MANAGEMENT OF TECHNOLOGY

Selected Discussion Papers
presented at the Vienna Global Forum

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Meeting Technology Needs of Enterprises for National Competitiveness

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Meeting Technology Needs of Enterprises for National Competitiveness

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Abstract

This paper addresses the question of how enterprises can improve their competitiveness through the acquisition and development of technology, and hence how countries are able to raise the level of industrial development and grow their GDP. It takes the example of East Asia to demonstrate how fast economic growth can be achieved through the "stages" approach to technology acquisition and development. It also provides some case studies of technology transfer to China as a means of illustrating how successful transfer can be achieved and the problems that can be encountered. Finally, some comparisons are made with, and among, the Arab countries and an attempt is made to draw some lessons for the development of the Arab world from experiences gained elsewhere.

Technology and the learning process

A fundamental point when understanding how technology is acquired is that technology is not just a physical thing but also comprises knowledge embedded in hardware and software. The acquisition of technological capability is therefore not a one-off process but a cumulative one in which learning is derived from the development and use of technology. There is a view that national competitiveness is obtained by strengthening the science base and developing Research and Development (R&D) capacity. However, activities formally identified as science and R&D are only one part of the overall process which includes learning by doing (increasing the efficiency of production operations), learning by using (increasing efficiency by the use of advanced equipment and complex systems) and learning by interacting with suppliers and customers. It should also be noted that in many industries only a fraction of the technological efforts of firms is carried out in dedicated scientific or R&D facilities. Evangelista et al (1998) recognise the different elements of innovation and innovation processes. They use evidence from a large-scale survey of European enterprises to show that 50 per cent of the total innovation expenditure is embodied in plant, machinery and equipment purchased by firms. The internal technological

expenditures devoted to R&D, design and trial production are 20 per cent, 10 per cent and 11 per cent respectively of the total innovation expenditure with the rest devoted to acquiring technology through patents and licences. Therefore reported R&D expenditures are only a proxy for innovation related activities.

The accumulation of skills, experiences and technical know-how at the levels of firms, industrial sectors and countries takes time and is essential for the long run development of national competitiveness. The existing knowledge base is important for developing further knowledge and capabilities and new products and processes. The above observations have clear implications for the absorptive capacity of a country. The policies and stances taken by enterprises and institutes are often based on the assumption that acquiring technology in the form of designs and hardware and possibly reverse engineering are sufficient for absorbing and using technologies and developing innovative capabilities. This may be true for some basic technologies but is unlikely to be the case with more advanced technologies.

Box 1 - Types of transferred technology and assessing its impact

It is important to recognise that there are two types of technology transfer. The first of these is vertical transfer, which is when technology is transferred from research to development to production. Thus it follows the progressive stages of invention, innovation and diffusion, with the technology becoming more commercialised as it proceeds through each stage. Vertical transfer can be within one organisation or there may be an intermediate transaction between, say, a research institute and a manufacturing company.

The second type of technology transfer is horizontal transfer. Here an established technology is transferred from one operational environment to another. The purpose of horizontal transfer is not to commercialise the technology, rather it is to disseminate the technology and extend its application into other contexts. This type of transfer is of concern to companies that wish to maximise the return from their technology, but may be unable to do this by direct selling of end products into the market place. More importantly for the purpose of this paper is that horizontal transfer is the most common type when technology is being transferred from industrialised to developing countries. There is usually no further improvement or change to the technology unless it needs to be modified to suit local circumstances or environmental conditions.

Regarding the technology being transferred, this itself can be of two types. First, it can be 'product technology', the transfer elements of which would involve the design details of a particular product and the know-how for part, or all, of its manufacture. Second, it can be 'process technology'. Here, transfer would be of the means of manufacture and could be used in connection with the production of different products or parts of products; either existing or new. These two technology types are not mutually exclusive. It is not unusual, for example, for the transfer of product technology to be accompanied by the transfer of some aspect of the process of making the product.

Box 1 (cont.)

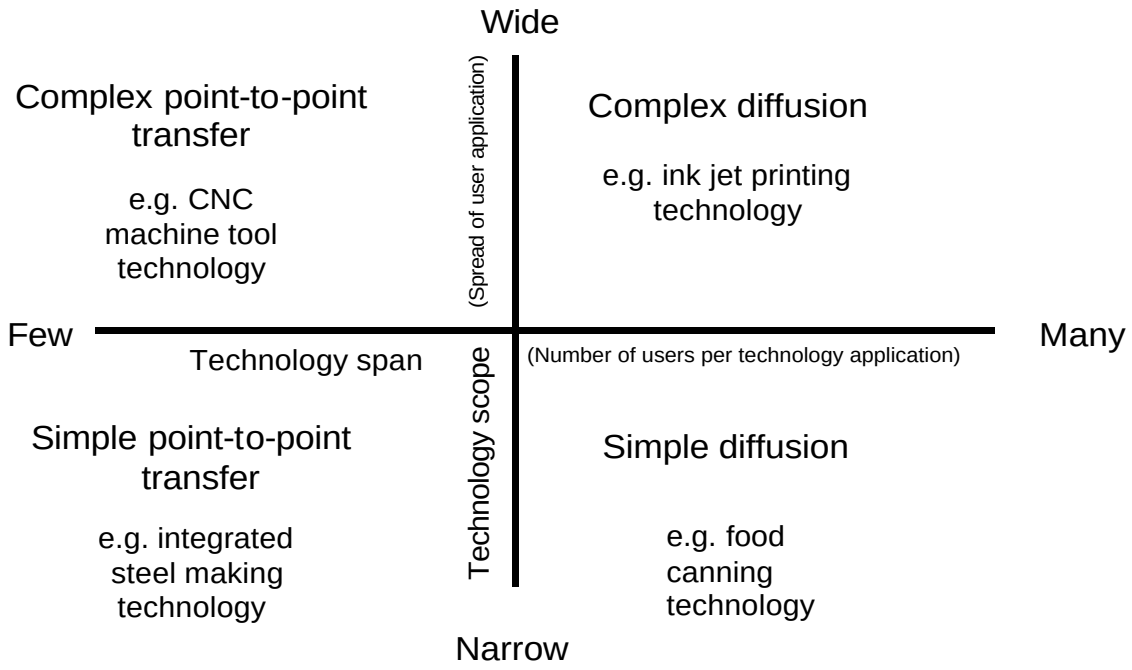
When technology is transferred it can be in various forms. For example, in product technology transfer it can involve the materials and components that together form the end-product, while in process technology transfer it can comprise production equipment and tools. This would normally be the hardware aspect of technology. However, in both product and process technology transfer it can also comprise documentation and procedures on the design and manufacture of the product or instructions in use of the equipment, which is the technology software. Also, in both product and process technology transfer it can comprise know-how and skills, which is often called the technology 'humanware'. This differs from software in that it will embrace the technology supplier's accumulated knowledge about how and why things are done, i.e. the 'tacit' knowledge aspects of the technology.

To further understand the impact of technology transfer through its subsequent dissemination in different applications consider the framework in Figure 1.

This places transferred technology on a vertical scale according to its scope, as determined by the spread of user application, and on a horizontal scale according to its span, as determined by the number of users per technology application.

Four modes of technology transfer are thereby defined by this classification. "Simple point to point transfer" is where the spread of user applications is narrow and the number of users few. An example could be the technology for an integrated steel making. Its use is strictly limited to the production of steel and the number of integrated plants in operation would be relatively small. "Simple diffusion" is where the spread of user applications is narrow and the number of users many. An example of this could be the technology for canning food. Again the use of this technology is limited but the number of applications would be much greater. "Complex diffusion" is where the spread of applications is wide and the number of users many. Here an example could be ink jet printing technology. Here the application goes beyond its use in printers for computers. It can also be applied in printing code numbers onto packaging, 'sell by' dates onto containers, seating details onto theatre tickets etc. Lastly, "complex point-to-point transfer" is where the spread of applications is wide but the number of users few. The computer numerically controlled, or CNC, machine tool falls into this category. The numbers produced are usually fairly low compared with other products while user applications are extremely diverse. In fact, it is quite common for each machine to be individually engineered for a particular application, which could be in a wide range of different industries.

Figure 1 Technology transfer modes and types of dissemination
Source - Adapted from Leonard-Barton, D (1990)



Technology and competitiveness

In discussing the relationship between technology, competitiveness and economic growth at the macro level, the OECD (1992) conclude that "the proposition that investment in R&D and technological progress are essential for future economic growth has not yet been conclusively empirically demonstrated". The difficulty of demonstrating this relationship is understandable as R&D is just one component of innovative activity that takes place within enterprises, albeit within the context of its external linkages and government policies. For an enterprise, competitiveness refers to the capacity to create and sustain cost and/or product advantages to gain or maintain strong positions in the markets for its products and a high level of profitability. In general, the advantages are based on the ability of a firm to (a) successfully define its scope, (b) manage and coordinate the core functions and operations within the enterprise as well as relationships with suppliers and customers, and (c) be aware of market demand characteristics and respond to them appropriately. In advanced technology sectors, technology and the ability to innovate are key aspects of the organisational knowledge of a firm that give it distinctive capabilities and competitive advantages.

However, it is also necessary to combine these capabilities with the ability to commercialise the technology. Such a combination requires effective interactive and responsive relationships between marketing, formal R&D and design engineering. In this respect, a strong correlation has been found between a corporation's competitiveness and its ability to commercialise technology. In a diverse range of markets and products (photocopiers, fax machines, computers, cars, semi-conductor production

equipment and pharmaceuticals), industry leadership not only rests on technology but on the superior commercialisation skills. According to Nevens et al (1990) in such R&D intensive industries "companies that are first to market the products based on advanced technologies demand higher margins and gain market shares. Companies that spin out variants more rapidly and leverage their core technology across more markets earn higher returns." The ability to make better use of generic features of key contemporary technologies is also another feature of firm level competitiveness.

There are some clear implications of the above observations for the competitiveness of enterprises. The recognition of commercialisable technologies and the capability to commercialise them are crucial. However, an important qualification is that most of the evidence is from industrialised countries. The gaining of technological capability in the newly industrialised countries was based initially on learning to use established technology. Their emphasis has therefore been less on basic research and more on combining applicable technological knowledge which could be appropriated from what was publicly available with that supplied by companies from industrialised countries in technology transfer arrangements.

The concept of competitiveness at the national level is more problematic and controversial. The debate on this subject is complex because of the confusion that arises between the implications of static comparative cost advantage and the dynamic gains that exist if a country has a significant number of firms and industrial sectors which gain market shares internationally because of their competitiveness. The OECD defines the competitiveness of a country as:

> *"the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, whilst simultaneously maintaining and expanding the real incomes of its people over the long term".*

The European Commission (1994) attempts to encompass entities other than countries in the following definition of competitiveness as:

> *"the capacity of businesses, industries regions, nations or super-national associations exposed, and remaining exposed, to secure international competition, to secure a relatively high return on the factors of production and relatively high employment levels on a sustainable basis."*

Krugman (1994) is a strong critic of the notion of country competitiveness and argues that the concept implies there are winners and losers in world trade. He argues, primarily on the grounds of static comparative advantage, that international trade is a non-zero sum game in which there are gains for all the parties. This is a valid point to the extent that all specialisation and trade generate gains for the trading parties and therefore trade is preferable to no trade.

In both the OECD and the European Commission definitions, competitiveness represents the ability to make dynamic gains in the form of higher growth rates. These gains need not be at the expense of other countries as the growth in world output and trade should, in principle, enable all countries to increase their volume of exports and growth. However, in practice, there are relative gainers and losers as indicated by differences in the long-term economic growth rates between countries. Typically, countries with high growth rates have also had high growth of exports showing that some have made relative gains at the expense of others. In this sense, a measure indicating maintenance of competitiveness is the long-term growth rate for a particular country or region in comparison with that of other countries and regions.

The definitions of competitiveness for a country or wider entity imply that the entity has a significant number of firms and industrial sectors which "meet the test of international markets" to maintain and expand "the real incomes of its people over the long term". However, a firm rarely develops competitiveness in isolation of the external linkages and environment in which it operates. This external context may include some or all of (a) competitive rivalry with national firms, (b) related and supporting firms, industrial sectors and industry associations, and (c) regulatory and enabling public agencies (see Nelson, 1992; Porter 1990 and Freeman, 1987).

Latecomer industrialisation and the role of technology in development

It can also be said that the fast economic growth rates achieved by Japan between the 1950s and the 1980s, the East Asian NICs between the 1970s and 1990s and China's recent fast industrialisation are demonstrations of country competitiveness, though not necessarily based on advanced technology. The following discussion refers to the earlier stages of acquisition of technological capability by the so-called "first tier" Asian NICs or the four tigers, South Korea, Taiwan, Hong Kong and Singapore.

Conventional economics based explanations put the industrialisation and growth performance of the Asian NICs down to the outward oriented economic policies pursued by them. Important components of such a policy regime are (a) fiscal and monetary management which ensure low inflation rates and a stable and competitive currency, (b) a liberal trade regime, and (c) as few distortions as possible in the factor, goods and services markets. This explanation is also related to the "stages" theory of comparative advantage in which advantage shifts from the relatively low labour cost based industries to more skill and capital-intensive manufacturing as an economy's factor endowments change in the course of development.

It is assumed that once the policy and price distortions are corrected, firms in developing countries are able to respond to world market demands using the comparative cost advantage offered by the country. There are two main arguments against this explanation. Amsden (1988 and 1989) and others have argued that in Korea a high level of government intervention and price distortions were used to support the major industries and Wade (1990) puts forward a similar thesis for Taiwan.

Further, as competitive advantage is developed by enterprises in specific product markets, macroeconomic policies are not sufficient explanations of competitive advantage. In fact, no model can capture the diversity of the experiences and policies of these countries.

The primary concern here is not with the economic policy issues but with the development of technological capabilities at the firm level in the Asian NICs and their lessons in understanding how national competitiveness can be developed through technology acquisition by industries and individual companies. These capabilities can be grouped into four broad categories:

(i) Knowledge and skills required for the processing of production where shop floor experience and learning by doing play an important role;
(ii) Knowledge and skills required for investment, that is the establishment of new production facilities and the expansion and/or modernisation of existing ones;
(iii) Adaptive engineering and organisational adaptations required for the continuous and incremental upgrading of product design, performance features, and process technology;
(iv) The knowledge required for product and process innovation and the creation of new technology in some manufacturing industries.

It is only in the last stage identified above that innovation and development of technological capabilities take place. In the early period of rapid industrial growth, most industrial production in the Asian NICs was concentrated in consumer non-durable industries with relatively low technology requirements. Production capability was thus restricted to the efficient operation of labour intensive production processes. Firms in the Asian NICs have acquired the technological capabilities first and foremost by making judicious use of foreign technology sourcing. To gain the required knowledge quickly they relied on customer firms to provide specifications and concentrated on developing the capacity to produce to specifications at low cost. Korean and Taiwanese firms used original equipment manufacturer (OEM) agreements and Singapore and second tier NICs relied largely on FDI as means of entry into world markets. What is important is how effectively a firm combines foreign technology elements with its own experience and knowledge in order to strengthen its internal capabilities.

This focus provided firms with valuable experience in mass production methods and the more successful of them were able to learn from this experience and upgrade product quality, improve production processes and efficiency, move into higher value added segments and develop own brands. The "stages" for South Korea are set out in Table 1. This model refers primarily to consumer products. As Amsden (1989), among others, has shown, for heavier industries such as steel, chemicals and shipbuilding, there was much greater state support and protection.

A striking feature of the early development of the Asian NICs is that they largely sought to benefit from available technological knowledge from abroad. In this sense they were "free riding" on the scientific and technological knowledge base developed by the industrialised countries. However, in order to absorb the technological and scientific knowledge, education, and especially technical education, had to be of a high level. The policy focus was on improving education and training to develop the capacity to absorb and use the imported technology efficiently. Table 2 shows that advanced R&D started relatively late in Korea. The technological capability had to be combined with complementary management skills for commercial success.

Table 1 Typical technological capability building process: the South Korean model

	The process of development	**Technology imports**	**Production and R&D**
1960s-1970s	*Goal:* establishment of production base. *Characteristics:* heavy dependence on imported technologies.	Packaged technology: turnkey based plants. Assembly technology.	Knock down production (SKD/CKD). OEM-dominated. Almost no in-house R&D.
Early 1980s	*Goal:* promotion of self-reliance. *Characteristics*: import substitution, localisation of parts/components production.	Unpackaged technology: parts/components technology. Operation technology.	OEM/own brand: high ratio. Product development.
Late 1980s-1990s	*Goal:* export promotion by means of expansion of domestic market. *Characteristics:* beginning of plant exports, learning advanced and core technologies.	Materials-related technology. Control technology. Design technology High-quality product technology.	OEM/own brand: low ratio. Product innovation. Process improvement.

Source: OECD (1996) Review of National Science and Technology Policy: Republic of Korea, OECD, Paris.

The Korean approach to technology development contrasts sharply with that adopted in India and China, both of which have long traditions of basic and applied science research, although a significant proportion of this is in military related fields (aeronautics, space and nuclear). Despite, or possibly because of, their scientific expertise and focus they have been slow to acquire proficiency in commercial applications of new technologies. This is partly because of sizeable barriers to diffusion of scientific knowledge, which raises questions about the effectiveness of the institutional structure or the national innovation system in the two countries. Another possible reason is that the scientific knowledge being developed was not of the kind that could be easily commercialised. Diffusion of scientific knowledge to raise the level of national competitiveness is by no means an automatic process and requires a number of relationships and appropriate incentive structures which are imperfectly formed in these economies.

Table 2 Main aspects of industrialisation and S&T (science and technology) development since the 1960s in South Korea

	Industrialisation	**S&T development**
1960s	Develop import-substitution industries. Expand export-oriented light industries. Support producer-goods industries	Initiate S&T education. Construct scientific and technological infrastructure. Promote foreign technology imports.
1970s	Expand heavy and chemical industries. Shift emphasis from capital imports to technology imports. Strengthen export-oriented industrial competitiveness.	Expand technical training. Improve institutional mechanism for adapting imported technology. Promote research applicable to industrial needs.
1980s	Transform industrial structure to advanced and balanced form. Expand technology-intensive industry. Encourage human resource development and improve productivity of industries.	Develop and acquire top-level scientists and engineers. Perform national R&D projects efficiently. Promote industrial technology development.
1990s	Promote adjustment of industrial structure and technical innovation. Promote efficient use of human and other resources. Improve information network.	Realign national R&D projects Strengthen demand-oriented technology development system. Internationalise R&D systems and information networks. Construct S&T infrastructure.

Source: OECD (1996) Review of National Science and Technology Policy: Republic of Korea, OECD, Paris.

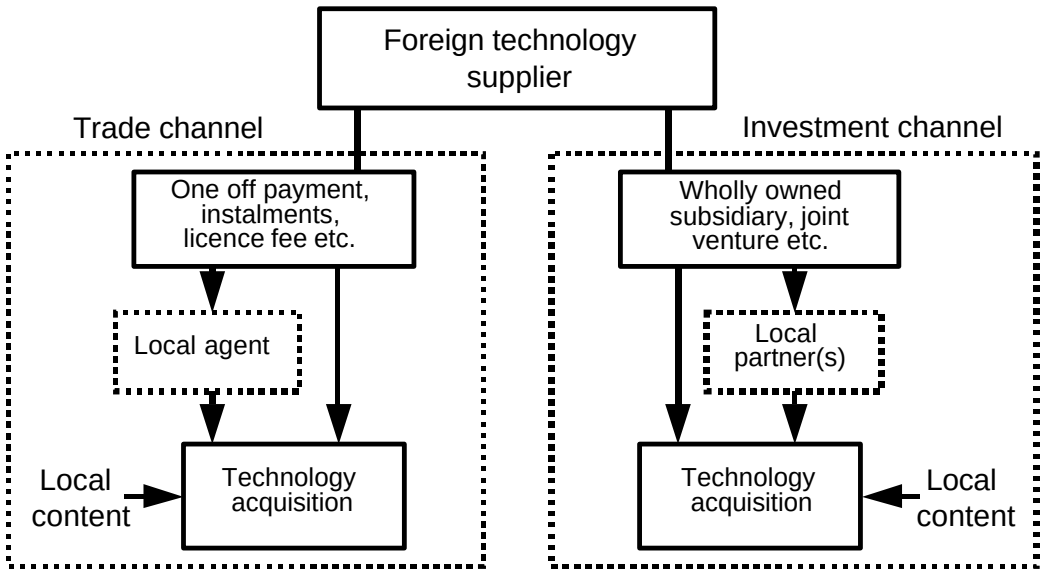
By contrast, in the Asian first tier NICs a much higher percentage of R&D is focused on commercial applications. Taiwan's R&D sector, for example, includes a number of quasi-public research institutes with close links to the private sector and scientists are encouraged to establish their own firms to commercialise the results of their R&D. Until the 1980s, Korean government research institutes concentrated almost entirely on improving production technology to support the needs of private sector firms. A reorganisation of the R&D infrastructure started in the 1980s in Korea. Under this reorganisation, new advanced technology programmes were launched in ultra-large-scale integrated circuits (ULSI), advanced materials for information electronics and energy industries, advanced manufacturing systems, bio-technology, environmental technology, energy technology and nuclear reactors (see OECD, 1996).

Box 2 - Trade or investment?

There are two recognised channels for transferring technology to enterprises, apart from the unofficial channels of espionage and copying (which is sometimes legitimised and termed 'reverse engineering').

