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Information Technology in The Learning Economy - Challenges for Developing Countries

by
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Abstract
This paper inquires how the concept of the "learning economy" can be applied to the requirements of developing countries. The main purpose is to develop an analytical framework to better understand how learning and capability formation can foster industrial upgrading. Special emphasis is given to te spread of information technology (IT). We inquire under what conditions developing countries can use this set of generic technologies to improve their learning capabilities. We argue that information technology should not be regarded as a potential substitute for human skills and tacit knowledge. Instead, its main role should be to support the formation and use of tacit knowledge.

In the paper we compare two stylised models of the learning economy, the Japanese versus the American model. The Japanese model is explicit in its promotion and exploitation of tacit knowledge, while the American model is driven by a permanent urge to reduce the importance of tacit knowledge and to transform it into information - that is into explicit,

well structured and codified knowledge. We show that each of these models has peculiar strengths and weaknesses. Developing countries need to develop their own hybrid forms of institutions that combine the advantages of both models in a way that is appropriate to their idiosyncratic needs and capabilities.

Keywords
information technology; learning; learning economy; knowledge; capabilities; networks; developing countries; economic development; industrial upgrading.

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Contents

"The engine of growth should be technological change, with international trade serving as a lubricating oil and not as fuel."

(W.A. Lewis, The Evolution of the International Economic Order, Princeton/N.J., Princeton University Press, 1978, p.74)

"..Both the pace and the acceleration of innovation are startling; nay terrifying....No-one can predict the ... range of skills which will need to be amassed to create and take advantage of the next revolution but one (and thinking about the next but one is what everyone is doing. The game is already over for the next).

(Bob Anderson, Director, Rank Xerox Research Centre, Cambridge Laboratory, "R&D Knowledge Creation as a Bazaar Economy", paper presented at OECD-IEE workshop on Competition and Innovation in the Information Society, 19th March, 1997)

Introduction

Research in OECD countries has shown that the capability to learn determines the economic success, not only of firms and industries, but also of whole regions (industrial districts) and countries[1]. This has given rise to the concept of the "learning economy" which is based on the following propositions[2]: learning is an interactive, socially embedded process; its efficiency crucially depends on the institutional set-up, the national innovation system. Of critical importance however is the contents of knowledge that is generated through learning: tacit knowledge is essential for adjusting to change (flexibility) and for implementing change (innovation).

This paper inquires how the concept of the "learning economy" can be applied to the requirements of developing countries. Our focus is on the industrial sector. The main purpose is to develop an analytical framework to better understand how learning and capability formation can foster industrial upgrading. Special emphasis is given to the spread of information technology (IT). We inquire under what conditions developing countries can use this set of generic technologies to improve their learning capabilities. As a growing

[1] OECD (1996a), (1996b), and (1996c)
[2] Lundvall and Johnson (1994) and Lundvall (1995) and (1996).

amount of knowledge becomes accessible through world-wide information networks, the establishment of national IT-capabilities should help to accelerate knowledge creation and diffusion. But the IT-revolution also poses new challenges: it increases the inequality of access to knowledge, while at the same time accelerating the pace of economic and technical change. In order to cope with these new opportunities and challenges, it is imperative that developing countries broaden their capability base. The paper emphasizes the need to improve learning capabilities in all parts of the economy. We argue that information technology should not be regarded as a potential substitute for human skills and tacit knowledge. Instead, its main role should be to support the formation and use of tacit knowledge. We proceed in four steps.

We start with a brief description of the challenge that developing countries are facing today in their attempt to cope with the impact of globalization and to upgrade their industrial sectors. (**I. The challenge for developing countries)** We show that trade has lost its predominant role as the engine of growth. Instead, developing countries are eager to participate in the international production networks of transnational corporations. This requires an upgrading of their sources of competitiveness: a shift is necessary to an alternative development paradigm, with learning and capability formation as the core elements of development strategy.

We then explain why tacit knowledge is essential for adjusting to rapid change in markets and technology as well as for innovation. **(II. The Critical Importance of Tacit Knowledge)** We show that, as globalization of competition, shorter product cycles and rapid technical change all combine to increase uncertainty, tacit knowledge has substantially increased in importance.

In the third part of the paper, we discuss how the diffusion of information technology affects the access to tacit knowledge for local agents in developing countries. **(III. The Impact of Information Technology .)** We show that a massive transfer of tacit knowledge into information systems in principle provides developing countries with better access to new recipes (process technology as well as products) developed in rich countries. At the same

time however, IT speeds up the rate of economic change and increases uncertainty, with the result that developing countries must permanently restructure and upgrade.

Finally in part IV, we ask which institutional features of a national production system are best suited for improving the diffusion of tacit knowledge. (**IV. What Kind of Learning Economy is Appropriate for Developing Countries?)**. We compare two stylised models of the learning economy, the Japanese versus the American model[3]. Our focus is on the role of tacit knowledge. The Japanese model is explicit in its promotion and exploitation of tacit knowledge while the American model is driven by a permanent urge to reduce the importance of tacit knowledge and to transform it into information - that is into explicit, well structured and codified knowledge. The American model emphasizes market selection, competition, income inequality and strict control by financial markets as a way of promoting learning, while the Japanese model puts more emphasis on cooperation, social cohesion and long term social relationships.

We show that each of these models has peculiar strengths and weaknesses. For any particular developing country, their usefulness depends on its stage of development. None of the two stylised models gives the full answer. Developing countries need to develop their own hybrid forms of institutions that combine the advantages of both models in a way that is appropriate to their idiosyncratic needs and capabilities.

I. The Challenge for Developing Countries

Developing countries have gone through a long history of unequal integration into the world economy. As W.A. Lewis observed in 1980: "For the past hundred years the rate of growth of output in the developing world has depended on the rate of growth of output in the developed world. When the developed grow fast, the developing grow fast, and when the developed slow down, the developing slow down."[4]

[3] For related papers that compare the Taiwanese and the Korean models, see Ernst 1997b and 1997c

[4] Lewis, 1980, p.555

This strong linkage continues to hold[5]. Yet, the forms of this integration have changed considerably, and this has had important implications for development strategies. These changes result from the combined impact of globalization and the spread of a set of generic technologies, especially information technology (IT), with a large potential for productivity enhancement. In this first section, we will briefly describe the new challenges that developing countries (DCs) face today as a result of globalization[6]. We show that learning and knowledge creation, more than ever before, determine the success or failure of development strategies.

1. Globalization

International trade was the main engine of growth for DCs until the mid-1970s, the period covered by W.A. Lewis` article. Lewis` main concern was that stagflation in industrialized countries would slow down North-South trade with the result that it could no longer act as an engine of growth. Lewis`s suggestion was to strengthen South-South trade through a variety of selective regional trading blocs among DCs.

With the benefit of hindsight we know that this well-intentioned scenario did not materialize. Attempts to promote South-South trade almost invariably ended in failure. World trade remains highly concentrated on industrialized countries and the concentration is rising: the North`s share of world trade rose from 81% in 1970 to 84% in 1989[7]. Consequently, North-South trade has fallen as a proportion of the total and the share of South-South trade remains insignificant.

World trade growth has been slowing over the 1980s and 1990s relative to output growth: the ratio fell from 1.65 in 1965-80 to 1.34 in 1980-90[8]. Trade continues however to grow at a considerably faster pace than GDP. This implies that an increasing share of production goes to foreign markets. This raises the importance of foreign markets relative to domestic

[5] Note however that this linkage did not hold during the two main global wars of this century which had led to a breakdown of the international economy. During these two periods, countries like Brazil, Argentina, colonial India and Egypt experienced bouts of growth, based on import substitution. Classical sources include Hirschman 1968 and Furtado 1970. For a review of these debates, see Ernst 1973

[6] The impact of IT is discussed in part III.

[7] "North" refers "developed market economies", virtually identical with OECD member countries. UNCTAD,1991, table 3.4. in appendix I.

[8] World Bank, 1992, tables 2 and 14.

markets. The result is that a country's relative income, its welfare, becomes more dependent on the ability of its firms to compete against imports in the domestic market and against other producers in foreign markets. This is true for developing countries as much as for industrialized countries.

