million	2.1 million	70

Source: Nua Internet Surveys (July 2000)

Table 7. Digital Divides: Indicators

I. ICT readiness

1. Teledensity (telephone main lines per 1,000)
2. Mobile phone density per 1,000
3. Internet hosts per 10,000
4. PC per 1,000
5. Internet users per 1,000
6. Internet monthly access charges (US-$) (phone call & ISP charges)
7. per capita GDP
8. Knowledge (combined first-, second, and third-level gross enrollment ratio)
9. Trust (1-piracy rate)

II. E-business readiness

1. Secure servers per 1,000
2. Size of combined ERP and ASP markets
3. Licenses for 2.5G and 3G systems
4. Investment in broadband infrastructure

III. Matching Production & Use of ICT

1. ICT investment, as % of GDP
2. ICT investment in electronics industry, as % of GDP
3. ICT investment in non-electronics industries, as % of GDP
4. Employment figures, electronics industry
5. Aggregated ICT employment
6. Investment and R&D in electronics industry

Table 8. New Economy: Unfulfilled Promises

Claims	Reality
The traditional business cycle is dead	• America's GDP growth falls from 5% in 2000 to 0.7% or lower • "Nobody understands what is going on" • "I have never seen anything like this before"
More predictable inventory cycles →→ Smother business cycle	• limited visibility", even for Cisco &Dell 1.Q 2001: Cisco had $2.2 billion worth of surplus inventory of components = equivalent to almost 50% of its sales during the period
• Nothing can stop rise in profitabilityShare prices are delinked from profitability: new rules apply for share evaluation	• Average profits are projected to fall by at least 10% in 2001 • Free fall in P/E ratios since the burst of the dotcom bubble
Non-IT industries will continue to invest heavily in ICT, even during recession	No: ICT investments are in free fall, across all sectors 2.Q 2001: ICT investment in U.S. fell > 15% in real terms (compared to 2.Q 2000)
Shift to higher sustainable growth due to faster improvements in labor productivity & TFP	• Accelerated productivity growth: yes (1995-2000: ca 2.0% for labor productivity in America's non-business sector) • BUT: Will productivity gains survive global recession? • U.S. productivity declines since 1.Q 2001
• Fundamental transformations in economic structures and institutions	• Yes, but this is only new to neo-classical economists

Table 9: Recommendations for Funding Priorities

A. Reaping the Benefits of Network Participation

- Local supplier development programs
- Co-funding of Skill Development Schemes
- Standards & ISO qualifications

B. Infrastructure Development

- Move beyond hardware bias: development of professional services

C. Market Development (domestic; macro-region)

- Training of potential sophisticated users (banks, local suppliers)
- Micro-finance for weaker/backward users

D. Reform of Educational & Training Systems

- Key: strengthen exposure to international linkages and procedures

E. Creating Robust Sources of Investment and Innovation Finance

- Corporate stock and venture capital have become critical sources of innovation finance worldwide.
- What changes does this require in Asian financial systems that were traditionally focused on directed credit?
- How to integrate micro-finance systems?

Figure 1. Taxonomy of Strategies and Sequencing Patterns