The first of these is the trade channel (Figure 2). This is where the foreign supplier provides technology in exchange for a financial return such as a one off payment, instalments, or a licence fee. The technology can be transferred though a local agent and there may be some local content added, depending on the conditions in the recipient country and the particular arrangement between the supplier and acquirer. is under the trade channel that there is the greatest risk of leakage or misappropriation of the technology, so for this reason suppliers often withhold key hardware components or important pieces of know-how.

Figure 2 The channels for transferring technology to enterprises



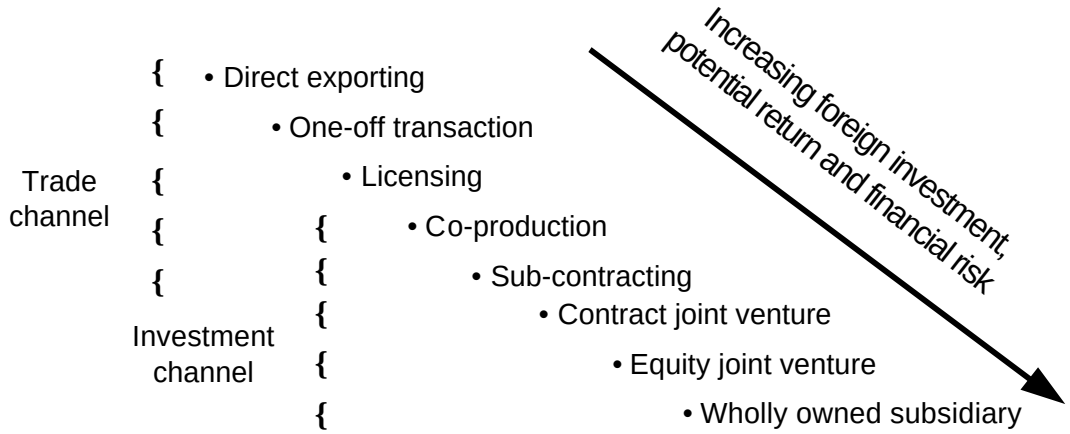
Box 2 (cont.)

The second transfer channel is the investment channel. This is where the transfer of technology forms part of the investment made by a foreign company in a host country. This can be through a wholly owned subsidiary, an equity joint venture or any other form of arrangement where there is a tangible or intangible contribution that gives the foreign supplier some management control within the host country. In anything other

than a wholly owned subsidiary this control would be shared with a local partner who will also contribute a minor or major part of the total investment, which itself will have an influence on the amount of control exercised by each partner. With the investment channel there is more likely to be some local content, but it will probably be greater than with the trade channel with the amount increasing as the project develops.

In practice there is a wide spectrum of types of arrangement for transferring technology (Bennett et al, 1997). These are shown in Figure 3. Direct exporting of technology products, one off technology transactions, licensing, co-production and subcontracting are all trade channel arrangements. Contract joint ventures, equity joint ventures and wholly owned subsidiaries are all investment channel arrangements, though there may also be some investment involved in co-production and sub-contracting. The extent of foreign investment, potential returns and financial risk increase as the form of arrangement moves increasingly away from pure trade and towards greater investment. Of course not all foreign investment is in the form of technology but in countries with fast economic growth a high percentage of technology based investment is a common feature. For example it is estimated that about 80% of the foreign direct investment into China has been in the form of technology.

Figure 3 Types of arrangement for transferring technology



Fast growth by acquiring technology through FDI: The case of China

As the global business environment becomes more competitive there is increasing pressure for companies in the industrialised countries to make maximum use of the proprietary resources that form the basis of their technological competencies. Therefore, there often becomes a need to extend the application of their know-how through some form of technology collaboration. The international transfer of technology is being seen increasingly as a means whereby companies can globalise their production operations in order to take advantage of resource or market factors (De Toni et al, 1992). To most manufacturing companies and many service businesses technology is a key resource that provides their distinctive capability and competitive advantage (Kogut and Zander, 1993). Often the transfer of technology will be to overseas subsidiaries, which may have been created as greenfield operations or could result from the takeover of a local company. However, in many cases, it will involve collaboration with foreign partners, possibly including some associated investment. Through joint use of technology, future added value can be generated that will provide a return to the technology 'owner' in exchange for its transfer, but only when the perceived benefits of transfer outweigh the costs and risks should owners share their technology through collaborative operations (Dunning, 1991). It is therefore significant that, during the 1970s and 80s, such a form of collaboration, the international joint venture, replaced wholly owned subsidiaries as the preferred method for US multinationals of transferring technology internationally (Shenkar and Zeira, 1987).

For the receiving country, technology transfer also has potential internal benefits. For example many developing countries regard the inward transfer of technology as a means of rapidly catching up with the industrialised nations. China has been promoting technology transfer for this purpose in a range of advanced technology sectors. Transfer though collaborative partnerships involving foreign direct investment has been encouraged by the Chinese authorities as the preferred means of acquisition since its "open door" policy was introduced in the early 1980s (Lan, 1996). At the same time the formation of technology-based collaborations provides foreign businesses with an important means of gaining entry to the Chinese market as well as providing the opportunity to take advantage of China as a production base. According to statistics provided by MOFTEC (the Chinese Ministry of Foreign Trade and International Cooperation) actual foreign direct investment into China since 1979 reached a cumulative total of around £306 billion by the end of 1999 and the number of foreign funded projects reached about 285,000 in the same period.

China's foreign investment and technology transfer policies

The policy on technology transfer has undergone a number of changes since the People's Republic of China was established (Saich, 1989; Zhu et al, 1995). At first, turnkey project investments supplied by the former Soviet Union and Eastern European countries were the most important form of technology transfer. These investments typically established whole industrial enterprises mainly in heavy industries such as steel, machinery and vehicle manufacture. After the deterioration of relations with the USSR, followed by the 'Cultural Revolution', China turned inwards and tried to develop its own technological capability. During this period there was limited technology transfer from Western countries and Japan, mainly key facilities and equipment for scientific research. During the 1970s the bulk of technology imports were still in the form of complete sets of equipment or turnkey plants (Shi, 1998). Investments during this time occurred mainly in the technologically backward sectors of petrochemicals, steel, electricity generation equipment and mining machinery industries, with the objective of developing technological capability in these sectors based on the more modern technology of the capitalist economies.

Following the end of the Cultural Revolution the decision was taken to begin some limited market reforms and to open up parts of the economy to more foreign trade and investment. A government review of technology transfer policy soon afterwards found previous approaches, which relied on turnkey projects and purchase of equipment, deficient in a number of respects (Bennett, Vaidya, Wang and Zhu, 1997). The turnkey projects were expensive and provided limited scope for developing local technological capability. This conclusion is consistent with experience elsewhere, that developing capability beyond simply the ability to use technology requires time to learning and often necessitates long-term collaboration with the technology supplier (Lall, 1992).

In 1986 the Chinese authorities announced the "Provisions of the State Council of the People's Republic of China for the Encouragement of Foreign Investment" to encourage the transfer of technology through foreign investment into what the government considered to be more 'productive' areas of the economy. Under these provisions, foreign joint ventures were granted a number of privileges including preferential taxation, simpler licensing procedures, freedom to import inputs of materials and equipment, more autonomy from bureaucratic interference, interest free loans, and the right to retain and swap foreign exchange with each other. Foreign investment enterprises that employed advanced technology and were export oriented also enjoyed additional tax benefits.

These improved incentives and a growing awareness of the potential of the Chinese economy stimulated a dramatic increase in foreign investment into China in the early 1990s. For example in 1993 alone the contract value of new foreign investments was US$110 billion, which was more than the entire contact value of investments up to the end of the previous year. However, much of the foreign investment was in relatively low technology, labour intensive, operations that took advantage of China's low wage costs and policies to attract investment into the Special Economic Zones (Thoburn and Howell, 1995).Many such investments were in subcontracting operations,

with higher-level functions such as design and marketing often remaining in the home country (Lan, 1996). Also, with many operations only involving assembly work of components supplied from outside (in 'screwdriver factories'), opportunities for local parts suppliers to upgrade their capabilities and grow their businesses were also limited.

Box 3 - The phases of China's industrial development and related technology transfer policies

First Phase (1950s)
Industrial development based mainly on projects introduced from the Soviet Union and Eastern Europe.
- Technology acquisition through turnkey projects into large scale industries.

Second Phase (1960's)
Largely independent industrial development.
- Small amounts of technology transferred from Western countries and Japan (mainly key facilities and equipment for scientific research).

Third Phase (1970s)
Industrial restructuring based on capital projects in technologically backward sectors.
- Technology acquisition mainly through turnkey plants in an attempt to develop technological capability in weak industries.

Fourth Phase (1980s)
Accelerating pace of industrial reform, particularly in the manufacturing sector.
- Emphasis placed on learning through technology transfer (mainly via Sino-foreign joint ventures - incentives for foreign investment through tax concessions etc).

Fifth Phase (1990s)
Rapid growth, less state ownership and intervention, extensive opening-up to foreign investment. Establishment of a 'socialist market economy'.
- More emphasis placed on the transfer of high technology. Concessions removed for low technology, labour intensive processing industries.

Sixth Phase (2000s)
Preparation for admission to WTO. Equalisation of tax regime for foreign owned and local companies.
- Transfer of high technology into wholly foreign-owned subsidiaries as well as joint ventures, including R&D and design capability.

As a consequence of this situation there has been some tightening of regulations and concessions affecting foreign investments. In 1994 the State Council announced a number of policies to promote foreign investment in specified key sectors including communications, energy and raw material sectors.There was also a tightening of procedures for the approval of contracts and the registration of foreign enterprises. These included stricter penalties if agreements were not fulfilled, new rules requiring foreign companies to invest capital within a prescribed period so as to reduce the gap between pledged and utilised investment, and new rules on the sharing of investment risks between Chinese and foreign investors to remove the need for investment guarantees.

In 1995 further guidelines were published detailing the foreign investments the government now wished to encourage, along with those that were to be restricted, prohibited or just permitted. These guidelines encouraged investment in high technology sectors (chemical fibres, micro-electronics, precision machinery, civilian aircraft, biotechnology and energy development) as well as infrastructure and agricultural developments. Investment in the priority sectors would continue to benefit from tax preferences and foreign invested companies in these sectors would be permitted to sell up to 100% of their output in the domestic market. Elsewhere, tax preferences were mainly to be phased out, although the authorities subsequently relaxed their stance when a number of high profile foreign companies made moves to reduce or withdraw their activities in China (Wu and Strange, 1997).

In 1998 the State Planning Commission identified eighteen industries, mostly in high-technology sectors, where China wished to promote further foreign investment. These sectors would be granted a restoration of duty free status on capital equipment imports (Note: foreign funded companies could import capital equipment duty free but this concession was not available to local enterprises, therefore the government was trying to phase it out as a way of restoring a level playing field). These newly promoted sectors were high-technology industries, new technologies, transport and telecommunications equipment, electric power generation, aviation, oil and petrochemicals, machinery, electronics, pharmaceuticals, medical equipment, textiles, metals and metallurgy, light industry, the service sector, and agriculture. At the same time the State Planning Commission also reaffirmed broad limits to foreign ownership in businesses in areas considered to be key sectors of the economy - such as nuclear power plants, satellites and aviation.

Also in 1998 the government announced that the tax systems for foreign and domestic companies were to be merged by the year 2000, a change that would more than double the tax burden on some foreign-invested enterprises. However, favourable treatment was retained for sectors and areas where China remains keen to attract foreign. This removal of some tax incentives for foreign investors signals a more discriminatory approach to foreign investment and is part of the Chinese government's attempt to redirect growth from basic industries (e.g. shoes and toys) in favour of higher-technology sectors. In effect, the foreign investment regime is now more closely linked with domestic industrial policy priorities and wider economic and social objectives.

Factors influencing successful technology transfer to enterprises

Empirical evidence from actual cases has provided information about the factors that influence successful technology transfer. These can be summarised as follows:

- Having compatible objectives between the foreign supplier and local acquirer of the technology.
- Establishing an appropriate relationship or partnership form between the technology supplier and acquirer.
- Agreeing a value for the technology that is acceptable to both the supplier and acquirer.
- Ensuring the necessary technical and managerial skills are in place to absorb the technology.
- Confirming that the transferred technology will gain market acceptance and provide sufficient commercial returns.
- Ensuring security of the technology and protection of the foreign supplier's competitive advantage.

Four case studies of technology transfer to China are now described in order to demonstrate the factors influencing success together with the some of various aspects that need to be considered when transfer is taking place within different contexts. A discussion on each is provided so as to highlight the main points in relation to the factors and aspects that have been identified.

The case studies illustrate the following technology transfer situations:

1. Transfer of technology for the manufacture of mobile telecommunications equipment through an equity joint venture.
2. Transfer of technology for the manufacture of airframes for civil aircraft through a contracting agreement.
3. Transfer of technology for the manufacture of automotive engines through a one-off purchase of product designs and processing equipment.
4. Transfer of technology for the manufacture and development of machine tools through a collaborative co-production agreement.

The cases are all of real situations that have been investigated by the authors but fictitious names have been used to avoid any inadvertent breach of commercial confidentiality.

Box 4 - Case Study: Nordica HongYing Telecommunications

Nordica is a Scandinavian telecommunications equipment manufacturer. In China it manufactures telecommunications systems and equipment and mobile phones. It is one of the main suppliers of GSM 900 networks, GSM1800 networks and mobile telephones. It is also one of the key suppliers for fixed switching and transmission systems to operators, railways and oilfields.

One quarter of Nordica's business is in the Asia Pacific region and there was a 30% increase in sales to China in 1999 making China now the second most important market for the company after the USA. Worldwide there are 12 telecommunications infrastructure manufacturing facilities in 5 countries and 10 telephone handset manufacturing facilities in 8 countries.

The company's business in China started during the 1960s and 1970s with sales of fixed telephone equipment. In 1985 a representative office was established Beijing. For mobile telephone equipment Nordica has two major competitors in China. One entered the Chinese market before Nordica selling pagers and the other earlier still with switching equipment.

Nordica's development within China has been in three phases, i.e.
Phase 1: market entry 1985-1996
Phase 2: local manufacturing 1997-1999
Phase 3: integration into the Chinese telecommunications industry 1999 -

Nordica now has 7 joint ventures in China and one wholly owned subsidiary. It also has branch and representative offices throughout the country. Altogether around 3,500 people are employed in China. Mobile communications are highly regulated. Wholly-owned foreign enterprises are not allowed to provide services but they can make products provided they fulfil certain conditions. For example, although Nordica's wholly owned subsidiary makes the same product as other sites it is required to focus on exports.

Beijing Nordica HongYing Telecommunications Systems Ltd. (NHT) was established as part of Phase 2 of Nordica's entry strategy for China. Negotiations started in 1993 and the business licence was granted in 1994. There was already a good brand awareness of the company's products that had been established under Phase 1 but without local production its markets were limited to the railways, oilfields etc. It therefore needed to have a local joint venture partner and manufacturing facilities in China to be a credible supplier.

Box 4 (cont.)

The Chinese partner is under the Aerospace Ministry, which it was thought had a strong influence and would provide good support from the Chinese government. HongYing already had experience of manufacturing telecommunications switching equipment from an earlier co-operation with a German telecommunications company to produce PABX exchanges. The joint venture contract is for 25 years. NHT's building is rented from HongYing which uses some of the space for its own production. HongYing also has a separate building on the same site.

Initially NHT produced fixed telephone switching equipment and between 1994 and 1997 had begun to sell to the PTAs (Provincial Telecommunications Administrations) and PTBs (local bureaux) in provinces such as Henan and Hebei. It did not have a very big market share but had established a good position in the market. However, local Chinese companies were improving their capability to produce fixed switching equipment and were becoming a serious source of competition.

In 1997 Nordica therefore examined how it could move its strategy forward and in 1998 decided to change its business scope in China to manufacturing mobile GSM systems. At the time it had a reasonably good position in the Chinese mobile telecommunications market but it needed to be improved. Aother joint venture had already been manufacturing handsets since 1996 and NHT therefore changed to manufacturing mobile switching equipment. At the same time the ownership was changed so that Nordica now has 70% of the shares and HongYing holds 30%. The new ownership arrangement was reached amicably because HongYing thought 30% was still a good share of the new business activities. An R&D facility was also established on the same site in the same year but was a separate wholly owned subsidiary of Nordica's holding company in China. It would not be easy for Nordica to acquire 100% of the shares of the manufacturing company. Given its business scope and local markets it would be prevented by the regulations. In any case Nordica did not wish to have complete control because having a Chinese partner is still vital in the telecommunications sector for reasons of access, to understand the local regulations, handling the interface with the authorities etc. There are no difficulties working with the local partner; the roles of the two parties are clearly defined and there is good co-operation.

Box 4 (cont.)

Between 1998 and the present time there have been big changes. A major technology transfer project was started in mid 1998 to bring in the latest technology and this has resulted in all mobile switching equipment for the Chinese market being supplied by NHT in association with its subcontractors in China and the local partner. In practice NHT does not actually manufacture any of the parts for its products (Nordica's core competencies are understanding market needs and designing new products fast). Manufacture of the major parts of products is completely outsourced to companies that have specialised manufacturing capability. NHT's activities are testing and integration so most of the production employees are software and systems engineers.

NHT is one of only two facilities worldwide for Nordica's mobile switching equipment, the other being in Europe. Therefore it is now moving from its original position of being simply a supplier to the Chinese market to becoming part of Nordica's global production network. NHT exports 20% of its output, but this will increase. Products are exported throughout the world, not just to the Asian region.

In the electronics sector NHT is ranked number 4 in Beijing in terms of sales and number 14 in China as a whole. Among mobile telecommunications equipment companies Nordica is now the leader in China for telephones, while another European based company is the leader for infrastructure. All Nordica's competitors for mobile telephones are selling in China, including some emerging Chinese companies such as HuaWae. Another Chinese company, EastCom, also produces mobile telephones but they are essentially re-badged products of an American partner.

NHT employs 170 people, more than 90% of whom are Chinese. Expatriates fill the positions of General Manager, Financial Controller, Production Manager and Head of the Software Centre. In the JV contract only the General Manager and Deputy General Manager positions are specified as being nominated by the respective partners. There are also expatriates in technical positions, typically for postings of 1 to 2 years. Chinese nationals are in the positions of Deputy General Manager (originally recruited from the partner company), Quality Manager, Human Resources Manager and Sales Manager. Nordica does not employ any 'overseas Chinese' staff It is the company's policy to develop its own Chinese managers, whereas some other companies such as Nordica's main American competitor places heavy reliance on using overseas Chinese staff (e.g. from its company in Taiwan).

Box 4 (cont.)

Very few employees were transferred from the Chinese partner - only some key managers. Recruitment is normally through advertising, job fairs and via the Internet. There is also some rotation around the Nordica companies in China, although there is still sometimes some difficulty with the authorities in transferring the personnel files between cities so this is mainly relevant within Beijing. Apart from the normal selection criteria regarding technical skills etc., a knowledge of English is usually important. The company also tries to recruit people with the correct 'attitude' so people who had spent a long time in state owned enterprises would not normally be employed.

The company has a positive employee development policy. Each person has a job profile and a training plan is arranged accordingly. There is a production and software training centre and both theoretical and on-the-job training is used. A large number of employees went to Europe for between one and three months in 1998 as part of the major technology transfer project. Among the engineers about 30% went to Europe (approximately 50 people). There is also considerable attention paid to management and leadership training. There is a lot of theoretical training in China but Nordica's global facilities are also used for practical management training. Its facilities in the USA are often used for this purpose, especially when training relates to new technology development. In addition to the formal study organised by the company a lot of employees enrol for part-time study in local institutions.

The main target of the technology transfer project in 1998 for mobile switching equipment was to transfer manufacturing totally to China and in particular to local subcontractors. The emphasis was on systems integration. The person who ran the project was subsequently appointed Production Manager. He had considerable experience with transferring technology to other countries previously. The project involved transfer of manufacturing technology, establishing logistics procedures and systems to support production and supply together with training. The company made the conscious decision not to have "troops" of expatriates going to China but to recruit

Local people first. The emphasis was therefore on fast recruitment of local staff and training. The company tried to make good use of the existing Chinese staff in the Nordica organisation. There were many project teams comprising both European and Chinese staff. Some were led by Europeans and some by Chinese.

The first objective was to develop competence within the Chinese operation. This took between one and one-and-a-half years. The parent company in Europe was surprised at the speed of knowledge acquisition by the Chinese operation and has used the experience as an example of how to transfer knowledge to other countries.

Box 4 (cont.)

The second phase of technology transfer was to further develop the company's subcontractors. There are 4 or 5 subcontractors with significant orders from Nordica in terms of volume. The company prefers to have a limited number and to get things right. One contractor is HongYing, the joint venture partner, some were in China already and others followed the company. Apart from the partner one other contractor is a wholly Chinese company. Developing logistics systems took a long time and by comparison the transfer of the necessary manufacturing technology was completed quite quickly. The idea that the competence in telecommunications is understanding market needs and designing new products, rather than manufacturing, is new to the Chinese authorities that have been more used to overseeing large vertically integrated enterprises. Nordica has been talking with MII (The Ministry of Information Industries) about this concept and it is enthusiastic about the idea. Under WTO Chinese telecommunications and electronics companies will be exposed to the full forces of the market and will need to operate in the same way so they have to become more focused. The MII needs to help Chinese companies to invest in resources and to recognise that it is not a labour intensive industry so labour cost is not important. Local companies such as HuaWei have this type of assistance. Nordica does not object to this and thinks it is understandable given China's circumstances.