What matters however are the following important changes. Since the mid-1970s, Japan and later on also a handful of socalled newly industrialising economies (NIEs), primarily in Asia, have emerged as important new competitors in a variety of industrial manufacturing sectors. Over time, their focus has shifted from low-end, labor-intensive products (like textiles and household appliances) to capital- and knowledge-intensive products (like cars and computer-related products). Furthermore, since the mid-1980s, international investment has grown considerably faster than international trade[9]. By the 1990s, sales of the foreign affiliates of transnational corporations (TNCs) far outpaced exports as the principle vehicle to deliver goods and services to foreign markets. Increasingly, the focus of international market share expansion has shifted from exports to international production. The result is that a growing number of national economies have become mutually interconnected through cross-border flows of goods, services and factors of production.

This has set in motion a process of destabilizing established patterns of competition: erstwhile stable national oligopolies have been considerably eroded[10]. Competition today cuts across national and sectoral boundaries - hence the term "gobal competition"[11]. Firms are now forced to compete simultaneously in all major growth markets. Cost leadership has to be combined with product differentiation. This has led to a rapid expansion of international production: new production sites have been added at a breath-taking speed at lower-cost locations outside the industrial heartlands of Europe, North America and Japan.

Yet, quantitative expansion is only part of the story. Of equal importance are qualitative changes: a shift from partial to systemic forms of globalization. In order to cope with the increasingly demanding requirements of global competition, companies are forced to

[9] UNCTAD, 1996

[10] See the growing literature on "contestable markets" which shows that high concentration can go hand in hand with high contestability or openess to entry (Baumol et al, 1982). For a review of this literature, see UNCTAD, 1997, part two: "Foreign direct investment, market structure and competition policy".

[11] The following is based on Ernst, 1996b, chapter I

integrate their erstwhile stand-alone operations in individual host countries into increasingly complex international production networks[12]. Companies break down the value chain into discrete functions and locate them wherever they can be carried out most effectively and where they are needed to facilitate the penetration of important growth markets. Reduction of transaction costs is one important motivation. Of equal importance however are access to clusters of specialized capabilities and contested growth markets, and the need to speed up response time to technological change and to changing market requirements.

2. The neo-liberal concept of globalization

Pressure to liberalize capital and financial markets has further accelerated the pace of globalization. Yet relatively little of the literature dealing with developing countries has addressed the impact of globalization [13] . The dominant view is that globalization will act as a powerful equalizer and that, over time, it will lead to a greater uniformity of development potentials [14] . Among nations, liberalization reduces distortions to international trade; as more and more nations liberalize, national policies converge. Convergence is also expected among firms. Faced with similar constraints, firms are expected to converge in their organization and strategies, irrespective of their national origin[15]. Boyer has nicely summarized the underlying logic: "...everywhere firms facing the same optimizing problems find the same solution in terms of technology, markets and products, for there is one best way of organizing production - a single optimum among a possible multiplicity of local optima."[16]

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[12] The concept of an "international production network" is an attempt to capture the spread of broader and more systemic forms of international production that cut across different stages of the value chain and that may or may not involve equity ownership. This concept allows us to analyze the globalization strategies of a particular firm with regard to the following four questions: 1) Where does a firm locate which stages of the value chain? 2)To what degree does a firm rely on outsourcing? What is the importance of inter-firm production networks relative to the firm's internal production network? 3) To what degree is the control over these transactions exercised in a centralized or in a decentralized manner? And 4) how do the different elements of these networks hang together? For details, see Ernst, 1994a; 1996b; 1997a and 1997b; and Ernst and Ravenhill, 1997

[13] For a detailed analysis of the impact of globalization on industrialization in developing countries, see Ernst and O'Connor (1989), and Ernst and O'Connor (1992)

[14] For a typical example of this neo-liberal globalization doctrine, see Ohmae, 1991

[15] Vernon 1971, 1977; Graham and Krugman 1992

[16] Boyer (1996) , pages 47 and 40. We agree with Boyer¥s conclusion: " This syllogism that equates globalization with convergence is logically flawed, and its premise may not correspond to the current state of the world economy." (ibid., p.50)

This dominant view also argues that globalization will accelerate the decline of the nation state as the relevant unit of policy-making and that anything that smacks of industrial policy is unlikely to improve local competitiveness. Governments, in this view, should concentrate on the pervasive deregulation and liberalization of national economies. The more willing a government is to embrace sweeping liberalization, the more this country can use international trade and investment as engines of growth.

3. The critical importance of local capabilities

We do not agree with this neo-liberal concept of globalization. Nothing is predetermined about the impact of globalization[17]. It can certainly increase geographical inequality, if left to the invisible hand of the market and to the quite visible hand of transnational corporations. The main reason for this is that TNCs have become much more selective and demanding in their choice of locations. Low labor costs are taken for granted, and alternative locations are judged by the quality of certain specialized capabilities that the TNC needs in order to complement its own core competencies. Those regions that cannot provide such capabilities, are left out of the circuit of international production. Vast areas of the international economy that house a majority of the world population have thus experienced a dramatic decline in their development potential.

Alternatively, regions that can provide such capabilities and, as a result, can attract higher value-added investments, have clearly benefited. Successful late industrialization in Korea and Taiwan are cases in point[18]. Take the development of Korea's electronics industry[19] which arguably has been the most impressive example of such successful late industrialization - an industry that barely existed 25 years ago, has been able to transform itself into a credible international competitor in a very short period of time.

Rather than letting foreign firms establish local subsidiaries and decide on the speed and scope of technology diffusion, Korean firms focused on learning and knowledge accumulation through a variety of links with foreign equipment and component suppliers, technology licensing partners, OEM clients and minority joint venture partners. By licensing

[17] The following is based on Ernst, 1996a
[18] On Korea, see Amsden, 1989 and Ernst, 1994 a. On Taiwan, see Wade, 1990 and Ernst, 1997b.
[19] The following is based on Ernst, 1997 a

well-proven foreign product designs and by importing most of the production equipment and the crucial components, Korean electronics producers were able to focus most of their attention on three areas:[20]

(1) the mastery of production capabilities, initially for assembly, but increasingly also for related support services and for large mass production lines for standard products;

(2) some related minor change capabilities, ranging from "reverse engineering" techniques to "analytical design" and some "system engineering" capabilities that are required for process re-engineering and product customization;

(3) and, finally, some investment capabilities, especially the capacity to carry out at short notice and at low cost investments in the capacity expansion and/or modernization of existing plants and in the establishment of new production lines.

In order to succeed, Korean electronics firms had to develop the knowledge and skills that are necessary to monitor, unpackage, absorb and upgrade foreign technology. Equally important was a capacity to mobilize the substantial funds for paying technology licensing fees and for importing "best practice" production equipment and leading-edge components[21]. Most Korean electronics producers arguably would have hesitated to pursue such high-cost, high-risk strategies had they not been induced to do so by a variety of selective policy interventions by the Korean state. Getting relative prices "wrong" has been important[22]. By providing critical externalities such as information, training, maintenance and other support services, and finance, the Korean government has fostered the growth of firms large enough to hurdle high entry barriers.

It is due to these particular and, as we know today, historically conditioned circumstances that Korea's electronics firms were able to reverse the sequence of technological capability formation[23]. Rather than proceeding from innovation to investment to production, they could take a short-cut and focus on the ability to operate production facilities according to competitive cost and quality standards. Production capabilities thus were used as the

[20] For the underlying conceptual framework of capability formation, see Ernst, Mytelka and Ganiatsos [1997]. See also the excellent analysis in Bell and Pavitt [1993].

[21] Already in the 1970s, most Korean electronics firms had to pay on average roughly 3% of their sales for technology licensing fees, a share which since then has increased to more than 12% (Lee Jin-Joo [1992], pp.132, 139).

[22] Amsden [1989]

[23] Dahlman, Ross-Larson and Westphal [1987]

foundation for developing capabilities in investment and adaptive engineering, while product and market development and process innovation were postponed to a later stage of development. Through judicious "reverse engineering" and other forms of copying and imitating foreign technology and by integrating into the increasingly complex international production networks of American, Japanese and some European electronics companies, Korean electronics firms were able to avoid the huge cost burdens and risks involved in R&D and in developing international distribution and marketing channels.

4. The role of the state

The Korean approach to capability formation reflects the fact that markets are notoriously weak in generating such capabilities. They are subject to externalities: investments in capabilities are typically characterized by a gap between private and social rates of return[24]. The result is that national policy interventions are required that can compensate for these market failures. In addition to the subsidies and tax incentives, suggested by Arrow, this also implies a variety of organizational and institutional innovations in the implementation of government policies. There is now a much greater need for national and regional policies to develop local capabilities that can attract high value-added investments.