NHT has done some benchmarking studies of its operations. It is now at about the same level as other Nordica plants worldwide across a range of metrics. The "bottom line" (i.e. cost of production) is about the same as the other mobile switching facility in Europe. Nordica's advantage is not simply in having low cost facilities in China but in having multiple production sites so it can balance supply and demand globally. Access to the China market is a secondary consideration now. The objective is to get "fair treatment" from the Chinese government and regulations. Having a manufacturing plant in China allows entry to the controlled market for telecommunications equipment. Then it is up to normal, competitive criteria such as having good products, competitive prices, good service and a local "presence". Establishing the Nordica brand is also important.

NHT has not experienced any big problems with technology transfer that has adversely affected the business. There have just been some technical issues that have required attention. The important thing has been to work closely with the Ministry of Information Industries to help influence the development of the industry in China. Most of the discussions are bi-lateral but there are also some multi-lateral "round table" meetings with several manufacturers, although these are mainly information sharing sessions rather than forums to discuss real issues.

Box 4 (cont.)

Essentially the main problem for NHT is that the Chinese market is still regulated. For example there are quotas on imports that would not be allowed in Europe. However, this is changing. With the impending entry of China into WTO there will be an eventual removal of barriers. Most negotiations with the local authorities can be done by NHT itself now the company has become established but the Chinese partner still needs to be involved in high-level discussions with the government. However, this is something else that will change in the future.

The NHT case illustrates a number of aspects of technology transfer through Sino-foreign equity joint ventures, which have been the most popular form of transfer in the late 1980s and 1990s. One of the most important is the selection of a suitable partner by the foreign owner of the technology. As was mentioned above, compatibility of partners' objectives has been found to be a key factor for ensuring successful transfer. HongYing was not one of the established Chinese manufacturers of telecommunications equipment. It was under the Aerospace Ministry. However it did have the necessary technological capability and experience of telecommunications equipment through an earlier co-operation and appears to have complementary objectives to Nordica. It has often been found that when partners are in exactly the same industry they may not necessarily have the same objectives. For example foreign companies transferring technology to China usually do so with the aim of accessing the Chinese domestic market. On the other hand Chinese companies in the same industry often have the intention of using the acquired technology to penetrate export markets, which may be against the interests of the foreign partner. Another common example of incompatible objectives is where the foreign partner is taking a long-term view while and the Chinese partner is taking a short-term one. This is often the situation where the Chinese partner is a state owned enterprise that is burdened with debt and making losses. It therefore sees the technology transfer partnership as a means of helping its survival rather than as a means of improving its competitive position. Such an objective would conflict with the foreign partner's own strategic aims and probably lead to operational difficulties for the joint venture.

Another important aspect of equity joint ventures is the relative ownership shares of the two partners. Generally the foreign partner's preference is for a majority share. However, there are some successful joint ventures where the foreign partner only owns 50% (e.g. Shanghai Volkswagen) or even has a minority of shares (e.g. the UK company Pilkington owns only 17% of Shanghai Yaohua Pilkington Glass, although this has now converted from a joint venture to a publicly quoted company). The 70% share of NHT held by Nordica ensures it has adequate control over the joint venture while enabling the Chinese partner to have a satisfactory share of a commercially successful business. Since wholly foreign-owned companies are effectively not permitted in telecommunications equipment manufacture the partners seem to have achieved the optimum ownership arrangement.

A further aspect that is important in the Nordica HongYing case is security of the transferred technology. If the foreign supplier's know-how is appropriated by a third party then it might find its competitive advantage is threatened. Chinese telecommunications manufacturers have the ability to copy foreign products and adapt them to the local market. It is estimated that their technology lags only about one year behind that which western companies are producing. Copying can be done more effectively if there is an 'inside track' to the foreign technology, which is why some of the software codes (or source codes) are not provided to Chinese partners. Acquisition of the source code is a common issue in negotiations between western telecommunications companies and their Chinese joint venture partners. The Chinese side usually tries hard during negotiations to have the source code included in the transferred technology. They would then be 90% of the way towards being able to completely replicate the technology. Sometimes the source code has to be provided for effective localisation of the product. For example with pay phones it is necessary to use it when designing LCD displays with Chinese characters.

Box 5 - Case Study: DuCheng Aircraft Corporation

The DuCheng Aircraft Corporation, located in one of China's inland provinces, was originally established to manufacture jet fighters. It was founded in 1958 and the first aircraft was produced in 1964. Although its military output is intended primarily for the Chinese armed forces some of its production has been exported, mainly to the air forces of developing countries. The plant carries out design and development of aircraft as well as production and testing. There are 20,000 employees and 10,000 machines, 30 of which are modern numerically controlled machining centres. Military production still represents about 80 per cent of the output by value at DuCheng. However cuts in orders due to a scaling down of the Chinese armed forces in recent years have necessitated a move towards the manufacture of civilian products to make use of spare capacity. However, as an enterprise in the defence industry, it has not been left to diversify entirely at the mercy of the market. Diversification into non-defence activities was undertaken within a seven-year programme supported by the government. Along with other military aircraft producers, the enterprise was set the target to reduce revenue from its military production to 60 per cent of the total by the end of the seven-year programme period. However, the company's view was that this was too short a period for the required adjustment for such a large enterprise.

The major diversification for DuCheng has been related to its core business of aircraft production. The enterprise won a contract with Air Corp, a major US manufacturer of civilian and military aircraft, to produce nose sections for the airframe of its AC80 civilian airliner. DuCheng was supplied with drawings initially and, in addition, most of the materials and subassemblies were supplied by Air Corp themselves or by suppliers approved by Air Corp and the FAA (US Federal Aviation Agency). The tools and equipment were paid for by Air Corp. The training manuals were provided by Air Corp and training was carried out jointly by the two companies. Air Corp quality assurance personnel were stationed permanently at the factory.

Box 5 (cont.)

Air Corp were looking for a low cost supplier in China and needed to make 'offset' agreements with Chinese companies as part of the contracts to sell its aircraft in China. It chose DuCheng as a subcontractor after considering a number of possible local companies. Other major world aircraft manufacturers also have similar subcontracting arrangements in China. Apart from the cost advantage offered by Chinese subcontractors, the Chinese civil aviation market is attractive for foreign aircraft manufacturers and subcontracting locally can be offered as a way to win orders. According to DuCheng, subcontracting from a Chinese company offers significant cost advantage to Western enterprises but the choice among Chinese subcontractors is not just based on cost but on competence and compatibility. Because DuCheng was not well located and transporting products overland to the coastal ports was difficult it needed to emphasise its technical competencies to compensate for this disadvantage. It had already carried out some work in cooperation with some European aircraft companies and had acquired a reputation for good quality work. Its inland location also meant that wages were lower than were paid by firms in the coastal areas of China. Although workers on civil aircraft production were paid 10% more than those making military aircraft the wage costs were still only a small fraction of those in the USA.

The contracting agreement was signed in 1989 and a number of DuCheng workshops were separated-out and transformed to standards set down by Air Corp. New lines were installed and production started after FAA approval with the first nose section being delivered in 1991. At the early stages of production Air Corp asked for quality improvements and increased production. The production capacity in 1994 was 24 per year but actual production was lower because of reduced demand. Therefore, although initially parallel production continued in the USA, DuCheng became the only producer of the nose sections for this particular model and all production was exported to Air Corp's plant in the USA where the final aircraft was assembled. A similar contract was subsequently undertaken to supply nose sections for another Air Corp aircraft, the AC90, with first delivery of these taking place in June 1996.

In the DuCheng case the technology transfer is of the "international subcontracting" type within a new value system created and coordinated by the technology supplier. Here, there is no ownership of part of the local company by the foreign technology supplier. The foreign investment in the project is also limited. Although Air Corp provided all the tools and equipment for DuCheng these were technically still the property of Air Corp. In the longer term, the capabilities and relationships developed through such contracts could lead to closer cooperation with foreign enterprises to develop aircraft for the fast growing domestic market. For aircraft production, such a

cooperation is likely to require a number of Chinese partners working with one or more foreign companies. However, at least two such potential cooperations for aircraft development and production have failed without any aircraft being produced. In one well-publicised case involving Chinese and European partners insufficient demand and limited public funds available in China were cited as the main reasons for the cancellation, while the reforms of China's aircraft manufacturing industry with planned cuts of 150,000 jobs were another consideration.

The case study has illustrated how DuCheng was able to use its existing capability for manufacturing military aircraft to absorb the technology supplied by Air Corp to produce civilian aircraft products. However, the business provided by Air Corp was insufficient to compensate for the shortfall in orders for fighters from the Chinese armed forces. Therefore, outside DuCheng's core business the company has diversified into a number of other product areas. These have included production of motorcycles, dry cleaning machines, hydraulic engineering products such as car jacks, water heaters, satellite dishes and wheelchairs. The company also won a contract from a Sino-German joint venture to produce the press moulds for car doors. Some of these other ventures are based on using DuCheng's in-house resources and skills to develop products and enter new markets (e.g. the car jacks were developed using its knowledge of hydraulics in aircraft and the order to manufacture press moulds was achieved because it was highly experienced in the use of CNC machine tools). Other ventures are examples of opportunistic diversification based on licences acquired from foreign companies (e.g. the manufacture of dry cleaning machines).

Box 6 - Case Study: NanBan Engine Works

NanBan Engine works, located in the suburbs of Beijing, is part of the New China Automotive Group (NCAG), which comprises a network of factories making engines and components for light trucks, tractors and cars. It is one of a number of automotive engine manufacturers given approval to develop engines by the Ministry of Machine Building Industry. Over the years product technology has been transferred into the group from the former Soviet Union, Germany and Japan. Traditionally in China the automotive industry has been horizontally integrated, with end product manufacturers (vehicle assemblers) being organisationally separate from the major producers of mechanical sub-units such as engines.

NanBan, which is the largest engine producer in the group, and the group as a whole, have been highly dependent on the sales of the MN283, an engine of old design produced in a number of plants within the group. The engine is used in locally produced light trucks and other indigenous vehicles such as 'jeeps' (the Chinese 'jeep', developed from the Russian 'Gaz' light military vehicle, has become a popular and cheap commercial road car). One aim in forming the group in 1988 was to bring together a number of plants producing the same or similar engines. The formation of the group has facilitated shared knowledge about the production of this engine within the group but no other rationalisation has taken place to date.

Box 6 (cont.)

Although the MN283 engine is inexpensive, moderately reliable and produced in large numbers it is not fuel-efficient and its emission standards are poor. Therefore in the early 1990s NanBan acquired product and process technology from a major US motor manufacturer, including a complete assembly line with capacity to produce 250,000 units per year, for manufacturing a more efficient, cleaner, four cylinder light petrol engine. The assembly line was purchased at a cost of some US$ 18 million but at this price it was considered a bargain as it had been installed in the USA at around double the price in the early 1980s, but had been de-commissioned because of excess capacity and was virtually unused. The technical task of transferring the assembly line to China and re-installing it, a major undertaking involving some 40 of the company's engineers and technicians, was considered a success. Installation of the plant and bringing it up to the capability to make production test runs took less time than was predicted by the US company that sold the line.

However, despite the technical success in transferring the technology, commercial aspects proved more problematic and full production on the assembly line was not started. The new engine was intended to replace the MN283 as the largest selling of the company's engines. However, the NanBan found that the cost of production with the assembly line working at full capacity would be 50 per cent higher than that for the MN283. Consequently, although the new engine is of better quality and offers greater fuel efficiency and reliability, the present customers of the MN283 (mainly assemblers of light trucks, 'jeeps' and other vehicles of local manufacture), who themselves face severe competition in the markets for their vehicles, have found this higher cost unacceptable.

NanBan therefore decided to wait until its existing customers were ready to accept the new engine and, meanwhile, tried to seek new customers. One idea was to try to sell the engines to a recently established joint venture between another Chinese company and the US motor manufacturer that had supplied the assembly line. This joint venture, located in Northeast China, had been set up to make light trucks and cars designed by the US partner. However, subsequent investigations revealed that several technical and commercial difficulties stood in the way of this opportunity. Most newer vehicles made in China involving foreign joint venture partners either produce their own engines or have established relationships with engine suppliers, thereby making market access for indigenous manufacturers very difficult. A further difficulty was that the engine made by NanBan was no longer used by the US company in its own vehicles.

NanBan was a technologically capable company and had demonstrated that it was able to transfer and implement both the product and process the technology for the new engine. However, the company found itself in a vicious spiral. During the time it was waiting for new markets to emerge or for its existing customers to accept the new engine the production line was becoming outdated, while spares and service for the sophisticated electronic control systems were becoming increasingly difficult to acquire. NanBan also did not properly assess the value of the technology. The price it paid seemed reasonable because it was much lower than the original cost of the technology (the production line). However, value and price are not the same thing. Value is a concept that is affected by many factors. Among these are the cost to the 'owner', the potential for the technology in commercial terms, any substitutes that are available, and the overall affect on the perceived worth of the company. It is also dependent on the point along the 'value chain' that it is transferred. NanBan's judgement of value was clearly wrong within the circumstances it faced at the time.

A major blow to the company came in the late 1990s when the Chinese government introduced environmental legislation banning high polluting vehicles from major cities, principally Beijing, thereby slashing demand for its core product, the MN283 engine. By this time the end-customers for cars, who are increasingly becoming private individuals rather then organisations, were being attracted towards imported vehicles and foreign models made by joint ventures rather than locally designed and manufactured models. Upgrading local vehicles with the new engine was therefore no longer an option. NanBan's entire market was therefore rapidly disappearing and the company's future was put into jeopardy. This is an example of a technically competent technology transfer that faced commercial difficulties because the product intended to be made with the technology was not appropriate for customers in the existing value system and development of new value systems was not possible in the short-term. Developments of this type either require a clearly identified market for the product or for the manufacturer to be within a vertically integrated production system. Importing this technology into a horizontally integrated group in the prevailing market conditions and industry structure proved to be fraught with difficulties.

Box 7 - Case Study: Midland Tools and ChangZhong: A technology collaboration for new product manufacture and development

Midland Tools, a UK company, and ChangZhong Machinery, a company in Northwest China, are both in the medium size category of machine tool manufacturers. Midland Tools' major products include CNC single and multi spindle automatic turning lathes and turning centres produced to international quality standards. Changzhong is also a specialised turning machine manufacturer. Approximately half its output is of conventional machines and half is CNC machines. The quality of its machines has been given a high ranking in terms of customers' satisfaction in the domestic market and in 1997 it shared with one other Chinese company a national best quality award for its CNC turning lathes from the Ministry of the Machinery Building Industry. ChangZhong has captured 24% of the Chinese market for CNC turning machines.

Box 7 (cont.)

The objective for ChangZhong in collaborating with Midlands Tools was to acquire the advanced technology the company haddeveloped. Through the transfer process ChangZhong could learn specialist subassembly skills, process programming know-how, design know-how and final assembly skills. In terms of technological capability improvement ChangZhong's eventual aim from the collaboration was to enable it to produce complete CNC turning centres of the type to be introduced to local market. Midland Tools' objective on the other hand was to improve product competitiveness by combining technological and cost advantage. Through the collaboration Midland Tools would be able technically to achieve greater competitive advantage and, together with ChangZhong, could developed the product at lower cost. From a long-term strategic point of view the competitive strength of their co-developed product, coupling with high technology with low cost, would be very important in enhancing their position in both local and world markets (see Table 3).

The technology collaboration agreement between the two companies was signed in 1997. The technology product was a CNC turning lathe of entirely new design. The form of collaboration comprised subcontracting, new product co-development and co-production. In the initial stage of the project the terms of payment agreed was that Midland Tools provided technology free of charge in the form of drawings and in return purchased machine carcasses supplied by CJC at reduced cost. The transfer arrangement was based on four phases.

i) In phase one the basic machine was to be manufactured and sold by Midland Tools with machine carcasses made and supplied to Midland Tools by ChangZhong.
ii) In phase two complete machines were to be made by ChangZhong.
iii) In phase three Midland Tools and ChangZhong would co-design and co-develop new versions of the machine.
iv) In phase four, carcasses of the newly developed machines would be made in China by ChangZhong for supply to Midland Tools and complete machines made by ChangZhong for sale in the local market.

Table 3 Objectives for the technology collaboration between Midland Tools and ChangZhong

	Midland Tools	ChangZhong
Objectives	Development of new product Cost reduction Development of market	Technology capability improvement Introduction of a new product Development of market
Financial benefit	Increased sales in world markets	Export machine carcasses and increase local sales
Technological benefit	Cost effective product	Acquisition of latest technology
Strategic benefit	Development of new product and market	Development of new product and market

Box 7 (cont.)

Midland Tools' main activities would include provision of drawings, key parts, training and technical supervision to ChangZhong as well as final assembly on the basis of carcasses supplied from ChangZhong and sale of products in the world market. ChangZhong's responsibilities would be for machining parts and assembling carcasses and for complete manufacture in the later phases. In relation to new product development both parties would jointly be involved in design and development. The focus of this would be to produce designs that would benefit from the opportunities offered for cost reduction from:

i) Local "in-house" manufacture of parts by ChangZhong;
ii) Purchase of proprietary and commercial parts by ChangZhong from local suppliers;
iii) Local assembly by ChangZhong;
iv) Joint selling of the newly developed products in local and world markets.

The collaboration arrangement between Midland Tools and ChangZhong was designed to ensure there was immediate financial benefit to both parties. In many technology transfer based collaboration arrangements, the acquiring partners have suffered financially because they have lacked the marketing skills to sell more expensive co-produced machines in local markets. This in fact has become one of the main causes of failure of many collaborative ventures. Midland Tools recognised that converting technological success into commercial results can be problematic, so from the start the company gave first priority to the issue of market sales. In phase one Midland Tools was fully responsible for the sale of products in all markets, so taking advantage of its established name and reputation throughout the world. Additionally, by sourcing materials (parts and machine carcasses) at lower cost, greater commercial benefits could be derived through either increased sales by offering lower prices or by maintaining prices and selling at higher margins. Meanwhile, ChangZhong could also achieve its commercial objectives by supplying carcasses to Midland Tools rather than trying to sell finished machines. Equally important, the subcontracting arrangement did not incur significant extra cost to ChangZhong because it already had sufficient expertise to manufacture the sub-contract parts and the general assembly skills to make the carcasses. Midland Tools and ChangZhong would be able to share the product development costs and future profits from sales when the newly developed products were introduced into the market, thereby ensuring a financially equitable arrangement in phases three and four. Midland Tools would also receive a royalty on future sales in China.

The main benefits of the collaboration for Midland Tools are in terms of cost reduction. There are three aspects of the collaboration from which this is derived:

i) The purchase of carcasses from ChangZhong which would otherwise be manufactured by Midlands Tools at higher cost.
ii) The purchasing of other parts from ChangZhong which otherwise would be supplied by subcontractors at higher cost.
iii) The effective use of each partner's expertise for co-design and co-development.

ChangZhong on the other hand obtained advanced knowledge and skills in the following ways:

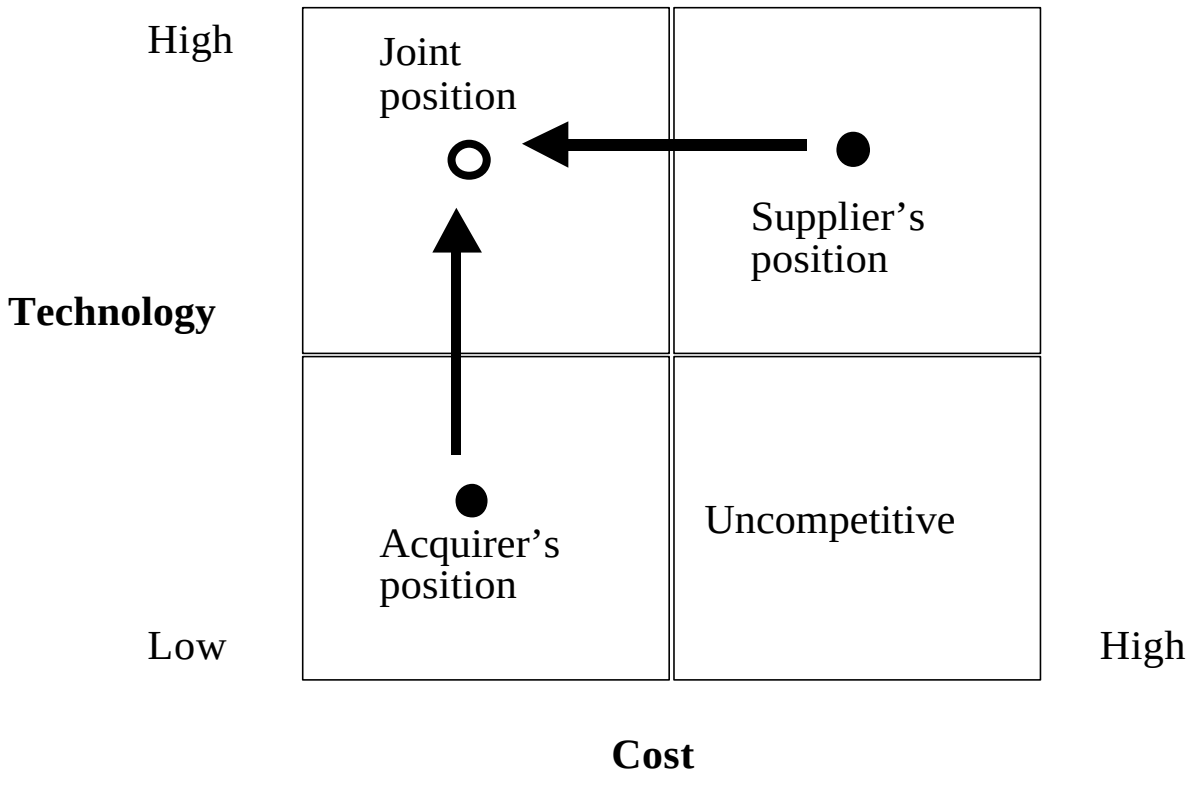
i) By learning process programming know-how and acquiring assembly know-how and skills from the process planning and build specifications.
ii) By acquiring product design and development know-how from drawings provided by Midland Tools and co-design and co-development exercises.
iii) By gathering quality control and production management knowledge through training and phased project planning.

The collaboration brought invaluable strategic benefits to both partners. Midlands Tools had the opportunity of exploiting the commercial potential of its technology by reducing cost, increasing sales in existing markets and developing new markets. It also benefited from the complementary knowledge of ChangZhong when co-designing and co-developing the new products. ChangZhong gained access to leading edge technology for a specific product, thereby enabling it to optimise its future product development. Since the machine being chosen for the collaboration was relatively smaller in size and lower in value compared with the other products in Midland Tool's product portfolio, the strategic benefit for both partners was the opportunity to develop a highly competitive new machine range in terms of performance price ratio, and consequently to a create a new niche in both the world and Chinese markets.

The collaboration was fundamentally based on the enhancement of joint competitive strength by exploiting each party's advantage. Midlands Tools (the technology supplier) and ChangZhong (the acquirer) obtained, respectively, the benefits of technological and cost advantages. Moreover, each other's respective advantage was the other's disadvantage. By jointly using their complementary advantages they could achieve a competitive position that would otherwise be out of reach of each partner on its own (see Figure 4). In line with this strategy the operational approach to the collaboration placed emphasis on how best to employ each party's strength along with its capability for improvement so as to achieve sustainable enhancement of joint competitiveness.

Successful transfer of technology through this type of collaboration depends on a commitment on the part of both parties that will lead to the realisation of mutually compatible objectives. Overall, Midland Tools' and ChangZhong's objectives were well matched but the question arises of how to guide the operation towards realising the mutual transfer objectives. As mentioned earlier, combining together high technology and low cost advantage is the core for such technology collaborations. However, in many such cases problems have been encountered in that acquirers may not have access to adequate knowledge if transfer is driven by cost reduction objectives alone. This in turn often leads to failure in achieving an adequate return with consequently neither of the two parties' objectives being realised. To ensure the realisation of both parties' objectives the collaboration arrangement between Midland Tools and ChangZhong was designed as a comprehensive package. One of the key features of the arrangement was to effectively link cost reduction practice with the technology transfer and learning process. In other words, costs were progressively reduced while technology was gradually transferred. Cost reduction targets and transfer targets ran in parallel throughout each phase so that further cost reductions could be achieved along with the acquirer's technological capability improvement derived from the transferred technology. The co-design and co-development of the new product was the thread linking together cost reduction practice and the transfer process and, based on this aspect, it was decided a new product featuring high technology and low cost.

Figure 4 Enhancement of joint competitive strength through exploitation of complementary advantage.



Lessons for the Arab world

This paper now looks at the situation in the Arab world and seeks to find some lessons based on the foregoing discussion about technology transfer to East Asian countries. As an initial comment, however, it should be said that no attempt has been made here to consider the special circumstances relating to the Muslim faith that are often considered relevant to Arab and other countries where Islam is the main religion among the population (Zuriek, 1978; Niazi, 1996; Hegasy, 1999). In finding lessons for the Arab world regarding the question of technology transfer and development it is first appropriate to make some comparisons between the respective economies of the Arab and Asian regions. Table 4 therefore compares the principal countries in the Arab region with those in the region of East and Southeast Asia.

In terms of total GDP it can be seen from the table that the economies of countries such as Saudi Arabia, Egypt and Algeria are comparatively similar to those of Thailand, Singapore and Malaysia. Also, in terms of GDP per capita the UAE, Qatar and Kuwait have similar figures to Hong Kong, Taiwan and South Korea.

Table 4 GDP and GDP per capita in the principal countries of the Arab region and East and Southeast Asia (1998)

Arab countries					Asian countries			
Country	**GDP (US$ mill)**	**Pop. (mill)**	**GDP/ Capita (US$)**		**Country**	**GDP (US$ mill)**	**Pop. (mill)**	**GDP/ capita (US$)**
S. Arabia	128,882	20.18	6,387		Japan	3,803,554	126.28	30,120
Egypt	82,704	65.98	1,253		China	989,100	1,260.00	785
Algeria	51,477	30.08	1,711		S Korea	318,528	46.11	10,360
UAE	46,490	2.35	19,783		Taiwan	253,510	21.20	11,958
Morocco	33,552	27.38	1,225		H. Kong	154,330	6.20	24,892
Libya	32,742	5.34	6,131		Thailand	114,269	60.30	1,895
Kuwait	25,234	1.81	13,946		Singapore	92,951	3.48	26,710
Syria	24,093	15.33	1,572		Indonesia	78,409	206.34	380
Tunisia	18,940	9.34	2,028		Malaysia	66,778	21.41	3,119
Lebanon	15,526	3.19	4,867		Philippines	64,625	72.94	866
Oman	14,174	2.38	5,955		Vietnam	23,501	77.56	303
Sudan	10,981	28.29	388					
Qatar	9,653	0.58	16,643					
Jordan	7,386	6.30	1,172					
Bahrain	6,184	0.60	10,307					
Yemen	5,160	16.89	306					
Iraq	3,949	21.80	181					

Source: United National Economic and Social Commission for Western Asia / Asian Wall Street Journal

Of course it is important to recognise that the high GDP figures of many Arab countries, especially those of the Gulf states, are inflated by revenues from the extractive industries, principally oil and gas production. Table 5 puts this into perspective. In the case of nine of the Arab countries in this table the added value for their extractive industries is in excess of US$ 3 billion and seven have GDP per capita figures for their extractive industries in excess of US$ 1,000. For comparative purposes this table also shows the value added and GDP per capita for the manufacturing industries of the Arab countries. Here, for eight countries the value added for manufacturing is more than US$3 billion and for five the GDP per capita for manufacturing is more than US$ 1,000 (For detailed information on GDP and the output of extractive and mining industries in the Arab countries see Appendices 1 to 5). However, these data should be interpreted with care because in many of the oil and gas producing countries their manufacturing activities are related to 'downstream' processes such as petroleum refining and chemical production. Therefore the final column in the table shows the ratio between the GDP per capita for each countries' manufacturing and extractive industries ('B' ('A'). Where there is a higher value for this ratio the manufacturing activities are likely to be less related to the oil and gas sector. For example Egypt, Tunisia and Morocco all have well developed textile, clothing and footwear industries while Lebanon produces furniture and metal goods. Iraq and Sudan are special cases in this analysis. Due to the international embargo on exports Iraq's oil production was only $US 26 million in 1998 compared with US$ 1,665 million in 1990, while Sudan's long-running civil war has had the effect of distorting its economic activities.

Table 5 The relative size of the extractive and manufacturing sectors in the Arab countries

Country	Value added of extractive industries (US$ mill)	GDP/capita for extractive industries (US$) 'A'	Value added of manufacturing industries (US$ mill)	GDP/capita for manufacturing industries (US$) 'B'	'B') 'A'
S. Arabia	35,870	1,776	12,542	620	0.34
Algeria	16,569	550	3,986	132	0.24
UAE	10,239	4,352	5,500	2,334	0.54
Libya	8,402	1,576	3,455	650	0.41
Kuwait	7,796	4,309	3,009	1,660	0.38
Egypt	5,879	89	10,112	153	1.72
Oman	4,327	1,816	669	1,231	0.68
Syria	4,055	264	1,723	113	0.43
Qatar	3,602	6,208	718	1,231	0.20
Yemen	976	58	629	37	0.64
Bahrain	841	1,402	788	1,308	0.93
Morocco	686	25	5,585	203	8.12
Jordan	305	48	1,197	190	3.96
Tunisia	243	26	6,066	650	25.00
Lebanon	39	15	1,538	482	32.13
Iraq	26	1	245	11	11.00
Sudan	5	2	637	113	56.50

Source: United Nations Economic and Social Commission for Western Asia and Arab Industrial Development and Mining Organization

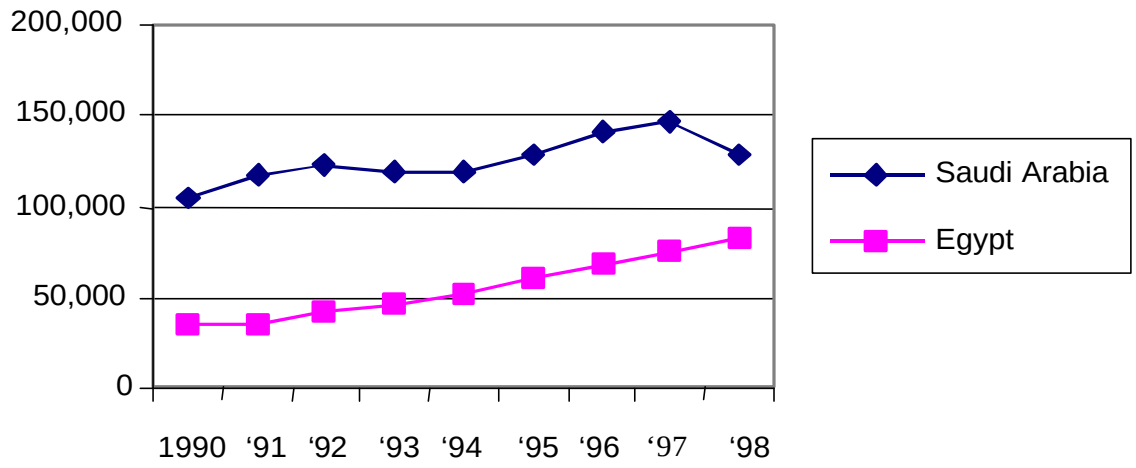
In terms of their incentive to attract foreign investment and transfer technology, as well as their ability to absorb and use the technology, the countries of the Arab region need to be separated into two groups, i.e. those with comparatively large energy resources and those without. Of course an additional factor for countries with energy resources is the extent to which these support the overall economy and the relative period of time their reserves are expected to last. Saudi Arabia has the largest reserves of oil in the world (26% of the proved total) and, relative to its size, Kuwait is similarly well endowed (10% of the world total). The UAE also has reserves of oil and gas that should last for over 100 years (CIA, 2000). All these three countries have a large GDP per capita and buoyant economies. However, not all the major oil and gas producing countries are as strong economically. For example both Algeria and Libya have high levels of unemployment (both around 30%) and low living standards (which in Libya's case is due to an uneven distribution of the country's wealth). Both these countries have therefore tried to diversify by attracting foreign investment outside the energy sector, but to date with limited success.

The most interesting case in the Arab region as far as technology acquisition is concerned is Egypt. Here, production of oil and gas is large in absolute terms but relative to the total population it is fairly small. It also has a moderately high unemployment rate (estimated at 12% in 1999). Through a reduction in the state-owned sector and the implementation of new business legislation it has increasingly attracted foreign investment, mainly in low technology industries such as textiles and clothing, but also in some higher technology areas such as automotive manufacture. It has also sought to upgrade its physical and communications infrastructure in order to improve its attractiveness to investors. As a consequence a number of industrial sectors have been developed (Abdallah et al, 1999):

The textile industry, representing 31% of total industrial output at US$ 2.3 billion
The chemical industry, representing 26% of total industrial output at US$ 1.6 billion
The food industry, representing 18% of total industrial output at US$ 1.2 billion
The metal industries, representing 8% of total industrial output at US$ 750 million

Egypt has also tried to foster the growth of small, technology based, companies though a nationwide incubator programme under the umbrella of the Social Fund for Development (Darwish, 1999). It is important to note that during the last decade Egypt has experienced one of the highest GDP growth rates in the Arab world, bringing it closer to energy-rich Saudi Arabia in terms of total GDP (See Figure 5). This been achieved through a combination of growth in both the extractive and manufacturing sectors (See Appendices 2 and 4).

Figure 5 GDP growths of Egypt and Saudi Arabia, 1990 - 1998 (million US$)



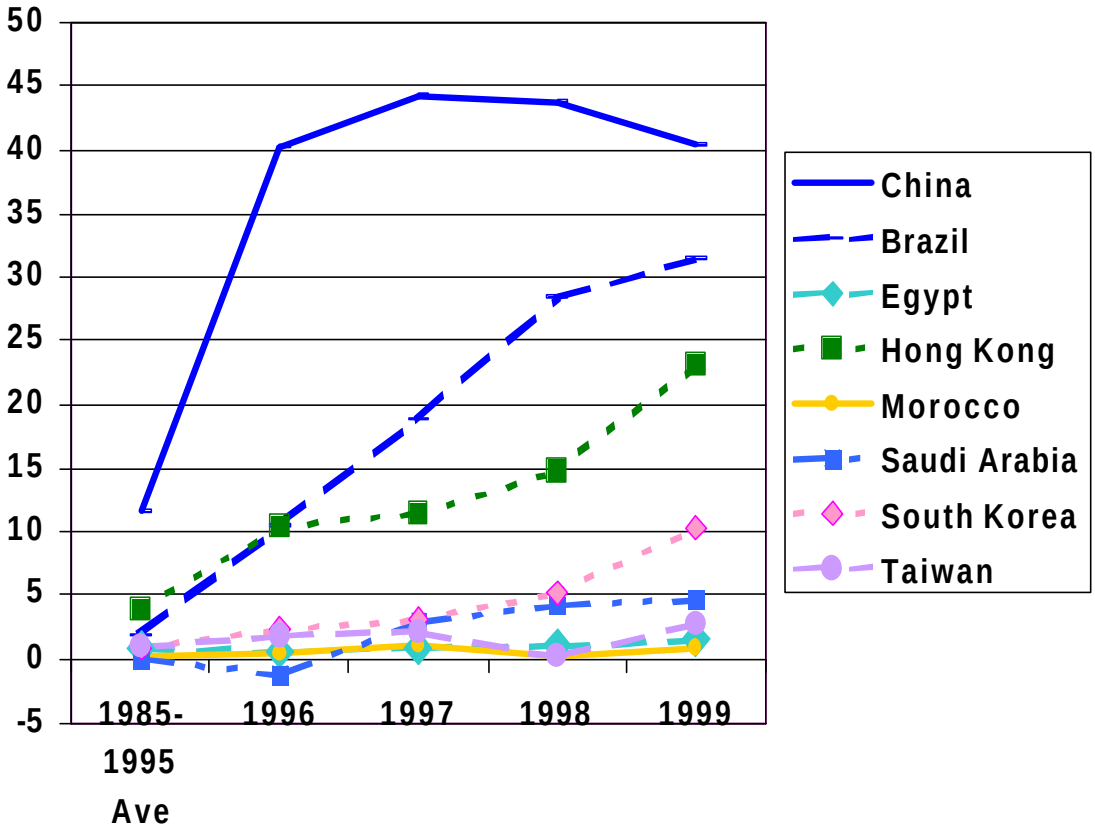
Box 8 - The foreign investment phenomenon

Foreign direct investment (as opposed to portfolio investment) is often assumed to be a proxy for technology transfer. Although not all foreign investment is in the form of technology (as was mentioned in Box 2), in countries with fast economic growth a high percentage of technology based investment is a common feature. In the case of China, for example, it is estimated that about 80% of the foreign direct investment has been in

the form of technology, much of which has been transferred into high value-adding manufacturing industries and this is generally regarded as being one of the main contributors to its success in becoming a major international competitor in a number of key sectors. Some of the industries into which this technology has been transferred include machinery, telecommunications equipment, steel making, consumer electronics, pharmaceuticals etc., as illustrated in the earlier case studies and elsewhere (Bennett et al, 1996; He et al, 1998).

However, when examining the situation in the Arab world the picture becomes less clear. Many of the Arab countries have foreign investments in the oil and gas industries that do not involve the type of technology that will raise the general level of productive capability and hence improve national competitiveness. Figure 6 shows the inward forward direct investment flows into a number of selected countries over the last 15 years, including some in the Arab region.

Figure 6 Inward foreign direct investment into selected countries, in billions of US$ (UNCAT, 2000)

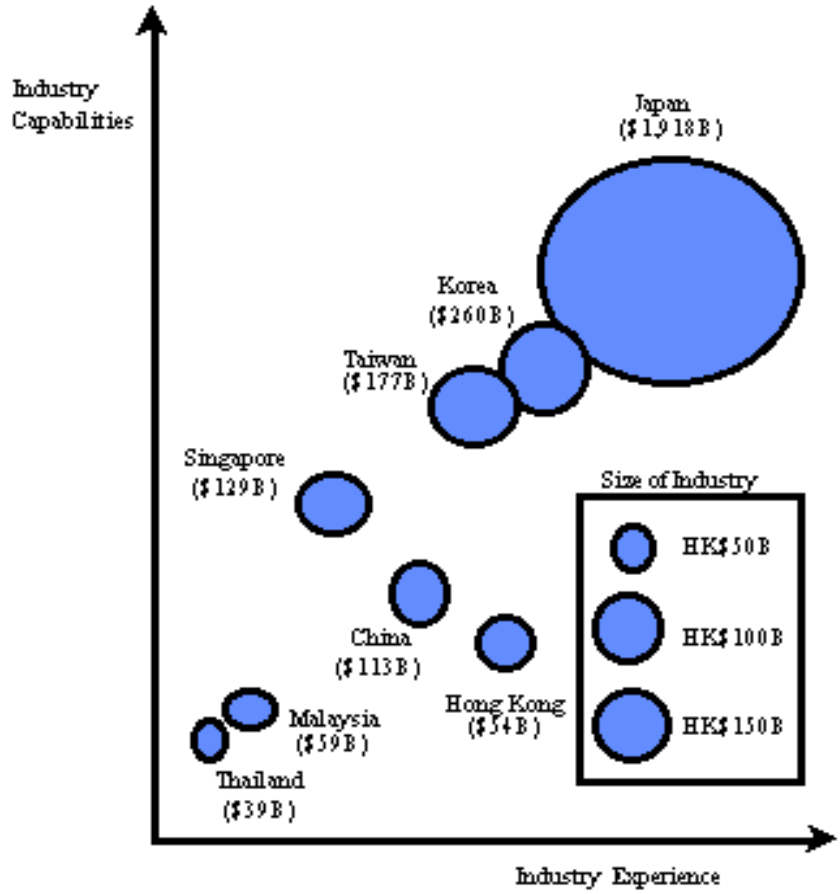


The very large amount of investment into China is evident, although this has reduced more recently. Brazil has also seen large amounts of investment, which have mainly resulted from the policy of privatising its state owned industries during the early 1990s. This has led to foreign companies investing in a number of large Brazilian domestic industries, especially in the telecommunications and utilities sectors, although not always with accompanying technology transfer. Hong Kong's situation is interesting in that it has always been a conduit for foreign investment into mainland China, so it is significant that the amount of investment has continued to rise since the handover in 1997. South Korea and Taiwan have also seen continued increases, except for a temporary downturn in Taiwan in 1998. This has led to both these countries developing world class productive capability in a number of high technology manufacturing industries, especially electronics production where they are now second only to Japan in the East Asian region (see Figure 7).

Box 8 (cont.)

Two of the Arab countries selected for this analysis, Egypt and Morocco, have received modest amounts of foreign direct investment compared with many of the countries in the East Asian region. Nevertheless, at around US$ 1 billion per annum it is significant compared to most of the Arab world. Among the Arab countries the greatest amount of foreign investment has been going into Saudi Arabia. Despite its huge oil reserves Saudi Arabia has a burgeoning population and has carried a budget deficit since 1983. The government has therefore increased the amount of private ownership of its economic activity and about 35% of GDP now comes from the private sector. In turn this has increased the amount of foreign investment into its petroleum and utilities sectors, although there has also been an attempt to increase the amount of non-oil exports. To this end the Saudi government is promoting a number of joint venture opportunities to foreign investors in such industries as food processing, automotive component manufacture; building materials and ceramics, chemicals, electrical equipment, engineering, furniture, paper products, plastics, rubber and textiles (US - Saudi Arabian Business Council, 2001).

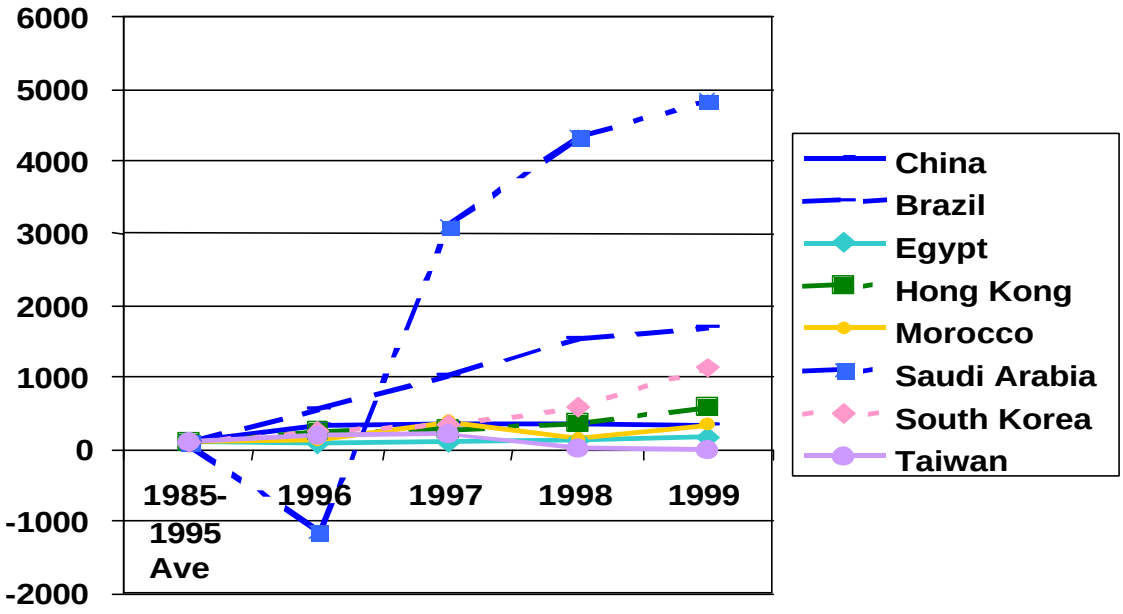
Figure 7 Output, capability and experience comparison of East Asian electronics industries (WTEC, 1997)



Box 8 (cont.)