But there is also now more space for national policy and politics to vary and to make a difference. A growing body of research on economic policy-making in advanced industrial countries has demonstrated that choice is possible, in terms of institutions and policy instruments, and that this applies to macro-economic policy-making as well as to industrial and technology policies [25] . The same is true for developing countries. The real question then is no longer whether national policies can make a difference, but rather: What kind of policies and institutions are most conducive for improving local competitiveness?

Much confusion results from the fact that few people understand the time dimension involved. Policy requirements keep changing over time for two simple reasons: increasing complexity and a greater exposure to the international economy. As a developing country moves up from simple and labor-intensive to more complex products, much more

[24] Arrow, 1962

[25] For macroeconomic policies, see Frieden, 1991 and Fraenkel, Phillips and Chinn, 1992. For industrial and technology policies, see the contributions by Boyer, Wade, etc in: Berger and Dore (eds.), 1996

sophisticated policies are required. The main reason is that, with increasing complexity, entry barriers tend to rise. For local enterprises this implies that they need to have access to more demanding externalities that would enable them to overcome their disadvantages in terms of size and weak proprietary assets.
Externality requirements vary, depending on the market segment and the stage of development of a particular industry. For textiles, they are obviously less demanding than for semiconductors. And within the same product group, i.e. semiconductors, such requirements become much more complex, once the focus shifts from low-end discrete devices for consumer applications to higher-end design-intensive devices.

A greater exposure to the international economy is a second reason why industrial development policies need to develop over time. An increasing complexity of the domestic industry necessitates more international linkages. Such linkages are necessary to facilitate local capability formation. They encompass not only critical imports of key components and capital equipment and inward FDI. Such linkages also involve participation in international production networks as well as in a variety of specialized and informal “international peer group” networks that are essential carriers of knowledge creation.

The dynamics of change thus is of crucial importance for industrial development policies. Peter Evans` model of four archetypical roles that the state has played in industrial transformation, can help in this context.[26]

Amongst "developmental states" such as Korea, Brazil and India and in the information sector in particular, Evans argues, one can distinguish four archetypical roles that the state has played, sometimes seperately and sometimes in combination. These are [a] the custodian role in which the state regulates the market, generally privileging the policing function over promotional policies; [b] the "demiurge" in which the state plays an entrepreneurial role, not just to provide public goods but out of a presumption that private capital is not adequate to attain the whole gamut of production; [c] midwifery where instead of substituting for the private sector the state tries to shape it out of a belief that the capacity of the private sector is malleable and [d] husbandry in which the state takes a long term

[26] Evans, 1995. The following quotations are taken from p. 14

view by recognizing that even if it successfully induces private groups to tackle promising sectors in its role of midwife, that may not be sufficient. As global changes challenge these firms, the state must continue to cajole and assist private groups to meet these challenges by signaling opportunities, reducing risks, engaging in R&D etc.

According to Evans,"...[s]ectoral outcomes depend on how roles are combined". Brazil and India "...made less use of midwifery, got bogged down in restrictive rule-making and invested heavily in direct production of information technology goods by state-owned enterprises. Their efforts to play custodian and demiurge were politically costly and absorbed scarce state capacity, leaving them in a poor position to embark on a program of husbandry that would help sustain the local industries they had helped create." Not so Korea, which built up firms through midwifery and then helped them through husbandry to meet competitive challenges in information technology[27].

Instead of using this classification for cross-country comparisons, it can equally well guide our understanding of how industrial development policies have changed over time in a given country. The case of Taiwan nicely illustrates how the state has moved from the custodian that regulates the market to the "demiurge" that takes on directly productive activities itself rather than leaving them to private capital[28]. Once the limits to these two functions of the state are reached during the 1960s, the Taiwanese state then moves on to midwifery and husbandry, actively introducing a variety of institutional and policy innovations that allow small enterprises to grow and to become more efficient, while at the same time providing an environment that is conducive for learning and innovation.

5. A focus on learning and capability formation

As a result of globalization, developing countries today face new challenges: in order to sustain access to markets and technology, they need to upgrade continuously the sources of their competitiveness. This has given rise to debates on the role which firm strategies and government policies can play in the transition from traditional forms of competitiveness, based on cheap labour, natural resource endowments and currency devaluation, to more

[27] While Peter Evans` classification is a highly innovative theoretical approach, it is hard to agree with his choice of Korea as the positive role model in the computer industry. Taiwan is much better qualified to play this role (Ernst, 1997b). This of course does not belittle Korea¥s tremendous achievements in consumer electronics and standard precision components like DRAMs. For a detailed analysis, see Ernst 1994a and 1997c.

[28] Ernst, 1997 b, chapter III.

sustainable forms of competitiveness, based on a wide diffusion of technological capabilities and organizational competence.

One important example is the current debate between accumulation theorists[29] for whom growth is largely a result of " a rapid movement along prevailing production functions" (Krugman (1994) and innovation theorists who, in the tradition of Schumpeter, argue that development in essence requires learning and innovation[30].

Our research does not support the assumption that development can be reduced to efficiency gains due to capital accumulation, i.e. investment[31]. In siding with Nelson and Pack (1995), we argue that investment needs to be complemented by learning and the formation of capabilities, in order to achieve sustainable development. That economic growth requires innovation is as true for developing countries as it is for OECD countries. Recent econometric analysis, for example, shows that "... the main factors influencing differences in international competitiveness and growth across countries are technological competitiveness and the ability to compete on delivery ... Cost-competitiveness does also affect competitiveness and growth to some extent, but less so than many seem to believe". [32]

Learning and capability formation thus are critical for development strategies. The question is what are the specific learning requirements that developing countries are facing today. We distinguish two components of technological knowledge. The first component covers all codifiable items such as engineering blueprints and designs and the underlying generic scientific knowledge plus management manuals and handbooks describing system features, performance requirements, materials specifications and quality assurance criteria and the organizational methods and routines which are used to implement them. As Nelson has shown, this also includes individual practitioners' knowledge of the way such scientific, engineering and organizational principles are applied or the knowledge about how things work in practice[33].

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[29] Young , 1993; Kim and Lau, 1994; and Krugman, 1994.
[30] Freeman, 1982 and 1991; Lundvall, 1988, 1992 and 1996; Bell and Pavitt, 1993; Nelson, 1993; and Nelson and Pack, 1995, and Maskell, 1996a and 1996b.
[31] Lundvall, Bengt-Ake, 1992; Ernst, 1994a and 1997a
[32] Fagerberg, J., 1990, pp. 370-71
[33] Nelson (1990)

The second component of technological knowledge is tacit and firm- specific. It is embodied in the organizational routines and collective expertise or skills of specific production, procurement, R&D and marketing teams. This is the part of technology which differentiates firms and which cannot be exchanged among them, as it is derived from and tied to the localized and collective learning experience of a given company through its own development of technological capabilities[34]. While the first element of technology may be traded between firms, the second element is the essence of firm-specific competitive advantage. It is non-tradeable and relies on learning, either within a firm or within an international production network [35].

Both types of knowledge hang together, they are symbiotic. Even though codified knowledge can be exchanged, to make it operational a firm needs to develop supporting tacit knowledge. This is in line with Edith Penrose's observation that "... a firm's rate of growth is limited by the growth of knowledge within it." [36] Nonaka and Takeuchi have convincingly demonstrated that a firm's learning efficiency critically depends on an institutional set-up that facilitates a spiral-type interaction between tacit and codified knowledge[37].

Technological learning in developing countries thus has to cope with two challenges: the acquisition of the codified knowledge element of technology and the development of tacit, firm-specific knowledge. Access to codified knowledge may at times be constrained by patenting, aggressive IPR strategies and the proliferation of "high-tech neo-mercantilism".[38] This first challenge results from some basic failures of international technology markets. While even the tightest technology appropriability regime is unable to prevent technology leakages, such restrictions can substantially delay the actual entry of such knowledge into the public domain. Codified knowledge remains subject to the constraints of entry

[34] The nature of these technological capabilities has been analyzed in a different contribution (Ernst, Mytelka and Ganiatsos, 1997).
[35] For an analysis of international production networks and their impact on technology diffusion, see Ernst 1994b and 1996b.
[36] Penrose, 1959/1995, foreword, pages XVI and XVII
[37] Nonaka and Takeuchi (1995)
[38] Today's arsenal of policy instruments, available to such "high-tech-neo-mercantilism" is impressive and includes subsidies for investment or research, restrictions on access to the domestic market by similar goods from foreign producers, restrictions on direct investment in the domestic market by foreign firms, or

deterrence strategies pursued by both firms and governments.[39] Technology leaders, for instance, can substantially increase the cost of external technology sourcing by charging high licensing fees[40]

This first challenge is of particular relevance for countries like Korea and Taiwan which today are confronted with the "successful catching-up trap" [41]. As these countries move closer to the technological frontier, they face a number of new constraints with regard to access to technology and markets. Access to codified knowledge becomes more difficult and costly, especially if it involves new product designs and core components. While such "access to technology" constraints are real and often quite serious, it would be misleading to focus our attention exclusively on them. Both Korea and Taiwan have reached a critical level in the development of their domestic capabilities. One way of another, they will always be able to circumvent such "access to technology" constraints[42] .