It must be noted that one peculiar characteristic of the foreign investment data for Saudi Arabia, along with some other Arab countries such as Yemen and Libya, is that there have been periods where inward foreign investment has been negative, possibly due to divestment of assets by foreign companies exceeding the investments made during that period. Among the major East Asian counties only Indonesia has exhibited this characteristic, during 1998 and 1999. The relative change in foreign investment, and the erratic nature of investment into Saudi Arabia, are clearly illustrated in Figure 8.

Figure 8 Growth in foreign direct investment into selected countries, 1985 - 1995 Average = 100 (Based on UNCAT, 2000)



The opportunities for national technology development

There appears to be common agreement that the countries of the Arab world need to improve the output of their non-energy related industries (Maeena, 1997). However, the Arab countries number around twenty with a total population of approximately 280 million. Although there is a view that economic integration is a prerequisite for achieving the desired level of industrial competitiveness the history of the region shows that numerous attempts at unification and cooperation have come to very little (Zineldin, 1998). Therefore it is unlikely that technological development could be achieved within a single economic policy as has occurred in China over the last twenty years.

The way in which technological development and improved national competitiveness of the non energy-rich countries could be achieved is through the "stages" approach of the Asian NICs in which advantage shifts from the relatively low labour cost based industries such as textiles and simple metal goods to more skill and capital intensive manufacturing as their economies' factor endowments change in the course of development. Like the Asian NICs the Arab countries tend to compete with each other rather than cooperate. Therefore the strongest companies that survive the intensity of competition would emerge as the major industrial enterprises. These will be the companies that can acquire and harness technology most efficiently to create their competitive advantage. The concept of technology acquisition is not new to the Arab countries. Zahlan (1978) refers to the fact that more than six hundred large and small petroleum and petrochemical projects were executed in the Arab world in a period of almost twenty years since 1959. However, it is most probable that these would mainly be turnkey projects with very little know-how being transferred to the host country. Therefore the technological dependence on the foreign technology supplier remains. The opinion of some, therefore, is that this technological dependence can be reduced by creating domestic research and development (R&D) capability (UNCTAD, 1978) although, as was mentioned earlier, R&D is only one part of the overall process of technological development and improved competitiveness.

Given the above arguments, the way forward for the non energy-rich Arab countries would seem to be based on the approach being taken by Egypt as being closest to fitting the "stages" theory of the Asian NICs. This takes the form of a dual strategy comprising liberalisation of the legislative and trade regime coupled with the acquisition and adsorption of technology through foreign investment (Youssef, 1999). The main incentive for foreign companies to transfer technology to Egypt is through a local content requirement that obliges them to develop the capability of indigenous suppliers so their own vendor quality standards can be met. This has worked with some success in the automotive sector. However, it is generally agreed that the automotive industry in Egypt is populated by too many manufacturers for the size of the market. Hence it is likely that this, and other industries, will eventually follow the pattern of development that has been common in Asia where rationalisation subsequently takes place involving closures and mergers between competing firms, leaving the most efficient to form the bedrock of the technology based economy.

Based on the experiences of the East Asian economies there are a number of mechanisms that could be explored as a means of encouraging and supporting technology transfer and development. They include the following:

- Liberalisation of foreign investment regimes and provision of opportunities for Technology based foreign companies to participate in local economic activity (e.g. Jomo et al, 1999).

- Identification and targeting of specific industrial sectors for special policies aimed at promoting their growth and competitiveness (e.g. Belderbos, 1997; Lee, 1997).

- Provision of support for innovation in small to medium sized enterprises (e.g. Huang and Ward, 2001).

- Establishment of high-tech incubators and industrial zones, i.e. creation of "technopoles" (e.g. Bennett et al, 1999).

Apart from such specific measures, which to be most effective would ideally require co-operation among the Arab countries as well as measures taken by individual governments, there is also a need for the Arab world to engage with the developed world on issues relating to technological development. This needs to be done within the context of any policy statements or papers that have been prepared by government bodies and agencies in, e.g. the USA and European Union (see for example Office of Technology Assessment, 1984; EU, 2001).

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Appendix 1 GDP of the Arab countries in producer's value at current prices (Bulletin of industrial Statistics for the Arab countries 1990 - 1998, United Nations Social and Economic Commission for Western Asia and Arab Industrial Development and Mining Organization, Fourth Issue)

Million US$

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Algeria	44,000	37,084	45,876	48,162	34,381	37,850	44,107	46,506	51,477
Bahrain	4,529	4,616	4,751	5,200	5,568	5,849	6,102	6,349	6,184
Djibouti	390	452	482	514	548	581	618	656	693
Egypt	35,491	34,228	41,647	46,677	51,471	60,000	67,690	75,605	82,704
Iraq	11,648	4,863	4,667	2,079	2,606	2,730	2,902	3,461	3,949
Jordan	4,012	4,206	5,209	5,568	6,076	6,506	6,645	6,976	7,386
Kuwait	18,308	10,833	19,886	24,022	24,848	26,595	30,696	30,242	25,234
Lebanon	2,784	4,151	5,464	7,539	8,924	10,968	12,822	14,293	15,526
Libya	28,415	33,209	31,083	34,932	32,593	35,337	35,811	33,272	32,742
Mauritania	1,087	1,196	870	911	975	1,013	1,076	942	939
Morocco	26,465	29,620	28,844	25,824	31,171	33,204	36,468	32,649	33,552
Oman	11,670	11,327	12,436	12,478	12,901	13,785	15,258	15,779	14,174
Palestinian Authority	2,219	2,362	2,845	2,874	2,976	3,575	3,897	4,173	4,532
Qatar	7,360	6,884	7,646	7,157	7,374	8,138	9,059	9,193	9,653
Republic of Yemen	8,903	6,607	6,414	4,783	3,329	3,697	5,167	5,611	5,160
Saudi Arabia	104,671	118,034	123,204	118,516	120,167	127,811	141,322	146,494	128,882
Somalia	875	671	…	…	…	…	…	…	…
Sudan	22,414	12,728	2,974	3,972	4,377	5,651	7,048	9,299	10,981
Syria	9,583	10,818	12,598	13,978	16,814	18,659	21,406	22,775	24,093
Tunisia	12,922	13,922	14,412	13,991	16,048	17,889	19,571	18,257	18,940
UAE	33,653	33,920	35,413	35,745	38,268	42,807	47,993	49,354	46,490
Total	391,401	381,731	404,720	414,920	421,414	462,644	515,660	531,886	523,292

Appendix 2 Value added of mining (extractive) industries for the Arab countries in producer's value at current prices (Bulletin of industrial Statistics for the Arab countries 1990 - 1998, United Nations Social and Economic Commission for Western Asia and Arab Industrial Development and Mining Organization, Fourth Issue)

Million US$

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Algeria	10,270	10,939	11,014	10,368	7,791	9,648	12,951	14,013	16,569
Bahrain	867	779	774	815	796	900	1,105	1,187	841
Djibouti	…	…	…	…	…	…	…	…	…
Egypt	1,678	2,881	2,891	3,595	3,958	4,834	4,686	5,286	5,879
Iraq	1,665	36	19	1	-1	-2	3	20	26
Jordan	291	229	234	191	182	262	268	285	305
Kuwait	7,222	1,161	6,146	9,840	9,531	10,528	13,816	12,158	7,796
Lebanon	8	11	15	21	25	30	35	37	39
Libya	9,544	9,743	9,797	8,169	7,602	8,017	8,205	8,259	8,402
Mauritania	…	…	…	…	…	…	…	…	…
Morocco	426	459	491	514	575	579	621	654	686
Oman	5,601	4,770	5,102	4,656	4,743	5,281	6,441	6,353	4,327
Palestinian Authority	8	8	10	10	16	20	26	22	28
Qatar	2,799	2,240	2,739	2,334	2,358	3,004	3,509	3,503	3,602
Republic of Yemen	1,250	699	494	306	249	613	1,566	1,658	976
Saudi Arabia	37,507	42,411	47,230	39,978	39,810	44,297	54,070	54,320	35,870
Somalia	…	…	…	…	…	…	…	…	…
Sudan	21	12	2	3	3	4	4	5	5
Syria	1,374	1,069	1,086	1,069	1,049	1,189	2,730	3,725	4,055
Tunisia	153	148	126	106	133	161	188	216	243
UAE	15,783	14,871	14,739	13,002	12,253	13,215	15,718	14,742	10,239
Total	96,467	92,466	102,910	94,977	91,072	102,577	125,942	126,424	99,886

Appendix 3 Percentage share of mining (extractive) industries in GDP for the Arab countries (Bulletin of industrial Statistics for the Arab countries 1990 - 1998, United Nations Social and Economic Commission for Western Asia and Arab Industrial Development and Mining Organization, Fourth Issue)

Percenage

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Algeria	23.3	29.5	24	21.5	22.7	25.5	29.4	30.1	32.2
Bahrain	19.1	16.9	16.3	15.7	14.3	15.4	18.1	18.7	13.6
Djibouti	…	…	…	…	…	…	…	…	…
Egypt	4.7	8.4	6.9	7.7	7.7	8.1	6.9	7	7.1
Iraq	14.3	0.7	0.4	0.1	-0.05	-0.1	0.1	0.6	0.7
Jordan	7.3	5.4	4.5	3.4	3	4	4	4.1	4.1
Kuwait	39.4	10.7	30.9	41	38.4	39.6	45	40.2	30.9
Lebanon	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Libya	33.6	29.3	31.5	23.4	23.3	22.7	22.9	24.8	25.7
Mauritania	…	…	…	…	…	…	…	…	…
Morocco	1.6	1.5	1.8	2	1.8	1.7	1.7	2	2
Oman	48	42.1	41	37.3	36.8	38.3	42.2	40.3	30.5
Palestinian Authority	0.4	0.4	0.4	0.3	0.5	0.6	0.7	0.5	0.6
Qatar	38	32.5	35.8	32.6	32	36.9	45	40.2	30.9
Republic of Yemen	14	10.6	7.7	6.4	7.5	16.6	30.3	29.5	18.9
Saudi Arabia	35.8	35.9	38.3	33.7	33.1	34.7	38.3	37.1	27.8
Somalia	…	…	…	…	…	…	…	…	…
Sudan	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05
Syria	14.3	9.9	8.6	7.6	6.2	6.4	12.8	16.4	16.8
Tunisia	1.2	1.1	0.9	0.8	0.8	0.9	1	1.2	1.3
UAE	46.9	43.8	41.6	36.4	32	30.9	32.7	29.9	22
Total	24.6	24.2	25.4	22.9	21.6	22.2	24.4	23.8	19.1

Appendix 4 Value added of manufacturing industries for the Arab countries in producer's value at current prices (Bulletin of industrial Statistics for the Arab countries 1990 - 1998, United Nations Social and Economic Commission for Western Asia and Arab Industrial Development and Mining Organization, Fourth Issue)

Million US$

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Algeria	4,083	3,309	4,167	4,588	3,008	3,081	3,225	3,724	3,986
Bahrain	493	517	516	640	808	1,026	896	932	788
Djibouti	…	…	…	…	…	…	…	…	…
Egypt	4,431	4,496	5,484	5,729	6,033	6,851	8,060	9,061	10,112
Iraq	1,029	311	457	119	86	106	65	175	245
Jordan	579	608	735	787	986	1,001	962	1,066	1,197
Kuwait	2,121	536	1,784	2,109	2,638	2,982	3,683	4,033	3,009
Lebanon	352	474	703	899	1,028	1,250	1,439	1,477	1,538
Libya	2,670	2,343	3,043	2,358	2,412	2,776	2,992	3,231	3,455
Mauritania	…	…	…	…	…	…	…	…	…
Morocco	3,553	4,042	3,936	3,690	4,522	5,056	5,218	5,260	5,585
Oman	342	390	456	525	560	643	616	634	669
Palestinian Authority	141	147	175	173	314	311	381	453	479
Qatar	874	852	814	717	694	683	687	688	718
Republic of Yemen	722	645	712	469	307	377	552	620	629
Saudi Arabia	8,511	9,559	10,481	10,090	10,540	11,434	12,546	13,509	12,542
Somalia	…	…	…	…	…	…	…	…	…
Sudan	1,996	1,193	265	346	385	495	500	600	637
Syria	699	783	865	1,013	1,237	1,551	1,645	1,460	1,723
Tunisia	3,349	3,651	3,646	3,490	4,118	4,688	5,077	5,587	6,066
UAE	2,643	2,661	2,861	3,035	3,907	4,452	4,883	5,511	5,500
Total	38,599	36,529	41,111	40,813	43,593	48,775	53,439	58,032	58,891

The Design and Management of an Engineering School as a Permanent Process of Development and Adjustment to Industrial Needs

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Dr. Laure Morel, Associate-Professor

Forum *"Innovation in Education and Coordination for Regional Development"*

Contents

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Outline

Ways and means of assurances of continuous updating of educational systems, to keep up with the industrial and market needs

INTRODUCTION

In 1990, the National Polytechnical Institute of Lorraine (INPL) asked the Research Laboratory in Innovation Sciences (LRGSI) to design an education program and define key teaching concepts with the objective of training engineers to be able to consider complex situations in all their dimensions, and to initiate and drive innovative projects.
This mission was carried out on the basis of:

A concept - Innovation as a permanent development process. This concept translates the transition, at an industrial level, from a logic of managing local performance (quality, productivity, finance, etc.) to a logic of "value" development.

A method - Drive the project for creating a school and a curriculum as a permanent process of development and adjustment to industrial needs. This approach resulted in the implementation of a method entitled Employment/Skills Referential" (ESR), the aim of which is to identify the skills needed to develop entrepreneurial and innovation

abilities in future engineers. This identification process is carried out with experts in a variety of industrial fields.

A team - The objective of the multidisciplinary project team is to organize dialogue and consultation with and between disciplines to construct a real cross-disciplinary training approach.
The team is also multi-skilled, bringing together researchers, lecturers, company presidents, consultants, executives and students to develop the ESR method as a tool for both monitoring and curriculum development with the various partners involved.

The ENSGSI (National School of Industrial Engineering) was founded in 1993 and drives this new approach to training engineers. Cooperation with the economic environment is organized around three actions :

- Accompanying industrial change within regional SMEs.
- Proposing actions to accompany the sparking of innovation in major industries as well as in service sectors such as health.
- Structuring the management of complex local government projects.

This paper will first present the environment which favored the foundation of the school. We will explain the importance of the Industrial Engineering Research Laboratory (LRGSI) and the research carried out in innovation science, as well as the opportunities presented by evolution in the economic demand requiring new profiles for engineers. We will show how this evolution in industrial and economic demand regarding the question of innovation, as well as the consideration of this in the orientation of the LRGSI's research projects, contributed to reducing the gap between corporate requirements for a new type of engineer and the capacity of engineering schools to meet this demand. Secondly, we will expand on our approach to founding the school. We will show how we went from a traditional project structure to a more global approach integrating the needs of both the internal and external environments. In the third part of our paper we will present the methods used to build our teaching referential which ensures a process of permanent adjustment to market needs. Finally, we will conclude with a description of the state of progress of our projects today.

I- FROM ECONOMIC DEMAND TO RESEARCH ISSUES REGARDING INNOVATION

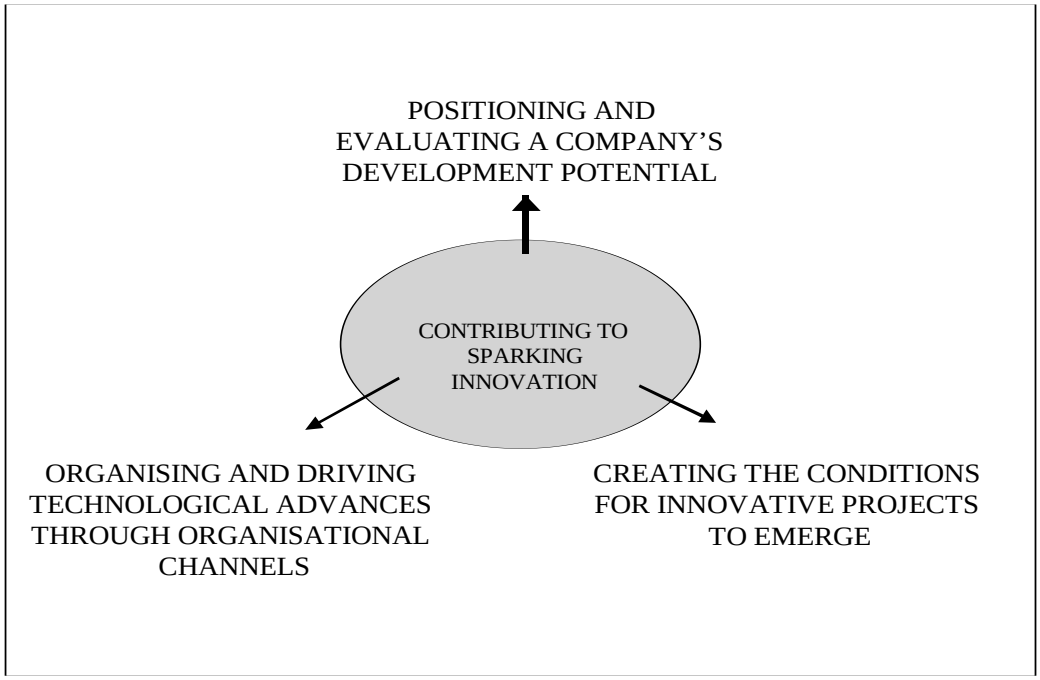
1- From economic demand…

Beyond the design of new products and processes, and the existence of systems to accompany innovative projects, three levers for innovation can be identified in a global approach to the innovation process.

- Creating the conditions for innovative projects in companies to emerge
- Organizing and driving the impetus for technological advances through organizational channels.
- Evaluating and positioning new value development potential.

These elements highlight a "missing link" in the innovation development chain, a link which can be described as "sparking" innovation.

Figure 1: The innovation development chain

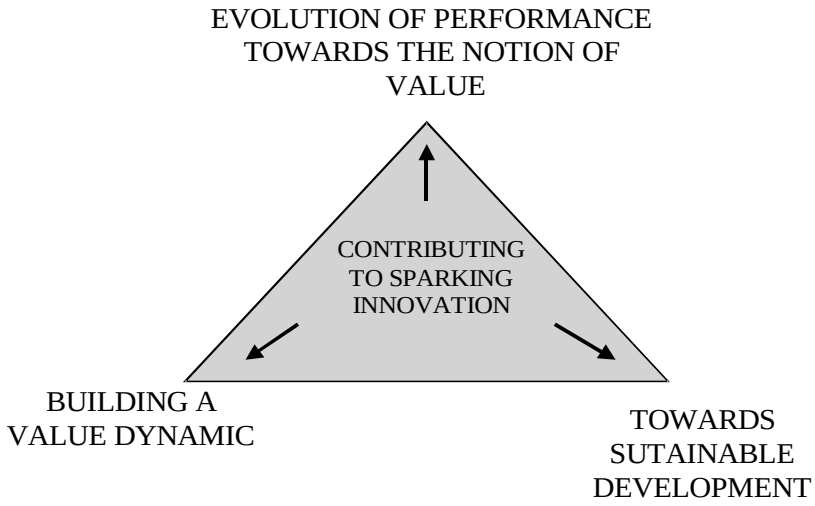


2- …To research issues :

Studying this missing link is based on three elements:

- A reflection on the notion of performance evolving towards a more global notion of value.
- The emergence of a notion of value dynamics which corresponds to "the adaptation of structures, aims and means linked to the value creation process in companies".
- The search for sustainable development.

Figure 2 : From economic demand to research issues



Within this context, the INPL's Research Laboratory in Industrial Engineering, the LRGSI, chose to tackle innovation not just as the design of new products and services, but more as a complex system oriented towards the production of new values. This approach leads to the definition of two concepts:

- Transition from the notion of "product" to the notion of "value" as a the ultimate objective of innovation.
- The notion of process.

It also leads to a change of paradigm at an industrial level:

- Transition from a logic of driving local performance to one of value development.

2.1- From product to value

A product can be seen as a specific result which can be material (an object) or immaterial (a service) and to which is attached a notion of performance in terms of quality, productivity or finance.
Value is seen as an evolving "target result" expressed through all the dimensions of an industrial system, be they technical, organizational, behavioral or cognitive. Value is characterized by a spatial extension of performance, evolving from qualitative performance (financial gains or increases in productivity), towards the development of new functions, new uses, production of know-how and knowledge that can then be disseminated and the learning of new behavior. It is also characterized by a temporal extension of performance (for example ten years ago a consumer was not prepared to pay more for a product because it was recyclable or had been made by unemployed workers).