This brings us to the second challenge for developing countries which in fact is of much greater importance than the first one. In addition, it applies to all kinds of developing countries. Even if all firms can gain access to a common pool of codified knowledge, they must undertake a costly and invariably time-consuming learning process in which they develop the tacit capabilities required to use, adapt and further develop the imported technology. We argue that the creation of tacit knowledge is the decisive prerequisite for successful development. A weak tacit knowledge base, in our view, constitutes a major barrier that delays or in some cases even obstructs international technology diffusion to developing countries.

II. The Critical Importance of Tacit Knowledge

1. On the importance of tacit knowledge

This paper is based on a hypothesis that we have entered a phase of economic development (the 'learning economy') where knowledge and learning have become more important than

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procurement policies that favour the domestic producer of a high-technology good. For evidence, see Ernst and O'Connor (1989), pages 26 passim and Tyson (1992).

[39] Ernst and O'Connor (1992), chapters I and II.

[40] For evidence, see note 21.

[41] Ernst and O'Connor, 1989

[42] For evidence, see Ernst, 1994a and Ernst, 1997 b

in earlier historical periods. In the learning economy, individuals, firms and national economies create wealth and gain access to wealth in proportion to their capability to learn.[43] This is also true for developing countries, regardless of their stage of development. To put it bluntly: there is simply no other way to reduce poverty but to place learning and knowledge-creation at the centre of development strategy. Foreign aid and windfall profits from oil and other natural resources can only produce sustained development if these resources are channeled into the formation of local capabilities.

This implies of course a broad definition of knowledge and learning. Wealth-creating knowledge includes practical skills established through learning by doing as well as competences acquired through formal education and training. And it includes management skills learnt in practise as well as new insights produced by R&D-efforts.

It is important to emphasize that learning takes place in all parts of the economy, including in so-called low-tech and traditional sectors. As a matter of fact, learning taking place in traditional and low-tech sectors may be more important for economic development than learning taking place in a small number of insulated hi-tech firms. The learning potential (technological opportunities) may differ between sectors and technologies but in most broadly defined sectors there will be niches where the potential for learning is high.

Finally, all kinds of labour have some skills and a capability to learn, including what misleadingly is called 'unskilled workers'. These precisions are made in order to avoid that the learning economy-hypothesis leads to a neglect of the developmental potential of those parts of the economy that rely less on formally acquired knowledge.

In short, tacit knowledge is as important as or even more important than formal, codified, structured and explicit knowledge.[44] One difficulty with such a broad definition of knowledge is that it is not easy to illustrate empirically the validity of the basic hypothesis.

[43] Similar perspectives have been developed by others. Amongst the most well-known is Peter Drucker (1993). Earlier contributions spelling out the characteristics of the Learning Economy include (Lundvall&Johnson, 1994, Lundvall, 1995, Foray&Lundvall, 1996 and Lundvall 1996)

[44] The concept of tacit knowledge was originally developed by Michael Polanyi (1958 and 1966).

Almost all indicators of knowledge-intensity and learning activities refer to formal education and R&D-efforts and generally they support the hypothesis of the learning economy. It can be shown that modern economic growth is biased in the direction of more intensive use of human capital, that sectors intensive in their use of trained labour and in their investments in R&D are the ones expanding their employment most rapidly and, finally, that there is a strong tendency towards a polarisation in labour markets in favour of skilled labour[45]. But these indicators, even if pointing in the right direction, give a biased picture of the learning economy. They do not reflect the importance of tacit knowledge and the results of learning taking place within regular economic activities of marketing, production and development.

2. Different kinds of knowledge - a taxonomy

In order to understand the role of learning for economic development, it is useful to distinguish different kinds of knowledge. Knowledge and learning are generic and general concepts which need to be further specified in order to become useful analytical tools. The following taxonomy has been proposed in an earlier paper[46]:

- Know-what
- Know-why
- Know-how
- Know-who

Know-what refers to knowledge about "facts". How many people live in New York, what are the ingredients in pancakes and when was the battle of Waterloo are examples of this kind of knowledge. Here, knowledge is close to what is normally called information - it can be broken down into bits.

Know-why refers to knowledge about principles and laws of motion in nature, in the human mind and in society. This kind of knowledge has been extremely important for technological development in certain science based areas such as for example chemical and electric/electronic industries. To have access to this kind of knowledge will often make

[45] Foray and Lundvall, 1996

[46] Lundvall&Johnson, 1994 . At least two of these categories have roots back to Aristoteles' three intellectual virtues. Know why is similar to Episteme and know-how to his concept Techne. But the correspondence is not perfect since we will follow Polanyi and argue that scientific activities always involve a combination of know-how and know-why. His third category Phronesis which relates to the ethical dimension will be reflected in what I am going to say about the need for a social dimension in economic analysis and about

advances in technology more rapid and reduce the frequency of errors in procedures of trial and error.

Know-how refers to skills - i.e. the capability to do something. It might relate to the skills of production workers. But it is important to realise that it plays a key role in many other activities in the economic sphere, as well. The businessmen judging the market prospects for a new product or the personnel manager selecting and training the staff have to use their know-how. And the separation between know-why as science-related and know-how as being mainly practical may also be seriously misleading. One of the most interesting and profound analyses of the role and formation of know-how (or personal knowledge) is actually about the need for skill formation among scientists[47].

Know-how is typically a kind of knowledge developed and kept within the borders of the individual firm or the single research team. But as the complexity of the knowledge-base is increasing co-operation between organisations tends to be further developed. One important rationale for the formation of industrial networks is the need for firms to be able to share and combine elements of know-how. Such networks cover all stages of the value chain, covering manufacturing as well as marketing and R&D[48]. The result is that each firm is embedded in complex and diverse networks of networks that frequently cover different time zones and continents

This is also the reason why know-who becomes increasingly important. Know-who involves information about who knows what and who knows to do what. But especially it involves the social capability to establish relationships to specialised groups in order to draw upon their expertise.

Learning to master and absorb the different kinds of knowledge takes place through different channels. While know-what and know-why can be obtained through reading books, attending lectures and accessing data bases, the other two categories are primarily rooted in practical experience and in social interacting. Know-what and know-why can more easily be codified and transfered as information. Some of it may even be sold in the market if the proper institutional instruments are developed. This is why main-stream economic

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the importance of trust in the context of learning.

[47] Polanyi, 1958/1978

[48] See again sources quoted in note 12.

analysis tends to focus on processes of learning involving the transfer of know-what and know-why while neglecting know-how and know-who.

Know-how will typically be learnt in something similar to apprenticeship-relationships where the apprentice follows his master and relies upon him as his trustworthy authority [49]. The importance of know-how in natural sciences is reflected in the fact that the training involves field work or work in laboratories to make it possible for students to learn some of the necessary skills. In management science, the strong emphasis on case-oriented training reflects an attempt to simulate learning based on practical experience. Know-how is basically tacit knowledge which cannot be easily transmitted. It will typically develop into its highest forms only after years of experience in everyday practice - through learning-by-doing and through interacting with other experts active in the same field.

Know-who is learnt in social practise and some of it is 'learnt' in specialised education environments. Communities of engineers and experts are kept together by re-unions of alumnaes and by professional societies giving participants access to bartering information with professional colleagues[50]. It also develops in day-to-day dealings with customers, sub-contractors and independent institutes. One important reason why big firms engage in basic research is that it gives them access to informal networks of scientists[51]. Know-who is socially embedded knowledge which cannot easily be transferred through formal channels of information. Neither can it be sold in the market without losing some of its intrinsic functions.

3. What is tacit knowledge?

The distinction between tacit knowledge and non-tacit knowledge is not always clear and it might be helpful to illustrate the distinction with some examples. As an illustriation of non-tacit knowledge we might take a simple mathematical relationship (2+2=4). This piece of knowledge can be globally transferred and very little is lost in the act of the transfer. It is highly structured, it is expressed in a code which is globally shared and it is generic also in the sense that it cannot be patented and transformed into private intellectual property. This kind of knowledge (elementary arithmetics) is useful because it is a basic element on which

[49] Polanyi, 1958/1978, p.53 et passim
[50] Carter, 1989
[51] Pavitt, 1992

further learning can take place but as such it cannot be exploited economically. Formal education is useful when it comes to learn this kind of knowledge even if practical experience might also be helpful in mastering it (as when children at an early age help out their parents in a small shop).

To illustrate tacit knowledge we might take two different examples. The first would be the classical one of the skilled worker/artisan who uses tools and materials to form a final product. It could be a baker who mixes flour with milk and eggs to produce pancakes. If the quality of ingredients and the process equipment were completely standardised and the environment completely stable, this tacit knowledge could easily be transformed into a recipe which non-experts could use with success (the knowledge could be reduced to a formula - 2 eggs+1 cup of flour+1 litre of milk=5 pancakes) which could be easily transferred. But if the ingredients vary in quality and the environment is unstable the proportions and the work process should be adapted accordingly to get an excellent product. This example illustrates that the degree of complexity and the rate of change in quality and environment may determine how far tacit knowledge might be transformed into non-tacit knowledge.

The second example of tacit knowledge refers to the management of firms. Should firm A take over firm B or should it leave things as they are? To make such a decision involves the processing of an enormous amount of information and attempts to analyse a multitude of relationships between ill defined variables. Guesstimates and hunches about future developments are crucial to the outcome. Evaluating the human ressources in the other firm is a complex social act. In this case there is no simple arithmetic to refer to (depending on future developments 1+1 may sum up to -2, +2 or even +10). It is obvious that the competence needed in this case is not easily transferred through formal education nor through information systems. It should also be observed that the decision is unique rather than one in a series of very similarly structured problems. Attempts to design formal decision models to cope with this kind of problem will not be meaningful and the knowledge remains tacit and local. Of course it is possible to learn the skills of artisans and business leaders, but this learning will typically take place in a kind of apprenticeship

relationship where the apprentice or the young business administrator learns by operating in close co-operation with more experienced colleagues.

The distinction between tacit and codified knowledge is appropriate for analytical purposes. In reality however, we find many hybrid forms of knowledge that blend elements of generic knowledge formulated in global codes with access for everyone and those of the individual's tacit competence which can be shared with others only in a direct social interaction - including face-to-face contact. One of the main issues to be addressed in future research is how this mix is affected by the information technology revolution and, more specifically, what kind of knowledge mix is most conducive for different groupings of developing countries.

Why is some knowledge tacit? The chess player faced with an immense number of possible combinations will use his capability to recognise patterns and design broadly defined strategies. This is a case of a pure mental exercise where the complexity of the task calls upon tacit knowledge.

Many activities call upon the mastery of physical skill. Artisans, circus artists and ordinary people pursuing everyday activities such as biking and swimming make use of tacit knowledge - they co-ordinate complex movements subconsciously and they would not be able to write down what they do in a manual which could instruct someone else in such a way that the reader could repeat exactly the same exercise.

Other economic activities involve the skillful and simultaneous use of many different senses - sometimes the texture of a material can be classified only by the simultaneous use of sight, touch and smell. The skilful wine taster is an important function in the production of wine. Less grandiose examples may be artisans working on natural materials of varying quality. Neither of these cases allow for a precise description of the action involved and the knowledge must be described as tacit.

Finally an increasing amount of economic activities is based upon interpersonal communication with customers, competitors and personnel and public bureaucrats. To understand how other people think and how to respond to their needs in a way which in the

long term promotes the objectives of the firm is an art which cannot be easily learnt through formal instructions. The great salesmen and the great managers of personnel have tacit social skills which cannot be transferred through manuals. Business management is an art where several of these different reasons for tacitness appear in combination. Like chess it is a complex activity which involves many alternative combinations including considerations of the opponents' strategies. But it is also a social activity involving the art of mastering social relationships.

In short, tacitness has its roots in complexity and in variations in quality. It prevails in situations where there is a need to use simultaneously several different human senses, when skilful physical behaviour is involved and when understanding social relationships is crucial. Globalization and the spread of IT have reinforced these reasons for tacitness, as they have dramatically accelerated the pace of change in economic life. If we were in a steady state (circular flow), a gradual movement from tacit toward non-tacit knowledge might take place. But since the long term economic success of agents increasingly reflect the capability to adapt to change (flexibility) and the capability to impose change (innovation), tacit knowledge will remain crucial for economic success.

III. The Impact of Information Technology

1. Codification of knowledge

Can tacit knowledge be made explicit through automating human skills? One way of overcoming the limitations of the transferability of tacit knowledge is to embody it in products, process equipment and software systems such as business information systems and expert systems. There is a strong normative bias in Western civilization in favour of explicit and well-structured knowledge and there are permanent efforts to automate human skills. One historical example is the effort to transfer the knowledge of skilled workers into machinery connected with Taylorism. Present efforts to develop general business information systems and expert systems go in the same direction.

So far automating human skills has proved to be economically successful only in relation to relatively simple repetitive tasks taking place in a reasonably stable environment. Highly automated process industries may be extremely cost-efficient but at some time when the

products loose their competitiveness because of the appearance of more attractive substitutes they leave behind them rust-belt problems difficult to solve.

Let us take a closer look at how IT affects the different elements of knowledge that we have distinguished. Some indicators seem to indicate that technology developments become more and more strongly connected to science and the diffusion and increased use of information technology enhances both the incentives and the possiblities to codify knowledge[52]. These and other data indicate an on-going transfer of knowledge from the tacit form to a codified form. An important issue is, of course, how these specific changes affect the relative importance of know-how and on the need to learn skills through learning-by-doing, learning-by-using and learning-by-interacting. As a first approximation, it points to a less important role for routine-based learning and for the tacit components, know-how and know-who. The trend toward codification might have a direct effect on the demand for skills and an uneven distribution of computer-related qualifications obtained through education and training might be part of the explanation of the growing polarisation in labor markets.

Without denying the importance of these phenomena, we suggest that the connection between the information technology revolution and the learning economy is more complicated. It is problably correct that one consequence will be that the elements of know-what and know-why which are already codifiable will become much less costly than before. The access to data bases, including those with texts on science (scientific articles) and technology (patent descriptions) will be enormously increased for those who have the capacity to decode the communication taking place. Also, even some elements of expert knowledge will prove to be transferrable into data and expert systems and the corresponding part of the skill structure will loose some of its value in the labour market.

While some skills will be transformed into a codified form, new ones will become even more strongly in demand than before. The very growth in the amount of information which is made accessible to economic agents increases the demand for skills in selecting and using information intelligently. For this reason experience based learning might become even more important than before. The major impact of the information technology revolution on the process of learning might, however, be that it speeds up the process of change in the

[52] David and Foray, 1995

economy. The codification, standardisation and formalisation of certain parts of the knowledge stock increase the rate with which some stages in the innovation process is progressing and the diffusion of this kind of knowledge might also be accelerated. In order to see why skills and the formation of skills will remain a core element behind economic performance, we need to take into consideration the relationship between learning and change.

2. Learning and change

Learning and change are closely related and the causality works both ways. On the one hand, learning is an important and necessary input in the innovation process. On the other hand, change imposes learning on all agents affected by change. In this context it is important to note that a significant and growing proportion of the labour force is designated to promote change while for the rest of the labour force change is imposed from the outside.

In a market economy there is a strong incentive to create and exploit novelty. Producing the same thing in the same way is not very rewarding, at least not in the long run. Finding new and more efficient methods of production and introducing new and more attractive products into the market is necessary for survival in most competitive markets. Learning in connection with production and in an interaction with users is fundamental for the success in process and product innovation[53]. Learning involves finding and defining the problems to be solved - to develop an agenda for problem solving - as well as forming the know-how helping agents to find the way to solve problems. Being able to learn from earlier experiences and to use the experiences from earlier rounds of problem-solving is also important.

Learning creates change and promotes innovation. But it is equally true that the change instituted by innovating actors imposes further change for the other agents. When a competitor introduces a more efficient process or a more attractive product the pressure for change increases. Also consumers, when confronted with new products have to change their

[53] Lundvall, 1985

behaviour.[54] And change involves learning. Introducing a new machine or addressing a new market or organising the firm differently than before puts everyone in a learning position. Unforeseen problems which call for a solution emerge in connection with change.[55]

In this sense learning is a self-reinforcing process. This reflects a pecularity relating scarcity and knowledge. Knowledge is not a scarce resource in the traditional sense: the more you use it the more you get of it. Using knowledge is in economic terms identical to imposing change and imposing change triggers further learning.