2.2- Notion of process

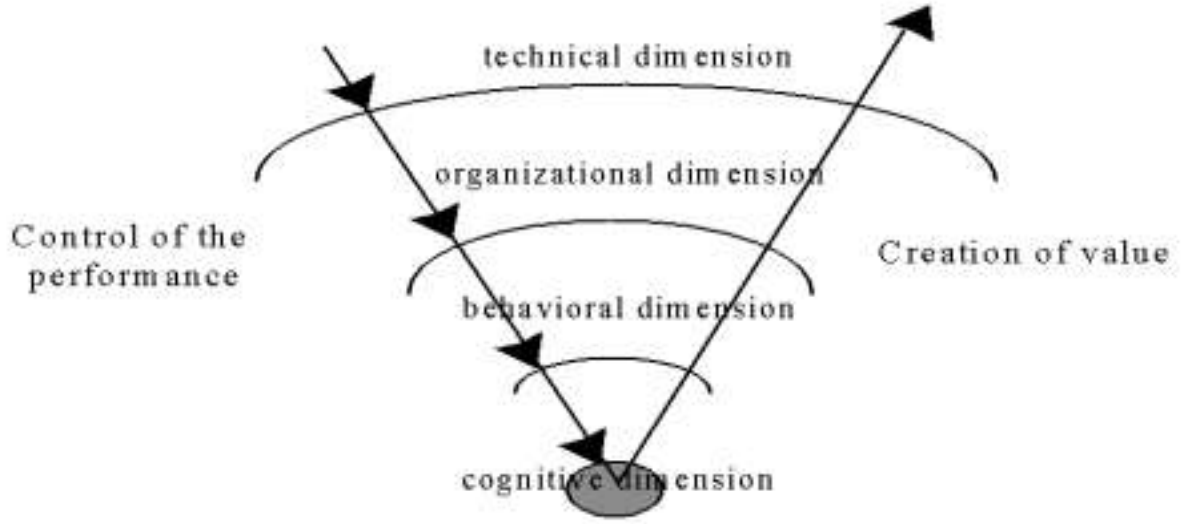
A process, as seen by J.P. Meinadier [1998], is a series of activities with criteria for the transition between activities defined so as to lead to a specific result through the progression from one activity to another. Research carried out within the INPL's innovation sciences laboratory in the field of innovative projects has enabled the existence of a heuristic development process to be postulated.
This is characterized by:

- The transformation of information into action
- An orientation of the project towards an evolving target
- A context in which the project is highly predictive
- An influence of representations on human actions

2.3- Changing paradigm

In reference to the four dimensions (see figure 3) of an industrial situation (technical, organizational, behavioral, and cognitive), it can be observed in both the industrial and service sectors that the increasing complexity of systems causes operational limits to be reached, which in turn leads to a change in the way in which situations are approached.

Figure 3 : From performance control to creation of value



This change of paradigm leads to an abandoning of the dominant logic of performance control which integrates a progressive accumulation of constraints. For example, the majority of companies start by optimizing their productivity from a technical point of view by adopting quality standards. Then, when results are no longer forthcoming, they look at new ways of organizing work, and finally they decide to implement training programs to help their employees adapt to this new context. The major limitation of this approach is that it takes little account of any retroactions that may affect the company or its employees.

Each result is therefore dissociated from any global action because the various dimensions are approached in a successive linear way: the technical dimension is dealt with, then the organizational, then the behavioral, then back to the technical, and so on.
In place of this, we propose that a more global approach to the situation be adopted which, from the inception of the project, takes into account the various dimensions of a situation and is placed within the perspective of a target that is functionally defined in terms of value.
These conceptual aspects highlight the main concept that underlies the school's philosophy: "Contributing to the sparking of innovation and managing innovation as a permanent development process", both in industry and service sectors.
This uses three levers :

- The organizational lever, being able to design and drive a heuristic development process which enables a real organizational learning to be developed within organizations.
- The lever to formulate technical concepts and new projects, which is based on tools for aiding reasoning in design and creation, such as TRIZ, and the modeling of cognitive processes for formulating new ideas and projects.
- The lever to evaluate and measure value development potential : from local optimization (technical, economic, safety, environmental, organizational, human) towards global optimization in terms of value.

3- Conclusion

Within the context of the evolution of the economic demand leading to these new conceptual approaches to innovation, the emerging need was to train engineers capable of contributing to the sparking of innovation in industry and service sectors.
In other words, the objective of our project was to design a school that could be identified as providing:

- A basis - general engineering
- A profession - organizational engineering
- A specialty - innovation
- A specificity - an entrepreneurial spirit.

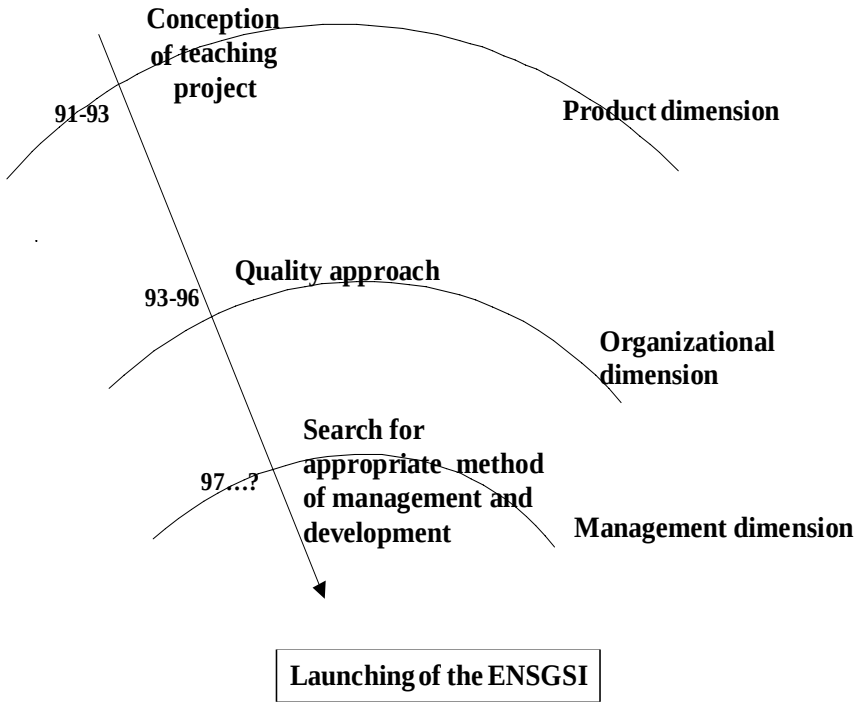
II - BUILDING THE SCHOOL'S PROJECT

1- From a traditional implementation of the project…

The ENSGSI, an Industrial Engineering and management school, was created in 1993. Its aim was to develop a teaching methodology to train engineers who must be able to cope with all aspects of complex problems, and initiate and direct new development actions.

In the course of time, a diagnosis of the design of this teaching project revealed a sequential and linear development (figure 4), which first consisted in creating the teaching product, in implementing it within the structure of an organization, then in managing the organization itself (implementation of a quality approach).

Figure 4 : Sequential approach of the development of the ENSGSI



This sequential development approach led to an accumulation of the operational problems we were confronted with on each dimension of development. This resulted in discovering the following risks:

- A tendency to rigidity or a chaotic operation of the system,
- A gradual lack of responsibility caused by the increasing standardization of the system,
- An anchoring in a territorial logic due to a dwindling of the sense of the collective project.

In addition to the perverse effects of this sequential and cumulative approach to development, strong external pressures reached the system at the end of 1996. We therefore needed to improve the legibility of the system, to strengthen its strategic positioning and to produce new means for the development and growth of its performance as a whole.

In the beginning of 1997, these operational difficulties in the classical implementation of development, and the strong sensitivity of the system to environmental pressures led the school's management team to rethink the development problem and to reconsider all the data, in order to transform the constraints into development opportunities. To do that, they tried to create a permanent "adjusting to the environment" dynamic. In this context, the research laboratory decided to investigate methods of creating a shared global development target for the organization in order to meet expectations.

2-…To a permanent process of redesigning the school project

2.1- Levers of action

In the previous section, we saw that a difficult context and limited means caused us, paradoxically, to forget our conceptual starting points and resort to a more traditional operational implementation of the project. In this section we will show that operational constraints led us to reexamine the organization and management of the school and create a shared development target, in order both to federate the team around this target and to better respond to the evolution of the economic demand.

Redesigning the school's teaching project was driven as an innovative project, according to 3 levers of action :

- Strategy : How to characterize the ideal training project that enables engineers to be trained as specialists in sparking innovation and having strong entrepreneurial potential ?
- Driving : How to define the modes of management and organization to be implemented in order to create the ideal organization ?
- Sparking : What kind of evolution in the roles of the people involved in the project (teachers, researchers, administrative staff and economic partners) has to be developed?

2.2- The methodology used : Proposal Of The Use Of Value Analysis To Create A Shared Global Development Target

Value Analysis (V.A) is a methodology for designing or, we should say, of redesigning, even partially, a product, its manufacturing methods, its maintenance, etc. It is defined by the French Standards : NF X 50-150, NF X 50-151, NF X 50-152, NF X 50-153. According to the NF X 50-150 standard (which became European standard: EN 1325-1), value analysis is a creative and organized method of competitiveness which aims at satisfying the user's need by a specific approach to design that must be economic, functional and multidisciplinary at the same time (AFNOR 85). It aims at extending the range of solutions that must be considered by taking into account the environment and market evolution. From the beginning, V.A. is a very normative methodology for product development. It is "Value Management".

A possible evolution is to link this first approach with certain rules given in the Value Management Handbook (Value 95), in order to conduct a value analysis in terms of "management by value". This leads to:

- More effective and better adapted management;
- A better understanding and formulation of the real needs of the customers or users of the systems and products, and of the relative importance of these needs;

- The possibility of quantifying arbitration between performance levels of functions and costs (or other factors such as weight, consumption of resource, time, social impact, etc); this helps reduce the degree of ambiguity as well as time to market.

This last aspect is very interesting for our study because it is possible to consider a criterion other than cost to qualify a function, as the AFNOR standards suggest.
The methods or specific tools of Value Management are: Value Analysis, Functional Analysis and the Functional Schedule of Conditions.

The "Value Analysis in order to create a global development target" schedule of action, linking normative aspects and Value Management Handbook rules, was organized as follows:

Phase 1 - Orientation Of Action

The orientation of action is usually defined by the applicant and the person who deals with Value Analysis. This phase consists in specifying for the action under consideration:

- The actors of the project
- The background to the project
- The targets

In our case, we wanted to privilege a dynamic approach to the process of design and so we created a work group whose objective was to manage all the aspects of the Value Analysis.

Phase 2 - Search For Information

During this second phase of preparation, we collected all useful information needed in the functional analysis. This research was particularly carried out during meetings in which industrialists and teachers gathered to pre-define the expectations and opinions of the various partners.

Phase 3 - Functional Analysis

This phase, which is the most typical of the method, was achieved by the group project made up in phase 1. It aimed at determining and analyzing the functions to be ensured by working out the functional schedule of conditions.

We adopted the following approach:

- Recording functions

  - Definition and characterization of external context

The relevant elements of the environment must be chosen, characterized and aggregated.

  - Identifying functions

The identification of functions enables the desired level of service to be determined, taking into account the external context.

- Criteria for validating the functions

Validation of the functions allows the stability of each function to be checked by answering the questions: why, what for, and for which development?

- Sequencing functions

The sequencing of the functions allows them to be presented in a logical sequence meeting the value (in terms of objective) allotted to the function independently of any financial criteria. Also called FAST (Function Analysis System Technique), the resulting Figure (or functional tree) gives a synthetic vision of the product's functions.

- Developing and processing the functions on a hierarchical basis

Processing the functions on a hierarchical basis allows them to be classified in order of the importance allotted to each of them by the Value Analysis group. Functions are categorized by highlighting the effort needed for a particular function, its place in the overall system and its importance in the evolution of the system.

2.3- The Results Of Functional Analysis

2.3.1- Characteristics of the method followed:

To define the value allotted to each function. We used the FAST method oriented towards results. Therefore, we first proposed a Figure corresponding to the period of time T = 1997/1998, then we gave an outline of the optimal shift of the functions T + n.

The results are presented in Figures 5 and 6 respectively.

Figure 5 : Sequencing of functions at T = 1997/1998 according to the FAST method

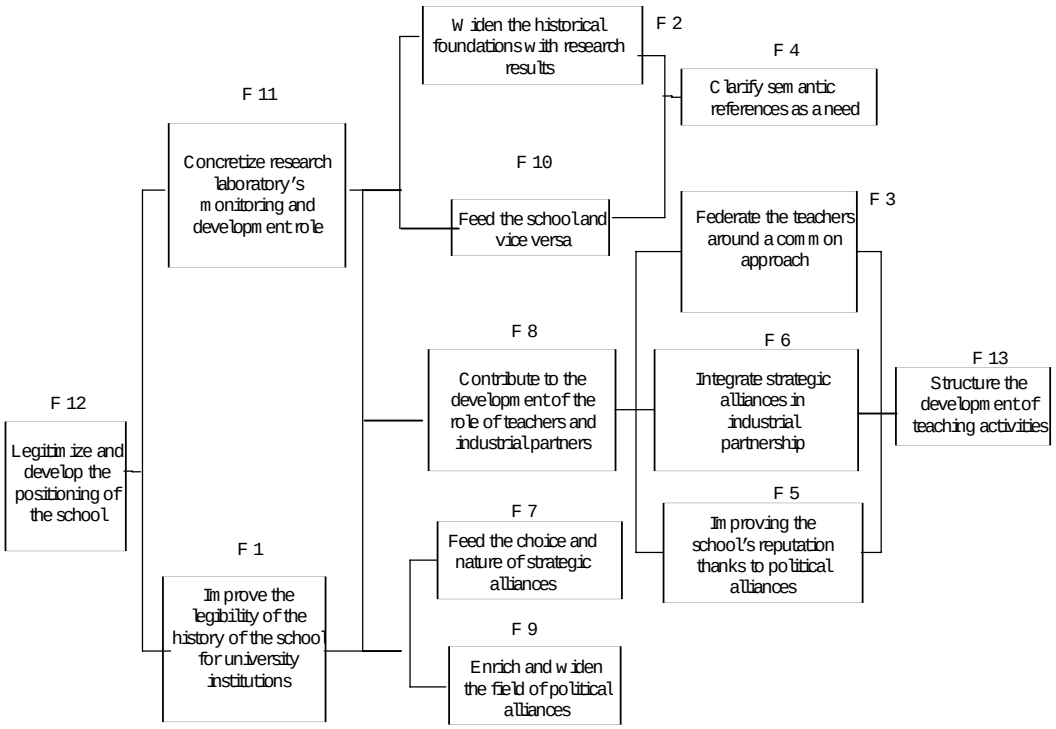
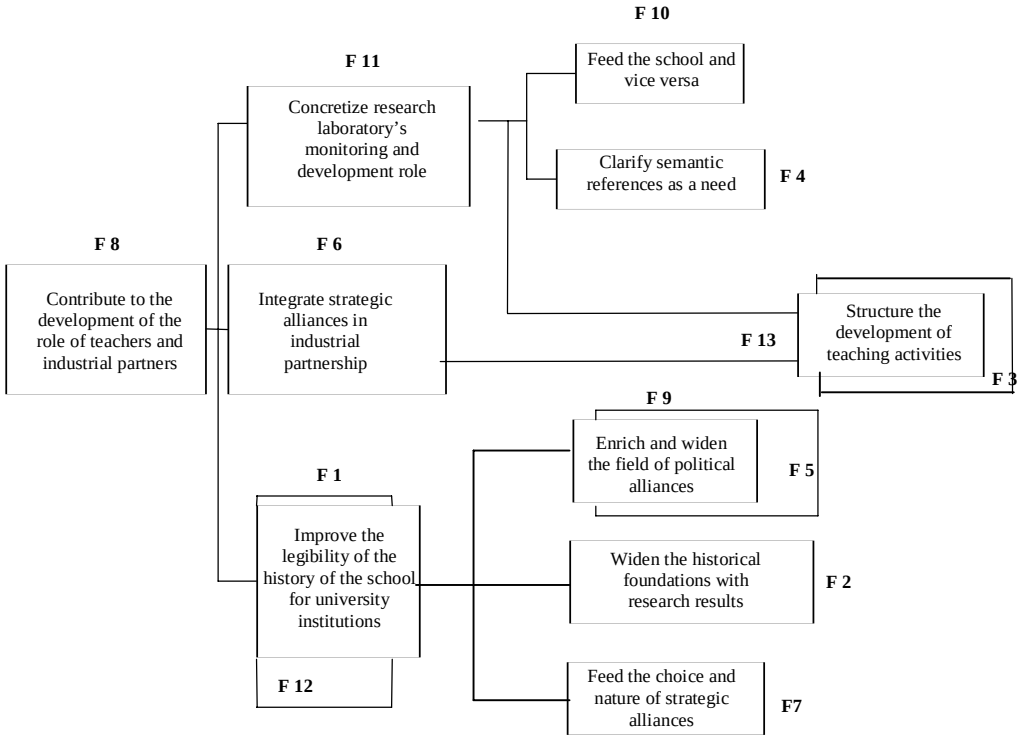


Figure 6: Optimal sequencing of functions at T + n according to the FAST method



In this configuration, we must underline the fact that the functions of the organization, which aim to:

- Legitimize and develop the positioning of the school (F12)
- Improve the school's reputation thanks to political alliances (F5)
- Federate the teachers around a common approach (F3),

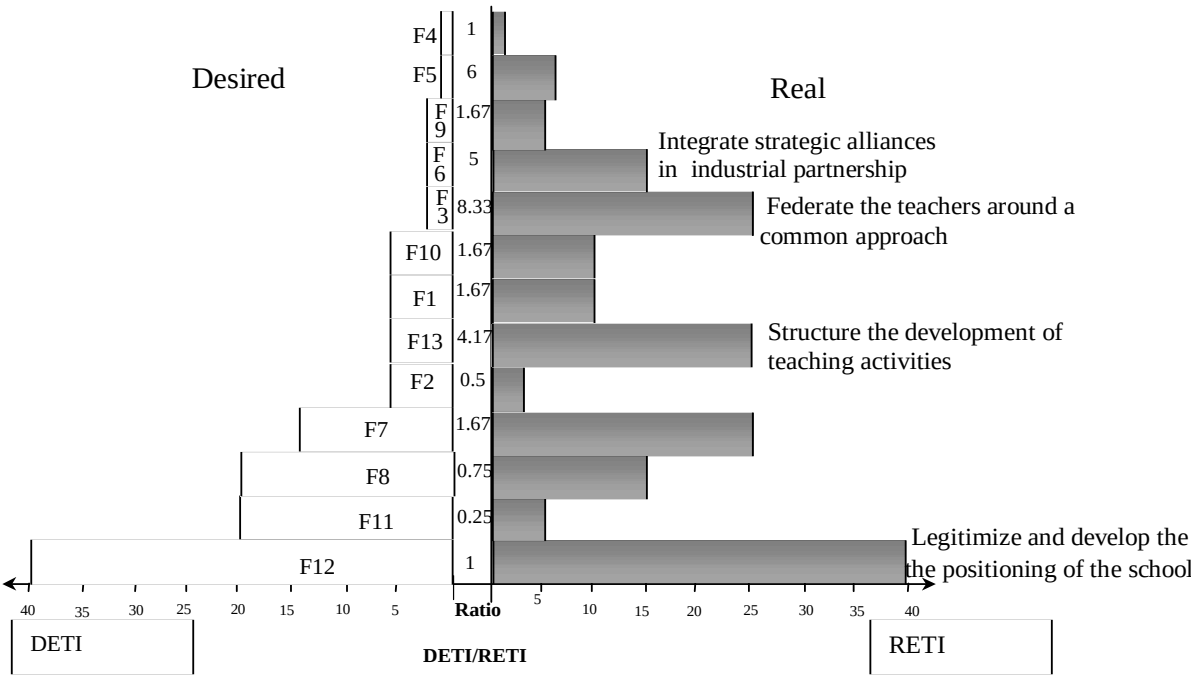
can form part of and continue to feed the following functions, which have a higher priority:

- Improve the legibility of the history of the school for university institutions (F1)
- Enrich and widen the field of political alliances (F9)
- Structure the development of teaching activities (F13)

2.3.2- Development Of Functions On A Hierarchical Basis

It was decided to classify the functions according to the Efficient Time Invested (ETI) criteria in performing a function. The work group defined the desired ETI (DETI) for each function and then calculated the real time invested in house on each function (RETI). The following Figure presents the results of these calculations as well as the ratio between real and desired time spent performing a function.

Figure 7 : Functions according to Efficient Time Invested



These results led to a certain number of conclusions and proposals for evolution:

- If the ration is higher than 1, the energy put into a function is higher than it should be. Given that the energy within a system remains constant, it can be assumed that when too much energy is used on one function, other functions will suffer from a lack of sufficient energy.
- If the ratio is lower than 1 or very close to 1, it is the opposite of the situation stated above.
- When a ratio is equal to 1, it can be assumed that, overall, sufficient energy is being applied.

It can be noticed that a certain number of imbalances exist. One can therefore wonder if they really correspond to the global strategy. We can state that the general objective is relevant and that the direction of the approach is confirmed (F12: the organization must help to legitimize and develop the positioning of the school equal to 1), but its development leads to strong imbalances:

Higher than 1 for the functions:

- federate the teachers around a common approach (ratio 8.33)
- integrate strategic alliances in industrial partnership (ratio 5)
- structure the development of teaching activities (ratio 4.17)

and lower than 1 for the functions:

- concretize research laboratory's monitoring and development role (ratio 0.25)
- widen the historical foundations with research results (ratio 0.5)
- contribute to the development of the role of teachers and industrial partners (ratio 0.75)

The objective for the year 98/99 was therefore to contribute to the inversion of the preceding ratios. The only particular point is the function F13 "structure the development of teaching activities" which suggests the implementation of long-term piloting through the development of a tool to federate teachers.

This approach has an impact on the total strategy because it acts on the quality of implementation and enables mistakes to be corrected. The energy being generally constant in the system, the "new school" context and the increasing number of students contribute to the fact that all the energy is not necessarily used where "theoretically", and in the short term, it should be. The focus is therefore on the search for equilibrium between the functions:

F3: federate the teachers around a common approach
F6: integrate strategic alliances in industrial partnerships
F13: structure the development of teaching activities

through an appropriate communication strategy targeted both internally and externally and through the integration of risks and disturbances in the laboratory's research program.
To do this, the laboratory proposed developing the prototype of a tool, the Employment / Skills Referential (ESR) of the students (Morel et al. 98), and implementing it in the school to link industry and the school, through a permanent process of adjustment. This disposed of the F12 function (legitimize and develop the positioning of the school) and balanced the functions F3, F6, and F13.

3- Conclusion

Value analysis, adapted to our background and conducted within our school, leads to interesting proposals to answer the initial questions, and to the building of an integrated strategy to follow. Furthermore, we want to emphasize the fact that value analysis is presented as an approach ensuring a good compromise between pragmatism and creativity. One should not propose solutions which, most of time, correspond to existing things, but rather suggest possible paths of development in terms of functions to be performed.

Furthermore, the construction of the ideal target is based on a functional concept that enables the evolution of the project to be managed taking into account outside partners and the environment.

III - THE SCHOOL'S TEACHING PROJECT : THE EMPLOYMENT/SKILLS REFERENTIAL

1- Which project for what need?

Beyond a classical functional conception, defining the teaching target was based on the Employment-Skills Referential, widely used in industry and tested by the French Ministry of Education.

Starting from the need to work, the meeting of industrial needs and including profiles and skills of engineers, we wondered how to use properly all the resources available at the School, which include :

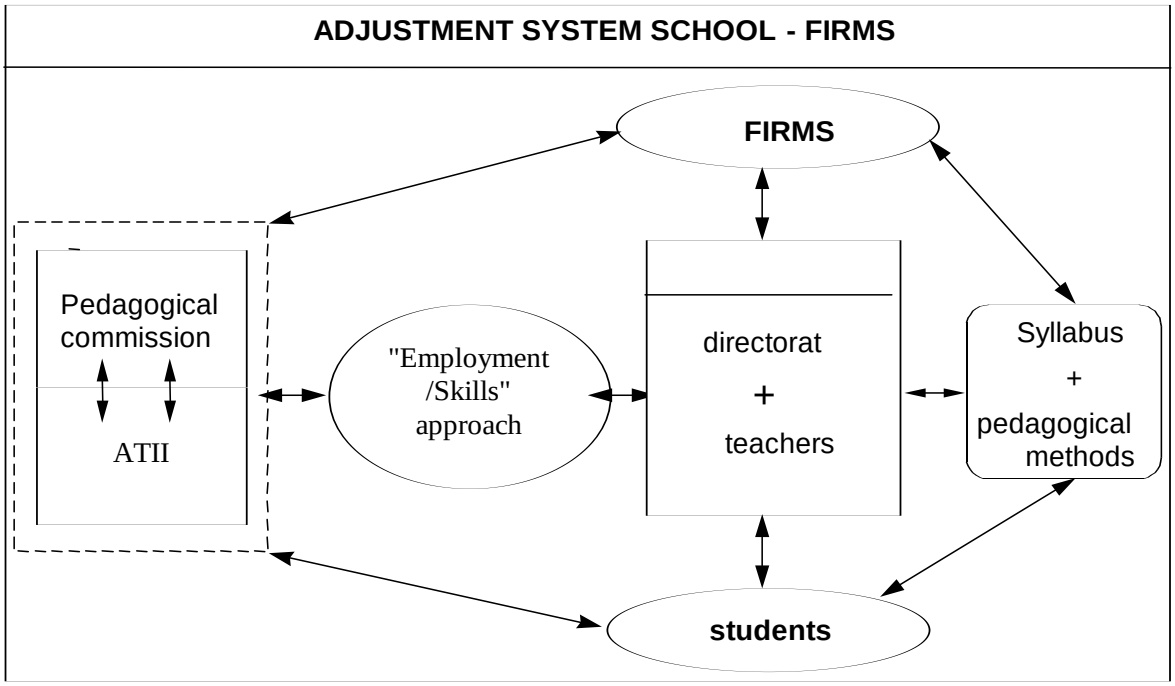
- a network of industrialists and related institutions (Chamber of commerce, SMEs, major groups, …)
- a research laboratory working on the dynamics of innovation and theories of learning through action
- a transversal structure within the INPL: the Innovation and Intrapreneurship workshop
- a student population with very diverse origins

in order to develop a pedagogy which would be useful for the training of development engineers specialized in Organizational Engineering.

The confrontation of these different elements emphasized three levels of expectations concerning employment :

- present needs
- real and perceived needs and
- hidden potential needs.

Figure 8 : school/firms adjustment system (ENSGSI Quality manual)



This led to the definition of a common target defining the vision of the "ideal" engineer in an uncertain context which is determined by an ever increasing search for innovation. The skills required are thus defined as :

- to know how to pose and explain problems in all their dimensions (technical, economic, organizational, management) in order to identify the levers and priorities for action,

- to know how to solve problems by proposing, driving and structuring approaches and methodologies which are well adapted to the context whilst ensuring their diffusion and integration at all levels in the company.

Consequently, the development of the training profile required by our partners necessitated the designing of an homogeneous skills referential integrating knowledge, know-how and behavior. We call this referential ESR (Employment/ Skills Referential).

2- The Employment/ Skills Referential

One can extract an Employment Referential built around 8 key functions (F) and a Skills Referential built around 4 associated generic skills (S).

2.1- Employment Referential :

The first validation of the Employment Referential emphasized 8 main functions :

F1 : project driving for a predetermined objective
F2 : technical performance optimization
F3 : product/market coherence
F4 : cost optimization
F5 : human resource management
F6 : human development
F7 : interface management and co-ordination
F8 : development and innovation project management

These functions were considered essential for : "the management of development projects within SMEs or autonomous units of major groups.

Each function is itself subdivided into several main activities which characterize it. Whereas the first five functions are usually considered as necessary for an engineer, the last three functions depend on an appropriate cognitive organization and also on the professional experience acquired after a minimum of 3 or 5 years.

2.2- Skills Referential : generic skills

Developing the skills required by the Employment Referential necessitates the implementation of a pedagogy adapted to innovation development as well as the adaptation capacities of student engineers.

The generic skills are :

S1 : to identify a situation globally
S2 : to create the conditions of commitment to initiate action
S3 : to drive actions

And transverse to the 3 others :

S4 : to mobilize, animate and develop

The objective behind the specification of these 4 generic skills is to guarantee that student engineers develop modes of reasoning that will enable them to tackle the complexity of innovation and development problems. To reach this objective, a progressive construction of the different dimensions, knowledge, know how and behavior is needed through an articulation of the learning themes and an appropriate pedagogy.

2.3- The Employment/Skills Referential

The Employment/Skills Referential is presented as a dynamic tool that allows methods and content to be connected in order to meet the global target aimed at within a projective vision.

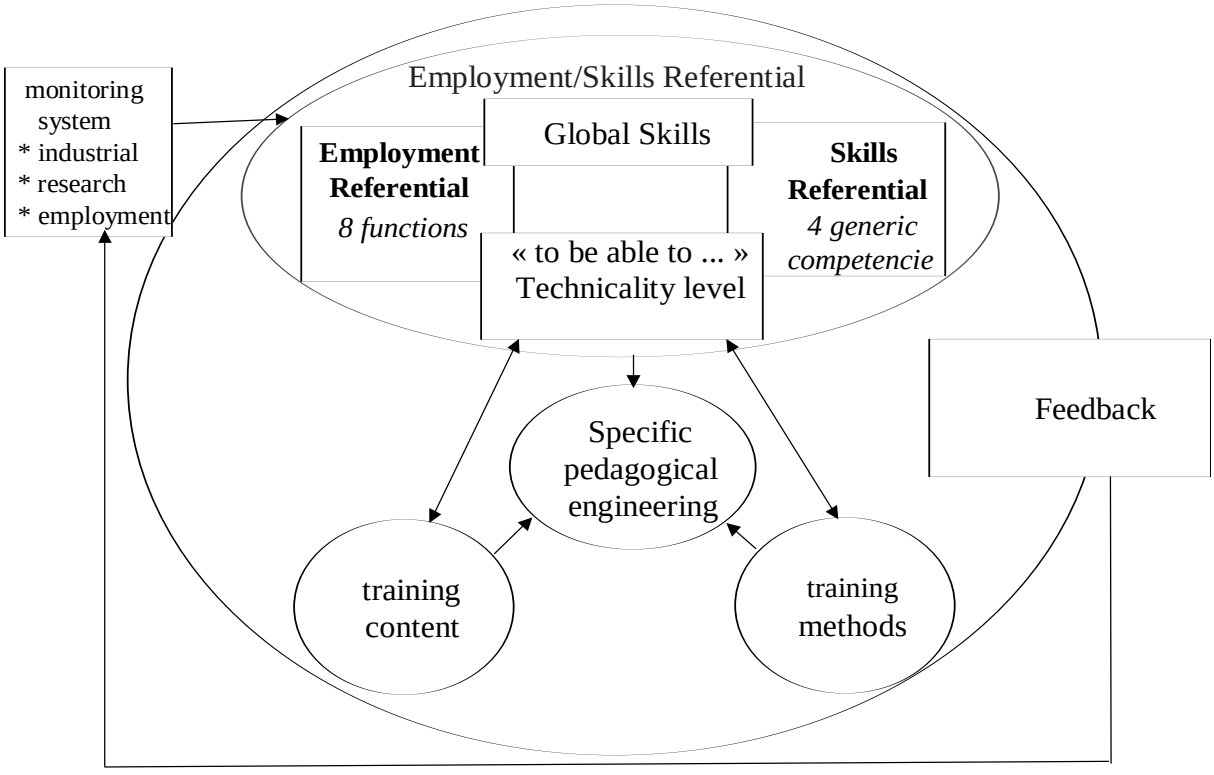
The following diagram clearly defines the two main axes of the ESR :

- The first one connects the Employment referential to the training program
- The second connects the Skills referential to the training methods

This diagram also shows 2 entities which are crucial for its smooth operation :

- pedagogical engineering situated at the interface of the two referentials
- A system combining industrial monitoring, research and employment which must contribute to the Employment Referential in order to make it live and Guarantee its continual updating.

Figure 9. The Employment/Skills Referential (Morel 1998)



The result of these two axes is a development engineer, a manager of innovation, equipped with the knowledge, know how and personal skills required to meet the needs originally defined. Moreover, this engineer plays a determining role in the validity of the ESR because he/she contributes to its development through feedback. Thus, the engineer becomes a partner as far as the quality of teaching and the industrial methods taught at the school are concerned, by participating in the evolution of the system.

3- Impact on training objectives and content

The ESR allows the appropriateness of course content to be checked against the Employment referential as well as furthering progressive development wherever necessary.
Concretely, this means that each subject taught (content) is expressed in terms of "at the end of the course, the students will be able to …" which is then checked against the 8 functions described above.
The result is a clear global vision of all the subjects taught. We can then check that training does indeed contribute to the development of one or more of the functions in terms of knowledge, know-how or behavior.
Moreover, this has enabled us to take out certain courses which did not meet the requirements of the defined target, or, on the contrary, to add courses that would help reach the stated objectives.
Finally, the ESR also induces an evolution in teaching methods in order to develop the acquisition of required target skills. This means having recourse to inductive teaching methods through projects that confront students with a variety of situations:

- Created situations (directed workshops) or
- Real situations (one year industrial projects).

In this way, the teaching staff can evaluate the ability of students to implement and use the theoretical input, both from a scientific methodology point of view and a behavioral one. The students' abilities to self-evaluate their work and request further knowledge input can also be assessed.

4- A new protocol for evaluation.

The ESR leads us to a more precise formalization of the role of teachers and their evaluation systems that help students appropriate experience and enable their progression to be monitored. Whilst it is relatively simple to evaluate concrete quantitative knowledge, the qualitative evaluation of student performance in workshops and projects requires a system whereby the teachers can assess the evolution in aptitudes, skills and behavior in relation to those described in the referential. The school's evaluation system therefore includes two elements:

- Quantitative evaluation of content or results
- Qualitative evaluation of the process that leads to results (especially logic applied and the impact of the time factor on a quantitative result)

5- Conclusion

This type of approach leads to a transformation of the role of those involved in the project. The personal accompanying of a student throughout his or her studies modifies the nature of the tasks and responsibilities assigned to the teaching team which must, above all, create a secure learning environment in which the student can learn by trial and error.
The role of companies also changes. From being the "object" of teaching they become the "subject" involved in the teaching program. The result is a new type of relationship between educational establishments and the world of industry from which both partners profit.

GENERAL CONCLUSION AND PERSPECTIVES FOR TRANSFER TO DEVELOPING COUNTRIES

Innovation, essentially a dynamic and evolutionary notion, requires an adaptation or an evolution in the way in which this subject is taught. It is therefore necessary to develop appropriate teaching systems which are themselves innovative. Within this perspective, we have shown the particular use we have made of value analysis, a tool originally used in product design, to develop first a global approach, and later a specific tool, the Employment /skills Referential in accordance with the expectations of both industrialists and teachers for engineers who are "entrepreneurs and managers of innovation". Beyond a change in curriculum content, this structure has lead to the development of a real project approach to training able to contribute to changes in the way of tackling innovation.
The experience of building the ENSGSI, a new engineering school based on new concepts, was the fruit of:

- A major conceptual contribution from research into innovation which forms the basis of the school's main specialty,
- The use of the Employment/Skills Referential which enabled the school to achieve the optimal positioning regarding industrial needs, both in terms of the training of future employees and services to accompany regional economic development.
- A system of monitoring that allows permanent adjustment to meet market needs

The main difficulty to resolve was the setting up of a way of managing the school which is oriented towards a development target in perpetual evolution with market needs. Here again, research led us to apply tools for driving innovative processes to the management of the school. This project is therefore an attempt at finding a permanent balance between several concepts in innovation: training in innovation, project management, innovative teaching methods and accompanying market needs for sparking innovative projects.

Today, our approach has lead to a reinforcing of:

- The links with our partners,
- The school's position, thanks to a better understanding of the training offered,
- The quality of our teaching program and our pedagogical approach.

Finally, although the ENSGSI's objective is to train engineers who are able to drive innovation, its vocation is more globally to contribute to the structuring and diffusion of a new "state of mind" that will favor new ways of tackling innovation in other structures or other countries.

Although implementing this approach may seem relatively easy in industrialized countries, it is not so obvious when applied to developing countries. The quality and the pertinence for transfer are closely linked to social, cultural and political aspects.

Indeed, culture induces behaviors which will influence the way of designing the project, for example, whether the logic applied is cooperative or power/mastering (figure 10).

Figure 10 : Coherence within design and implementation of an innovative school project

Logic for designing the global approach and tools	Logic for implementation
cooperation	Cooperation or power
power	power

The most important thing is to ensure the transversal coherence between the two types of logic, whatever the nature of the project, and consequently to adapt the way of managing the project by using either a participative approach or a directive one.

For this reason, the research laboratory has, and will continue to play, a vital role, both in the strategic evolution of the school as it remains at the forefront of scientific developments (especially in the fields of learning and technological innovation) and modifications in economic demand, as well as in the adaptation of the methodology to new contexts.

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Emerging New Economy -- Responsive Policies

by
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President, International Association for Management of Technology
and
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ABSTRACT

The world has been witnessing drastic changes in technology and the business environment. The pace of technological change has increased to levels unprecedented in history. Technology has dominated every aspect of human endeavor. It is vital to economic development, to progress of society and to the improvement in the quality of life. Technological progress has brought with it improvement in communication, transportation, information dissemination, and has brought the world closer together as one global village. Proper management of technology is what creates wealth for nations, companies, and individuals. It forms the foundation for economic growth and determines national and organizational competitiveness. Multinational corporations and all successful enterprises realize that business competitiveness is no longer a matter of luxury but a matter of survival in an increasingly global, fiercely competitive marketplace. The distinction between developed and developing economies lies primarily in the ability to effectively manage resources and technological assets.

Developed economies rely heavily on innovation to bring high added value to customers, command high prices, and maintain market dominance. Innovations and improvement in information and communication technologies commanded by industrialized countries bring about not only fundamental changes in the core institutions of those countries, but also the emergence of new knowledge-intensive products, services, industries, and inter-organizational forms. In order for developing countries to avoid being marginalized, they must formulate strong public policy, and their companies must improve the way they manage technology and innovation.

This paper discusses the role of management of technology in creating wealth and prosperity. It demonstrates the impact of technology on fostering national development and improving competitiveness. It contrasts the wealth created in industrialized countries and their companies with the wealth created in less industrialized countries. It also defines the necessary ingredients for enterprise competitiveness in the current environment.

The paper covers the drivers of change in the new economy of the twenty-first century. It then discusses the responses in public policy needed by governments of developing countries. It also recommends strategies to be followed by corporations in these countries. Special attention is given to the human resource development effort required to prepare a workforce capable of supporting development and for competing in a global market place. Recommendations will be made based on the authors' experience in the Arab world.

INTRODUCTION

The world is witnessing a technological revolution with far greater impact than the Industrial Revolution. The consequent changes in economic growth and social behavior are bound to be drastic. The Industrial Revolution, which started in the British Midlands in the eighteenth century, transformed the western countries economy, and work patterns, from an agricultural base to an industrial base. The release of steam power and the use of mechanical implements to supplement human power changed production and transportation habits. These changes resulted in a radical improvement in workers' productivity and created major economic growth in industrialized countries. Social and work habits also changed. The factory system emerged. It brought people from the farms to work in concert in clustered communities (Cadbury, 1995). Workers had to abandon their personal tools and individual work habits in favor of factory-issued tools and more structured work habits. Hand made and single-unit produced products gave way to machine made and standardized, mass-produced, products. People moved from the farms to their factory communities. Rural life style gave way to city life style. Responses in local, state, and national public policies ensued. New laws and regulations were passed to deal with the new environment and harness its potential.

The technology revolution that we are witnessing today has its strength in information, communication, and improved knowledge. It contributes to the augmentation of intellect and know how. This adds totally new dimensions to human development. This revolution will, once more, bring major changes in patterns of work, job markets, and social behavior. It will contribute to improvement in productivity and carry with it major potential for economic growth and improvement in the quality of life. Changes will occur in this new knowledge era, and it will bring with it new challenges, a new economy, and a renewed need to examine public policies needed to harness its potential.

TECHNOLOGY AND THE CREATION OF WEALTH

Technology is the way we do things. It is the means by which we accomplish objectives. It is all the knowledge, tools, products, processes, methods, systems, and procedures that are applied to achieve desired objectives. Technology is the application of knowledge to create products and services that serve human needs and aspirations. As such, technology encompasses several areas: hardware, software, brainware, and know how (Khalil, 2000). Progress in technology depends on the acquisition of knowledge and the conversion of this knowledge into useful applications. This requires the generation and accumulation of knowledge, spinning it out into innovation, and creating a system that successfully exploits innovation to achieve desired goals.

Since the dawn of civilization, technology has been the backbone of almost every human endeavor to sustain life and improve human conditions. When our early ancestors were foraging for food, they invented tools and implements to help them acquire plenty. When they needed shelter, they innovated methods of building construction. When they roamed the earth, they used animal power to transport themselves and their goods. They also created weapons to defend themselves and amass power. These early creative solutions helped to satisfy human needs and create wealth for those who exploited their technology to gain power or engage in trade. The world today still revolves around the same fundamental issues which faced our ancestors - using technology to satisfy needs, gain power, and increase wealth. Technology has been, is, and will continue to be the engine for wealth creation in human societies. The major difference between yesteryear and today is the accelerating pace of technological change. While progress in technology has been steady for thousands of years, it significantly accelerated following the Industrial Revolution and has reached a frantic pace with the technology revolution of the last two decades.

History has taught us that countries that have exploited technology in an effective manner have achieved great wealth and power. The ancient Egyptians built great civilization by mastering agricultural technology, construction technology, and transportation technology. The Chinese, the Greeks, and the Romans built their civilizations based on knowledge, strategy, and the development of war and peace technology. Western industrialized countries such as the United States, Great Britain, and France have accumulated wealth and power through the use of technology. Germany and Japan restored their power by rebuilding their technological assets. The tigers of Asia succeeded in transferring, absorbing, and exploiting technology.

The same observation is true for corporations. Those that muster technology have created great wealth. Companies such as General Motors, Ford, IBM, Microsoft, Mitsubishi, and others have produced revenues exceeding those generated by many countries or even groups of countries combined. In fact, out of the top one hundred economies of the world, fifty-one are those of corporations, not countries.

The wealth creating capacity of nations as well as companies does not only depend on the acquisition of technology but more importantly on the ability to manage their resources and technological assets. It is only when technology reaches the marketplace and is accepted and paid for by customers that wealth is created. This is the essence of the relatively new Management of Technology discipline. The challenge that faces every country and every company today is how to harness technology for wealth creation in this era of exponential growth in technology. In this context, the definition of wealth creation includes the well being of government and non-profit organizations, the quality of life, and environmental concerns. It is important that the economic growth achieved through technological progress be sustainable on the economic, social, and environmental dimensions.