3. Acceleration of learning and change?

We hypothesize that the rate of change and learning in the economy has accelerated since the eighties. There is little doubt that over a longer time span this has been the case. We have to go just a few generations back to find ancestors who were doing the same thing as their grandparents and normally in the same locality. Change has accelerated enormously since the beginning of the industrial revolution and people have been forced to engage in learning to do things differently and to survive in new environments.

But what about the more short term? It is not easy to find reliable and valid indicators in this field. The amount of scientific articles is growing exponentially, but this might have more to do with the institutional context than with an increase in the rate of learning. Patent statistics and other indicators of technical progress may also indicate an acceleration, but again the institutional setting may be more important than the actual rate of learning in explaining such patterns. The rate of growth of the economy is actually slower than in the fifties and the sixties and indicators of structural change in terms of changes in the sectoral composition of production and employment do not give any clear indication in this respect. While changes in the structure of employment seem to slow down in the eighties a slight acceleration seems to have occurred when sectors are measured in terms of output[56].

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[54] 1992 in connection with the 20 year anniversary of OECD-work on information technology an international colloqium gathering leading representatives from the industry and academia discussed the problems of the sector. It was a rather general agreement that the stagnation in demand had to do with a very rapid rate of product change with a weak link to the needs of fianal users. The basic problem was one of an imbalance between the velocity of producer learning and the slower rate of user learning .

[55] An interesting case-study of how change in the rather trivial form of introduction of new production machines triggers problem solving at the level of the firm is presented in Von Hippel&Tyre (1995).

[56] OECD, 1994a, and 1994b

Given the difficulties to obtain reliable and valid data, let us turn to some anecdotal evidence. In 1993 the theme of the annual conference of European R&D-managers - EIRMA - was "Accelerating Innovation", and among the experts present there was little doubt that there had been an acceleration since the eighties at least in some crucial respects. The key to success in innovation was now time - that is to move as rapidly as possible from the original idea to the introduction of the novelty in the market and the major theme of discussion at the conference was different methods to attain this goal. When these strategic agents of change accelerate their activities they will impose the need for more rapid learning on the other agents in the economy[57]. In this context, it is relevant to quote from the introductory remarks of the EIRMA President, Dr. E. Spitz:

" In a time of intensive global competition, speeding up the innovation process is one of the most important ingredients which enable the company to bring to the market the right product for right prices at the right time.

We know that it is not only the R&D process which is important we have to put emphasis on integration of technology in the complete business environment, production, marketing, regulations and many other activities essential to commercial success. These are the areas where the innovation process is being retarded.

This subject is a very deep seated one which sometimes leads to important, fundamental rethinking and radical redesign of the whole business process. In this respect , especially during the difficult period in which we live today, where pressure is much higher , our organisations may in fact, need to be changed. "(op.cit.. p. 7)

Another tendency which involves a broader set of actors than the R&D-intensive firms is the movement towards flexible specialisation where producers increasingly compete by a rapid response to volatile markets. Among academic scholars as well as among consultancy firms, this has been recognised as a strong tendency and many firms have drastically changed their organization in order to be able to meet this challenge. Again rapid change will imply a strong demand for a capability to learn and respond to new needs and markets.

A third phenomenon has to do with the introduction of more intense competition in sectors which have been living a more protected life. Competition may come from the opening of national markets for services for imports or from deregulation and privatisation of activities.

[57] EIRMA, 1993

In this process the rate of change will accelerate even more rapidly than in the ones which have been used to competition. The rate of learning will be accelerating all the way from the top to the bottom of the organisation and include the development of completely new management concepts as well as new forms of organisation.
So, all in all, there are several indications of an acceleration of change and learning. The more easy access to codified knowledge may be one factor reinforcing this tendency since some elements in the process of creating novelty now will take place with less delay than before. The truth might as usual be more complex than we want it to be, however, and while change has accelerated in some dimensions and segments of the economy it might have slowed down in others. It is an interesting task for further research to clarify these issues. As one step in this direction and to get the focus back on the issue of polarisation we shall refer to one of the few, but very original, attempts to measure the rate and costs of change.

Anne P. Carter has recently introduced a new perspective on economic change[58]. Her analysis, which only covers manufacturing, demonstrates that there is a strong correlation between the proportion of non-production workers and the rate of change in a sector. Sectors with high proportions of non-production workers grow more rapidly, their rate of productivity grows more rapidly and they include among them the most science-based activities.

On this basis, Carter argues that the majority of non-production workers are engaged in either to promote or to adapt to change. R&D-personnel is the most visible in the first category but it includes many more professions. Why should you need such a big staff of engineers, accountants, sales personel and managers if there was no or very little change?

The purpose of this analysis is to develop a perspective where the growing costs of change are made explicit. Standard economics takes into account only the costs of production and neglects the costs of change or mistakenly treats them as costs of production.

[58] Carter, 1994 and 1996

4. Learning as creative destruction

It is obvious that change increases the value of certain skills and competencies while undermining the market value of others. What really matters in an economy of rapid change is therefore the competence to learn. Learning reinforces some of the existing skills, creates new skills while it at the same time makes old skills obsolete. Even more fundamental is the fact that skills may be barriers for learning. The fact that you know how to do things in one way may block your learning to do something different or differently. This is important in the economy where whole sectors may disappear because of an incapacity to adapt. For instance, it has proved almost impossible for firms having a core competence in working with traditional materials such as metal and wood to enter the production of plastic substitutes for their original products. Many firms in office equipment production which were based on mechanical technology did not succeed in moving on to electronics based products etc.

This illustrates why forgetting must be an integrated and important part of the learning process and why it is appropriate to regard learning as a process of creative destruction. This has been implicitly accepted as characterising the modern economy and many different institutions have been established to cope with the social impact of this process. Governments have engaged in supporting economically the ones who lose their jobs and especially in European welfare states like Sweden the public sector has organised ambitious programmes to give new skills to workers whose competence has become less in demand.

The problem today seems to be that the process of creative destruction has accelerated to such a degree that the threshold to enter into the process has become too high not only for individual workers, but also for whole regions and countries. An hyper-acceleration of change and learning tends to excludethose countries that are slow learners. The bias in favour of the most rapid learners increases the rate of change and the rate of learning even further. A vicious circle is put in place that is bound to increase international inequality.
The most fundamental problems of IT have to do with difficulties to absorb, allow for and promote change. In a stable environment characterised by a high degree of standardisation in inputs and outputs, it would be possible and economically attractive to build information

systems which substituted for at least some of the functions which had so far been pursued by skilled labour and human intelligence. But when materials, processes, product, markets and regulations all change, these efforts will often prove to be counter-productive - they will become barriers to flexible adaptation. It will also be difficult to pursue innovative activities in an organisational environment where human skills where automated.

The difficulties with automating tacit knowledge do not rule out that new attempts will be made to formalise and structure tacit knowledge and it is also reasonable to assume that the growing importance of information technology will further stimulate such attempts. Already one can see a number of new applications which change the character of knowledge-creation at certain stages of the innovation process. Developing and testing drugs, and aircrafts with the help of computer power and the use of computer aided design in many other areas illustrate a successful transfer of problem-solving from human skills to computers [59].

In short, the main impact of IT is not the reduction of the importance of tacit knowledge but rather a speed-up of specific phases of the innovation process. Such a speed-up might paradoxically increase the demand for skills which are tacit. When the rate of change accelerates it faces all economic agents with a need to analyse and react to a complex and rapidly changing flow of knowledge and here we know that the exclusive use of strictly analytical models does not work.

Our conclusion is that tacit knowledge in the form of back-bone based reactions, creativity and practically based intuition is needed both to adapt to change provoked by customers and competitors and to impose change in the competition with other agents and that attempts to impose too ambitious analytical models will hamper rather than stimulate decision making in such a context.

[59] Foray and Lundvall, 1996, pp 14-15

5. An alternative perspective - information technology as a flexible tool supporting interactive learning

Information technology may be regarded from a different perspective where the emphasis is upon its potential to re-inforce human interaction and interactive learning. Here the focus is not upon its capability to substitute for tacit knowledge but rather on how it can support and mobilise tacit knowledge. E-mail systems connecting agents sharing common local codes and frameworks of understanding can have this effect and broad access to data and information among employees can further the development of common perspectives and objectives for the firm. Multi-media exchange may be helpful in transferring elements of tacit knowledge for instance by using combinations of voice and pictures in an interactive mode etc. But in these respects the IT revolution, even if moving very rapidly, is still in its infancy and its real potentials are still not easy to assess even by the leading experts[60].

One of the most problematic aspects of attempts to analyse learning and knowledge so far has been the tendency to neglect the distinction between tacit knowledge and information. Information is something which can be reduced to bits and put into a computer while tacit knowledge is knowledge which cannot be transformed into information, at least not without changing the content of the knowledge.

Let us assume an 'information economy' where all practical knowledge has been successfully transformed into simple recipes which could be accessed and applied by everyone. In such an economy - which corresponds to the assumptions of complete mobility of techical knowledge made in neo-classical trade theory - there would be no transnational corporations and regional disparities in wealth would reflect only differences in the accumulation of tangible capital.

Introducing tacit knowledge, including shared tacit knowledge rooted inside firms or in local knowledge-intensive networks of firms, changes the workings of global competition completely. In such a world it becomes profitable for firms to exploit their specific

[60] Eliasson, 1996

knowledge assets all over the world and it becomes clear why the access to such knowledge for local agents in less developed regions is limited. This implies also that any kind of systematic changes in the borderlines between tacit knowledge and information are of fundamental importance for the prospects of developing countries.

An optimistic scenario would be one where a massive transfer of tacit knowledge into information systems gives developing countries access to new recipes (process technologies as well as new products) developed in the rich countries at a lower cost and much more rapidly than before. This would imply an acceleration of the catching-up process and prospects of narrowing global inequalities.

The experience of East Asian firms with learning from international production networks, desribed in part I of this paper, provides reason for some cautious optimism. The crux of such arrangements is an increased exposure to modern methods of organizing not only production, but the complex interaction between different stages of the value chain. This indicates that participation in international production networks can help, over time, to accelerate the formation of a variety of technological and organizational capabilities, provided of course that: i) a certain minimum threshold of such capabilities already exists; ii) DC firms pursue active strategies of learning and technology acquisition; and that iii) the government and other intermediary institutions in the DC play a very active role as suppliers of necessary externalities.

The main remaining institutional problem in such a world would be to establish appropriately balanced intellectual property right (IPR) regimes which on the one hand stimulate the creation of new technology and which, on the other hand, do not restrict the diffusion of new knowledge to late industrializing countries.

Two alternative scenarios which are less optimistic but more realistic must be considered. One is that the access to the new recipes is limited by the capability to master the language and codes connected to information technology and that access can be gained only by countries and firms having a well-trained labour force with a capability to master symbolic languages. But there are much more mundane and fundamental constraints. In a great

number of developing countries, especially in the socalled “least-developed countries”, many firms are not logging on to the Internet. Either they don’t have computers, or they don’t have Internet access nodes and providers, or the cost of telecommunications is prohibitive[61]. Future research therefore will have to inquire what kind of network-linkages firms in the Third World are maintaining, in terms of their content, structure, and how these affect their access to tacit knowledge[62].

These constraints obviously exclude a large number of developing countries from the possiblity of catching-up. It will not be easy to overcome these constraints. Most of these countries have experienced a drastic decline in inflows of foreign capital, both concessionary and commercial[63]. Most of the incoming capital is used for the purchase of equipment, leaving very little for the crucially important task of investing in human capital. Without such investment, developing countries are doomed to remain excluded from the marvels of the “learning economy”.

But this is only part of the story and much more is required in order to reap the benefits of IT. In essence, these countries need to create the necessary institutions that provide incentives for and externalities necessary for domestic learning, which we define as "learning within the domestic economy, by both national and foreign actors”. Learning efficiency is critically dependent on the existence of such institutions. They are shaped by the interaction of policies, firm strategies (including those pursued by inter-firm networks) and “markets”. Such institutions need time to develop and there is no single optimum solution. Each individual country has to find the idiosyncratic mix of policies, market structure and firm organization that best fits its own strengths and weaknesses. Nor is there any guarantee for success: Institutions can also experience malignant growth[64] or they can get stuck with obsolete features that once were useful, but now have become barriers to a further upgrading of local capabilities. In short, the dynamics of change of institutions matters; but nothing is predetermined about the outcome of these processes, in terms of their impact on capability formation[65].

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[61] Mytelka, 1996
[62] On some of these issues, see UNCST, forthcoming, chapters III and V.
[63] See latest report by OECD-DAC
[64] Holmstroem, 1997, p.
[65] See Ernst, 1997b

Probably the greatest challenge for developing countries however results from the fact that IT accelerates creative destruction. Let us consider a third scenario which follows from our earlier discussion. This scenario takes as its starting point that information technology, in the context of globalization, speeds up the rate of economic change and that, as a result, the need for rapid learning of tacit as well as codified knowledge has dramatically increased. Not only does this require increasing investment in human and fixed capital. At the same time, this requires constant, and frequently drastic changes in existing patterns of organization and in existing strategies. Both constraints are very real and difficult to overcome.

Recent developments in Korea show that, even if there are sufficient investment resources available, the rigid and hierarchical structure of firm and industry organization and of regulatory institutions can act as a major barrier to such change[66]. Accumulating tacit knowledge, required for a quick response to changing markets and technologies, has turned out to be a bit easier in the very different organizational and institutional context of Taiwan[67].

This has important implications for developing countries in terms of the institutional set-up that is conducive for learning and capability formation which we will discuss in the last part of this paper.

IV. What Kind of Learning Economy is Appropriate for Developing Countries?

1. The new challenge recapitulated

We have seen that the spread of IT has changed the role of information: IT enhances the divisibility and storage of information, its processing, transportation and communication, and consequently its accessibility and tradability. In principle, this has improved access to codified knowledge. Yet, in order to benefit from this improved access, developing countries need to strengthen their tacit knowledge base.

[66] For evidence, see Ernst, D., 1994 a
[67] See Ernst, 1997b

This has far-reaching implications for the process of knowledge creation: its effectiveness critically depends on linkages and interactions among participants in this process. Knowledge generation within a society " is strongly influenced by the network of relations among its firms, ... with externalities, communication and interdependence playing crucial roles."[68]

The same is true for international networks[69]. For developing countries, such international linkages are of critical importance in order to overcome the vicious circle of underdevelopment[70]. Many of these countries are stuck with a truncated sectoral specialization, dominated by low-end, homogeneous products (commodities) with limited productivity-enhancing potential[71]. The limited size of the domestic market constrains the degree of specialization and places tight restrictions on its ability to function as a buffer against heavy fluctuations in international demand. Insufficient domestic market size also constrains the development of sophisticated "lead users"[72] that could stimulate innovation. It also limits the scope for technological spill-overs[73]. Finally, the limited size of the national knowledge and capital base restricts the choice of industries in which such nations might successfully specialize.

In principle at least, the spread of IT could help to break this vicious circle. By allowing for an increasing specialization in the production of knowledge, it could improve the chances for developing countries to participate in and to benefit from international production networks. Knowledge generation now shifts from vertically integrated hierarchies to networks: "The vertical integration structure of knowledge, characteristic since the second world war, is being progressively replaced by the institutional creation of an information

[68] Antonelli, 1997, page 2
[69] Ernst, 1996b
[70] Ernst, forthcoming, chapter III
[71] The classical source remains Fajnzylber,1998
[72] Von Hippel defines "lead users of a novel or enhanced product, process, or service" as those that "...face needs that will be general in the market place, but...(who) face them months or years before the bulk of that marketplace encounters them..." and who will "... benefit significantly by obtaining a solution to those needs." (Von Hippel, 1988, p.107)
[73] Technological spill-overs are assumed to be mainly domestically generated by innovation theorists (Lundvall, 1992 and Nelson, 1993) as well as by "new growth" theorists (Grossman and Helpman, 1991 and 1993). If this is so, then large countries will benefit more from an investment in R&D than smaller countries, where some of the spill-overs of R&D are likely to benefit its trading partners. (Zander and Kogut, 1995)

exchange market, based on real-time, on-line interaction between customers and producers."[74]. In other words, the spread of IT facilitates and promotes the formation of separate and specialized knowledge markets.

2. Two competing models of the "learning economy": the Japanese versus the American model

Under what conditions can developing countries benefit from these developments? And, more specifically, what types of institutional arrangements are most conducive for enhancing the formation of learning capabilities?

In what follows, we compare two stylised models of the learning economy, the Japanese versus the American model [75].

Both models differ in their approach to tacit knowledge[76]. The Japanese model is explicit in its promotion and exploitation of tacit knowledge while the American model is driven by a permanent urge to reduce the importance of tacit knowledge and to transform it into information - that is into explicit, well structured and codified knowledge. The American model emphasizes market selection, competition, income inequality and strict control by financial markets as a way of promoting learning, while the Japanese model puts more emphasis on cooperation, social cohesion and long term social relationships. Both models furthermore differ in terms of firm organization (including the organization of inter-firm networks) and in their approach to international linkages through trade and investment.

3. Knowledge-creation in Japanese firms

Nonaka and Takeuchi give a series of examples of how large and well-managed Japanese TNCs organise the process of product innovation in ways which explicitly take into account the important role of tacit knowledge[77]. Japanese managers do not give detailed instructions

[74] Antonelli, 1997, p.3

[75] Both models are ideal types which do not exist in real life. There are, of course, substantial variations both among American and Japanese firms. There are also instances of selective convergence between both models. On both issues, see Ernst 1996b and 1997d. Nevertheless, both models capture essential differences in the process of knowledge creation that reflect the very distinct patterns of economic development and institutions in both countries. See also note 3 above.

[76] There are of course equally important criteria for comparing different paradigms of the learning economy. For instance, American and Japanese firms differ substantially in how they approach the development and application of IT. For a discussion of some of these issues, see Ernst 1996b and 1997d.

[77] Nonaka and Takeuchi (1995)

in order to tell in what direction the search of their innovative teams should go. Instead they promote the search for innovative solutions by formulating metaphors and analogies. These are based on the intuition of management and they leave ample room for creativity and the formation of new intermediate concepts. An intermediate layer of project team leaders make these open concepts interact with the tacit knowledge of skilled workers and engineers. They formulate somewhat more concrete slogans and gradually the conceptualisation of the new product takes place.

All through the process face-to-face interaction and hands-on experimenting is given high priority. There are several examples of how information technology is used to give all participants more easy access to banks of information in order to support the knowledge creation, but these efforts are always combined with direct human interaction. They are not regarded as substitutes for them.

Nonaka and Takeuchi argue that the organisational model best suited to the creation of new knowledge is a 'hypertext organisation' where there is one regular divisional structure which is overlayered with ad hoc horizontal teams directly aiming at creating new products and new knowledge. Members of these teams should be completely taken out of their regular function and division[78].

The focus of the analysis is limited to management strategies in connection with product development in big knowledge-based firms. It is, however, possible to extend the basic perspective in order to understand other characteristics of the Japanese innovation systems such as the long term close inter-firm relationships, the labour market and the life-time employment contracts, the patient capital market with a long-term perspective, etc.

In short, the Japanese model of the learning economy places mid-level team leaders at the centre of innovation. The top management gives direction to innovation in the form of

[78] The analysis is much more complex than indicated by these short remarks. For instance a model of knowledge-creation which assumes this process to be a spiral movement moving from tacit to explicit and than back to tacit knowledge is developed. The conversion between these forms plays a crucial role in the theory. This is a point worth critical attention. In some of the examples it is not obvious to what degree what is illustrated is an interaction between the different forms of knowledge rather than a conversion of one into the other.

metaphors and analogies. They establish frameworks promoting direct social interaction (face-to-face) and hands-on experimenting in order to mobilise and develop tacit knowledge at all levels of the firm. Monetary incentives are secondary and income differences are suppressed. Job circulation is stimulated in order to avoid narrow specialist perspectives.

Markets are characterised by long term relationships between sellers and buyers and they transmit qualitative as well as quantitative information. Direct interaction with customers is a key element when marketing new products.[79] The creation of trust and communication channels are crucial to the success of developing and introducing new products.

4. Key elements of the American model

Central to the American model is an attempt to transform tacit knowledge into explicit knowledge through the automation of human skills. This is in line with a strong normative bias in Western civilization in favour of explicit and well-structured knowledge and the high priority given to formal natural science as the ideal for all other sciences. Engineering disciplines and especially those with a weak science-base have a much lower status. In practical life there are permanent efforts to structure and formalise or automate tacit knowledge. Economists tend to share and re-inforce this bias also because economic models have even greater difficulties in analysing tacit knowledge than information[80].

Typical for the American model is a hierarchical understanding of competence - there is a lot of competence at the top and very little at the bottom. Operators at the shopfloor have a very limited role to play in the process of learning and knowledge creation. This goes hand in hand with an approach to labour management where the emphasis is on top management as an authority selecting competent teams and designing material incentives to stimulate the top teams in the firm. If anything it is assumed that the bias in compensation goes against

[79] The case of Nissan developing its Primera model for the European market is an extremely interesting illustration of how Japanese firms try to absorb local tacit knowledge from the potential market (Nonaka&Takeuchi, 1995, pp. 200 ff.).

[80] Eliasson (1996) shows that the fascination with automation in the form of generic business information systems again and again has proved out of proportion with reality. An enormous number of articles have been written on the fully automated factory while the real counter-part has been of negligible importance. The same has been true for the exaggerated office-automation prospects.
In practical terms this bias has been costly for many firms. The case-studies of Hatchuel and Weil (1995) show that so far automating human skills has proved to be economically successful only in relation to simple repetitive tasks taking place in a reasonably stable environment. Their work on expert systems shows that even when the tasks are reasonably simple the mode of operation of the expert system developed will differ radically from the operation of the expert.

the most competent participants. The idea that social cohesion could promote learning and innovations is not accepted.

In product markets, American firms favor low entry barriers and fierce competition which are perceived to create the best environment for experimentation and for eliminating inefficient non-innovative firms. Inter-firm cooperation is still considered as a second-best solution to the free play of the market forces.. The most important function of the financial market is to intervene and enforce a shift in top management when it fails to produce the ROI (return-on-investment) required by the market. US-types of capital markets combining take-over threats, junk bond markets and venture capital is presented as the ideal in this context. Little is said about the problem of short-termism in Anglo- Saxon financial markets.

Finally, one of the basic credos of the American model is that the government should not intervene in the market mechanism because government is by definition incompetent when it comes to recognize and correct its own mistakes - a key competence for the successful firms. There is no reference to historical cases where active governments have stimulated economic development by indicating broad trajectories for industrial development.
In short, the American model is characterized by a clear hierarchy and the main responsibility for promoting innovation rests at the top. This responsibility is performed by hiring, firing, and promoting competent people and by designing incentive systems. Monetary incentives are predominant and inequality in competences should be reflected in inequalities in earnings. Specialised expertise is crucial to problem solving.

Finally, competition dominates inter-firm relationships. Industrial markets as well as markets for consumption goods are regarded as characterised by arm's length and anonymous relationships between sellers and buyers. Markets serve as media for information exchange when the tacitness of knowledge constrains the scope for organisational learning.

5. Hybrid models and economic development: Implications for developing countries

We have seen that both models of the "learning economy" have peculiar strengths and weaknesses. For any particular developing country, their usefulness depends on its stage of development. The American model promotes short-term static allocation efficiency, yet neglects two equally important types of efficiency problems: distributive and learning efficiency. For developing countries, this may have negative consequences for long-term capability formation[81]. The Japanese model, in turn, is conducive for rapid capability formation that can facilitate catching-up. This, however, comes at a cost in terms of static allocation efficiency and speed-to-market.

For the majority of developing countries, the main concern is to create the necessary institutions that provide incentives for and externalities necessary for domestic learning. For these countries, the U.S. model has less to offer than the Japanese model: its disregard of the importance of tacit knowledge leads to a misconception of the role of information technology in the learning economy. For those countries, however, that have reached a certain degree of development and need to upgrade their existing institutions, none of the two stylised models give the full answer. These countries need to develop hybrid forms of institutions that combine the advantages of both models in a way that is appropriate to their idiosyncractic needs and capabilities.

Such pragmatic new combinations may become more realistic in a world where there is a certain convergence between the two models. The reason why American firms have regained some of their competitiveness is that they, in their practice, have started to use organizational solutions which are much closer to the Japanese model than their shared ideology would indicate. On the other hand, the on-going debate about industrial policy in Japan emphasises the limitations of the old catching-up strategy and the need to borrow institutional elements from the US-model in order to promote individual entrepreneurship and short term flexibility[82].

[81] This is in line with research on the "specialization dilemma" . Andersen (1996, p.105)shows that specialization may involve substantial trade-offs: pushing static allocation efficiency gains to the limit could undermine a firm¥s and a country¥s capacity for knowledge creation.

[82] For an analysis of these issues, see Ernst, 1996b and Ernst, forthcoming

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The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation
- Competence building and inter-firm dynamics
- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

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