ON GLOBALIZATION

Advancement and proliferation of technology has brought the world closer together into one small global village. The explosion in information and communication technologies has permitted information, news, and personal and company communications to flow easily across boundaries. Innovations in transportation and logistics have allowed movement of people, technology, and goods across international borders, permitting an integration of economies around the world. The influence of the Internet on the growth of e?business is creating an upheaval in business practices and organizational structures around the world.

Globalization has a major impact on several areas that influence people's standard of living and quality of life. Effects of globalization on the political, economic, cultural, and technological scenes will only expand in the future. With the dissolution of the Soviet Union, eastern block countries joining the European Union, and most world countries opting for a combination of democracy and market economy, political globalization seems to have been realized. Increased trade, mutual economic dependency, worldwide capital markets, and strong global sourcing characterize economic globalization. With the General Agreement on Tariff and Trade (GATT) and most nations joining or applying to join the World Trade Organization (WTO), economic globalization is well under way. Cultural globalization is being facilitated by access to the Internet and to communication networks, particularly television, movies, and multimedia systems. Cultural globalization has many consequences for societies, both good and bad, and its implications still require studies by governments as well as companies in order to deal with its effects (Khalil, 2001). Technological globalization, however, has yet to occur in a harmonious and equitable fashion. Multinationals in developed countries are achieving technological globalization through the use of information and communication technology. They have been connecting their R&D and production facilities across boundaries and connecting with suppliers and customers through integrated networks. They have also been able to move production facilities and R&D laboratories in search of optimal conditions. In contrast, most companies in developing countries have yet to achieve this level of technological sophistication. In fact, the gap in technology between countries with developed economies and developing countries is still huge and the economic divide is widening.

Equitable technological globalization can occur through international technology transfer. However, the host receiver of the transfer has to be well prepared to receive the technology, absorb it, and advance it through innovation.

COMPETITIVENESS

Competitiveness is the process by which one entity strives to outperform another. For a company, being competitive implies that it has the ability to produce a product or provide a service, in a timely and cost effective manner, which meets the test of the marketplace and the needs of customers. To maintain its competitive position, the company must continue to outperform its business rivals. In today's global markets, those rivals may be operating within local, regional, national, or global markets (Khalil, 2000). In today's business environment, competitiveness is no longer a matter of luxury but a matter of survival in the global marketplace.

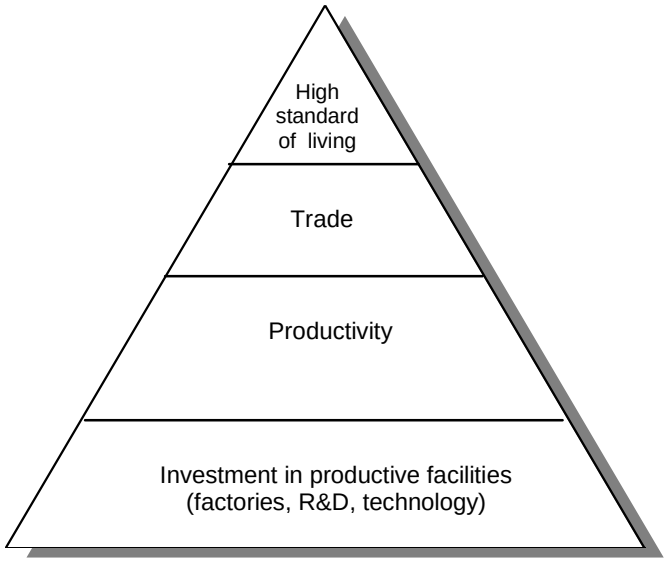
At the macro-level, national competitiveness is a consolidation of business performance at the micro-level of companies and individuals -- the true agents of economic growth. Competitiveness of nations reflects on the standard of living of their citizens.

In 1985, the U.S. President's Commission on Industrial Competitiveness defined it as follows:

> *Competitiveness is the degree to which a nation can, under free and fair market conditions, produce goods and services that will meet the test of international markets, while simultaneously maintaining or expanding the real income of its citizens.*

The Washington-based U.S. Council on Competitiveness adopted this definition and illustrated competitiveness using a four-tier pyramid as shown in Figure 1 (Council on Competitiveness, 1995).

Figure 1. The Competitiveness Pyramid (Council on Competitiveness, 1995)



Investment

Investment is the base of all economic activities. It includes investment in productive facilities, R&D, capital equipment, as well as investment in people through education and training.

Productivity

Productivity is the efficiency of utilization of resources. The level of technology used, the investment in capital equipment, the performance of the workforce, and the effectiveness of the management system influence it. Productivity is both a determinant and an indicator of national competitiveness (Council on Competitiveness, 1995).

Trade

Exporting to other nations is essential for increasing wealth. High export levels are indicators of a nation's industry success. It is a reflection of the efficiency of its productive enterprises and the quality of its products. Growth rate and levels of export are indicators of national competitiveness. Currency exchange rates can influence the magnitude of exports and should be traced.

Standard of Living

A high standard of living is the goal of every nation. It is the crown of the competitiveness pyramid and the reward for citizens living in competitive nations. A nation's wealth can be expressed in terms of its Gross Domestic Product (GDP). An index for the standard of living is GDP per capita.

The distinction between developed and developing countries lies primarily in the ability to effectively manage resources and technological assets to be competitive. It is, however, impossible to think of developing countries as a homogeneous group due to the emergence of some countries faster than others. Therefore, an analysis of each country's special circumstances, weaknesses, and strengths is more appropriate.

PHASES OF INTERNATIONAL ORDER

Competition among nations in the production and marketing of goods and services is a relatively new phenomenon. In the modern era of the nineteenth and twentieth century, industrialized countries of the north dominated the international scene. They had their factories produce goods and market them nationally and to the rest of the world. These countries accumulated great amounts of wealth. It was not until the later third of the twentieth century that competition for goods, services, and markets intensified. The reemergence of Germany and Japan, followed by several Asian countries such as Taiwan, Korea, Malaysia, Singapore, Hong Kong, and more recently China, has brought new players to the competitiveness game. The international scene and its politics can be divided into several phases (Khalil, 1998):

First Phase -- Following the Industrial Revolution, the world went through several phases of change. During the era of colonial dominance and up to World War II, wealth was channeled towards the major world powers.

Second Phase -- After World War II, the second phase was dominated by the politics of the Cold War period, and wealth was channeled to industrialized countries with technological know-how. Up to the end of the Cold War, world politics were heavily influenced by a tripartite block of countries: the first world, also known as the free world; the second world, or the communist world; and the third world, or the non-aligned countries, also known as the developing countries (some of which had been colonized in the past). With the near disappearance of the second world, the concept of "non-aligned" countries lost its frame of reference.

Third Phase - This phase presents a new world order where countries need to work together to increase the economies of all. Nations around the world have started focusing on economic growth, as evidenced by the number of countries that have signed up for the General Agreement on Tariff and Trade or applied to the World Trade Organization. Since technology and the management of technology are recognized as major drivers of economic growth, the economic development of the less-developed countries and the issue of wealth distribution have become a global problem; integral to that is how to manage technology in a global economy.

The Next Phase -- The issues as we go forward are not only the economic growth of individual countries, but also how to deal with issues of social justice around the world. Individual governments cannot do this on their own. A strong role must be played by industry since multinational organizations seem to be at the forefront driving globalization. Public policy leaders in countries with developed economies, such as the U.S. and Europe, as well as managers of multinational corporations, have a significant role to play in order to allow countries with developing economies to be part of the global economic growth movement. Additionally, these countries and multinational corporations should exhibit sensitivity to the local conditions and cultural characteristics. Countries with developing economies should be allowed to evolve and grow, otherwise a collapse of the global economy may occur. Ideally, strategy makers should display a shift in thinking from simply creating wealth for their own constituencies, to concern about the distribution of wealth within countries and around the globe. In simple terms: it does not mean much to be an awesome enterprise in a market that cannot afford your product.

THE BUSINESS ENVIRONMENT OF THE TWENTY-FIRST CENTURY

To understand what will drive change in the future, one needs to examine what futurists have predicted as potential scenarios. Such scenarios not only derive their underlying assumptions from past history but also borrow heavily from projections of current and emerging technologies and their impact on future lifestyles and indeed the very nature of man's evolution of thought. One such scenario is what futurists have noted about future global competition being on the economic front. Some, in fact, have dismissed the likelihood of armed conflict as a means for resolving international differences, pointing to economic wars being waged instead. Another important element of the new order is for cooperative competition ("coopetition") to replace a right-out competitive environment. As such, alliances will be forged, and at times between what seem to be odd partners - partners who no longer see each other as adversaries but rather as a marriage in which everyone brings specific strengths to the partnership. The body of knowledge humanity possesses today is expected to double every two years as opposed to every two decades in the past century. Furthermore, disseminating and mining information and communicating experiences and lifestyles will continue to see exponential growth. As a consequence, expectations will be raised and personal aspirations for prosperity and customization will drive significant growth of the services sector.

In such an environment, it stands to reason that the international scene will undergo significant and rapid change and that indeed the "deck of nations" will be reshuffled. The most vulnerable, as this occurs, will be the developing nations. It is therefore of vital importance to give these scenarios high priority on the national agenda. Supporting this notion will be accessibility of information, how that influences society as a whole, and the new avenues to generate real wealth as well as the boundless opportunities for contribution.

At the very heart of all of this will be technology: its creation, development, implementation, and management. As the engine that transforms knowledge into wealth, it will serve as the mechanism that will enhance the organization's strategic degrees of freedom: the ability to enter, exit, and manipulate knowledge to one's advantage and instill some predictability and control over events and well being.

One can, within this context, view the technological health of a society as a measure of its growth potential and prosperity. Indeed, one can, by the same token, use it as an indicator of key strengths, critical weaknesses, and the national (or regional) ability to respond to threats and opportunities.

Two fundamental notions, however, need to be kept in clear view. It doesn't matter whether it's high tech or low tech - what matters is that it has to be the right tech; and that the global game is going to be won on speed and agility. In simple words, one has to choose what best serves one's purpose, and that fast responses and the ability to reconfigure one's assets to meet challenging realities are imperatives.

In a series of workshops held under the auspices of the National Science Foundation (NSF) and the International Association for Management of Technology (Khalil 1998,2001), we have identified several issues as the primary drivers of change in the twenty-first century. These drivers can be classified under seven main areas:

- Technology
- Changes in Business Environment
- Communication, Integration, and Collaboration
- Strategic Directions of Industry
- Changes in Organizational Structure
- Financial Sector Structure
- Education and Training

The intensity of changes in technology is projected to continue into the next century. The rapid communication and diffusion capabilities of information will grow, resulting from technological advancements. The Internet, for example, is an avenue for the provision of extensive amounts of raw information, accessible by many people. Through it, interactions can be two-way or multi-way and will foster collaboration in departments within organizations as well as between organizations.

In addition to information technologies, another technical area where major and rapid change will continue is molecular biology. Industries such as healthcare, agriculture, and genetic-based corporations are likely to be privy to great changes in technology within genetic engineering, biotechnology, and connecting to nanotechnology.

Also continuing will be the enhancement of performance of technology as a whole by the advancement of technology and technology sharing between various disciplines and concentrations. Fusion of technologies will continue through the development of multiple products that integrate material, mechanical, electronic, and manufacturing technologies, leading to even more complex products. This, in turn, will require engineers and managers to be wired together and adaptable to a multi-disciplinary world. Thus, the increased technological complexity drives the environment towards multi-disciplinary cooperation, cross-disciplinary training, and cross-cultural contexts. The cost and complexity of technology, as well as the drive to maintain a competitive edge, also prompt increased pressure on corporations to respond by creating new technology. Pressures continue to lead to collaboration among companies who have been traditional rivals.

Changes in the Business Environment

Changes in business environments are occurring, being partially driven by the use of the new information technologies. The imperative of the new information technologies continues to drive a kind of technological imperialism in different areas of business disciplines. Finance, marketing, innovation, engineering, and public relations all use technology and innovation as the common core to compete. Innovation in all business processes will be a dominant factor in determining business success.

Companies face the emergence of multiple stakeholders. Besides the traditional stakeholders of shareholders and employees, there are the customers, suppliers, environmentalists, and the global community. This leads to the need for a manager who is able to deal with demands of a diverse array of issues as well as diverse stakeholders.

Communication, Collaboration and, Integration

As a result of rapid technological advancements, it is not only important to recognize the drivers for industrial, technological, business, and educational changes, but it is also necessary to muster the ability to deal with such drivers through improving the capabilities of industry, particularly with regard to the integration of technology and business strategy. (The field advocating this integration has been called the "Management of Technology" or simply MOT.)

Changes to the educational systems are also indicated. Knowledge generation is always a key entry point for effectively managing technology and must be supported by innovative policy development and a resurgence of research funding in the development of new technology.

Due to the new information technologies, Intellectual Property Rights (IPR) has become a fast-changing and multifaceted area and poses new legal and logistic challenges for corporations. This emphasizes the need for better-structured Intellectual Property Rights agreements. There is a need for a change in corporate records and information systems for enhanced security and protection from legal liabilities. The need for corporations to master communications technology is particularly important because of the quantity of corporate records stored in cyberspace.

Moreover, the context for technological change continues to be global. Stakeholders and competition encourage more alliances. A dynamic global marketplace creates the need to educate members of the organization in international business practices. This is particularly important in view of the increasing trend in industry towards greater dependence on the outsourcing of some aspects of technology to small and midsize companies. These worldwide trends foster greater collaboration, mergers, and joint ventures in order for companies to compete effectively. As a result, multiple parties involved in innovation may create multiple ownership by competitive corporations working in the same technology.

The explosive use of the Internet has caused a "bottom-up" revolution, where communication within companies and communication between the business and the customer have been utilized in order to foster business growth. Accordingly, collaboration, communication, and integration among departments and organizations are increasingly important as information technology continues to change. Collaboration among companies consists of increased global alliances, joint research, development, and production projects. The integration of departments within the organization is also needed to build synergy and create a unified organization working collaboratively around an end product. Increasingly, there are more sophisticated consumers and more collaborative relationships between government and business.

Strategic Issues for Organizations

As the changes in the competitive environment continue, the traditional issue of social justice around the world continues and changes in form. Because of the global economic environments, individual governments can no longer attempt to effect changes completely on their own. A strong role must be played by industry. This creates more complex interactions between different sectors, forms, and capital.

At the company level, strategic planning must take into consideration the integration of technology and business planning. Strategic plans must recognize core competencies including intellectual capital. This process should also help to define the culture of the organization and that of employees and customers.

New technology continues to fuel entrepreneurial activities within and outside the corporate structure. It also leads to growth of small businesses. The proper use of these small businesses can contribute to the overall growth of technology and the country's economy at large.

Changes in Organizational Structure

Another consequence of changes is the growing trend to move away from a fixed, permanent organizational structure to more mission-oriented and flexible structures. Organizations may be assembled to meet specific needs or special technology and disbanded as the technology changes or the need disappears. Thus, organizations are increasingly changing their structure from a vertical hierarchy (the traditional model) to a more horizontal or network model. There is an additional expectation of greater integration among and within organizations, especially aided by the computer/information technology and the incorporation of the Internet.

Financial Sector Structure

Financial opportunities, using mergers and acquisitions, enable corporations to realize the benefits of combining technological expertise, economies of scale, and the elimination of organizational duplication. This is particularly true of organizations dealing with mature technologies, and the model should not go unnoticed by developing nations. Another interaction between technology and finance is a result of the ever-increasing complexity of some technologies. This has created a need for new techniques to assist venture capitalists in justifying investment in technology (making the "business case").

Education and Training

Industry has been leading the way towards the change and organizational flexibility necessary for survival in the twenty-first century. In the educational arena, universities and schools need to adapt to constantly changing technologies. This adaptation is required in curricula and in the way of delivering education.

The linking of technology creation to the sustainability of economic, environmental, and social development becomes increasingly important for education. Moreover, the potential of the changing information technologies can facilitate the delivery through the emerging channels of distant learning and electronic educational delivery methods. Universities are beginning to emerge from delivering only local education to delivering education throughout the world. Multiple degree seekers are increasing, probably resulting in a future where few managers will only have a single advanced degree. The need for more technological and managerial education for all managers continues. Business leadership running companies of the future must focus on knowledge generation and application, putting emphasis on innovation, integration of organizations, and collaboration.

New models of education based on knowledge infrastructure integration and cultural acceptance are needed to prepare people for the future. Moreover, hands-on training and involvement should be part of any educational model.

CHARACTERISTICS OF SUCCESSFUL COMPANIES

The Technology Revolution that occurred in the last two decades of the twentieth century and continues into the twenty-first century has created new paradigms for business practice. Today's organizations have to manage in a dynamic environment where the only constant is change. This situation forces a set of guiding principles that must be observed if enterprises are to be successful. Betz et al. (1995) and Khalil (2000) summarized these as follows:

Value Creation The basic social responsibility of the enterprise is to provide value-creating activities for society. The failure in the twentieth century of the communist approach to economy was its inability to foster value?creating activities in the economy. The focus upon the nature of the enterprise's products (goods, processes, or services) as to how they add value for the customer and how that value may be increased is the key to the long-term survivability of the enterprise.

Quality Quality is a fundamental requirement influencing competitiveness. In a highly competitive situation, the quality of product and production must be at least equivalent to (or better than) competitors at the same price. Quality and cost are not necessarily tradeoffs. There are several kinds of quality: quality of conformance, quality of performance, quality of safety, and quality of production. Both quality and cost leadership are necessary for long-term competitive success.

Responsiveness There are rapid changes in technology, markets, competition, communication, transportation, national economies, resources, environment, and in global interrelationships. An enterprise must not manage only for stability but also for change.

It must be able to manage short cycles and respond to environmental changes and customer demands promptly. This responsiveness is to the changing environments outside the organization.

Agility

A production facility must be flexible enough to: (1) produce a variety of product lines, and (2) facilitate communication and operation between suppliers, production, and customers. Therefore, to adjust to rapid changes in technology and gain profitability from quick response to changing opportunities in the market, agility in production capability is necessary. One of the major costs of producing a product is investment in the production facilities, which then must be paid back over the product lifetime. Short product life cycles make this a formidable problem if the facility's fixed cost is high. Computer-based technologies and multipurpose machines in manufacturing are making it possible to quickly adjust to new product specifications. The Internet is facilitating communications with suppliers and customers. Agility may require changes within an organization's existing structures and management style.

Innovation

Because all technological capability eventually diffuses and all new technologies mature, no firm can continue to gain a technological competitive advantage without the ability to innovate. Otherwise, a firm has no advantage over competitors in differentiating its product or in having lower production costs and higher quality. Innovation produces the distinct competencies that provide products, production, and services that are superior to those of competitors. A firm must be able to improve its ability to innovate and use innovation to gain competitive advantage over its competitors. Innovation may fall into a number of categories, including products, production, and services. Competing with technology is a mark of our time.

Integration

Most modern products, production, and services require several complex technologies as core to their design and production. A modern firm must be able to acquire and integrate a portfolio of technologies that would give it a unique and defined advantage over its competitors. The portfolio may include more than one generation of product or process technologies. A firm must also be able to acquire or reconfigure skills and integrate technologies using different skill and knowledge bases in engineering and science. Integrating all resources including technology, people, energy, information, and capital are essential for improving productivity and increasing effectiveness. Integrating technology strategy and business strategy are essential ingredients in proper management of technology.

Teaming The combination of (1) the rapidity of technological change, (2) the complexity of integrating mixed technologies, and (3) creating high?quality, low?cost production requires that the firm hire and encourage a work force with high levels of training and continual upgrading of skills. Workers must be able to work together as interdisciplinary teams in carrying out and coordinating the operations of the enterprise. The complexity of integrating mixed technologies with varying life cycles requires a workforce with high levels of training. Flatter organizations, higher levels of skills, employees' empowerment, and working in teams are the marks of modern successful and innovative companies.

Fairness For a firm to survive over the long term, it must create conditions of fairness in the type and distribution of the wealth created by its success. The firm must develop a fair way to share with all its stakeholders the wealth created by a successful production operation. Fairness reduces conflicts among managers, labor, government, and the public.

Based on the above, the successful enterprise of the future has by necessity to be different from what it is today. We can advance a model (framework) that we believe not only captures the key ingredients but can also rationalize the necessary organizational strategies together with the supporting initiatives. Such a model will define the "enterprise" (a company, an endeavor, a nation, a region, etc.) as leadership of that enterprise bringing assets (skills being the most crucial asset) to bear on issues and opportunities. Needless to say, the speed and effectiveness of any response will be critically dependent on the systems (policies, infrastructure, etc.) installed to support the organizational agenda. One by one, we examine the key elements of our model, hopefully adding perspective and focus to how its elements naturally integrate.

The differences between leadership and management, although thoroughly discussed over the last two decades, still appear to elude many organizations. While both are clearly needed, it is not unusual for a leader to default to managing at the expense of inspiring the organization. Many can manage what is, but relatively few can envision what could be. Indeed, the responsibility for change lies at the top; and as leaders exhibit competence and integrity, they earn the trust of the organization, which is an absolute necessity for success.

The most valuable asset of an organization competing within the future order is the people and the skills they bring to the game. In addition to the fact that people make things happen, it is through integration of their skills that the core competency of the enterprise is derived. Such competencies become the strategic capability that gives the organization a substantial advantage, hopefully so unique it would be difficult for others to duplicate. Defining the competitive edge is almost half the game. For example, while cheap labor might be (and currently is) viewed as an advantage, there always will be someone else with cheaper labor. Furthermore, over time, cheap labor

will cease to be cheap and what might have been perceived as a unique advantage will evaporate. On the other hand, a patented process to increase the yield of an acre of land or the throughput of a factory will provide longer-lived advantage and will invariably lead to subsequent improvements, as is often the case in the development of property.

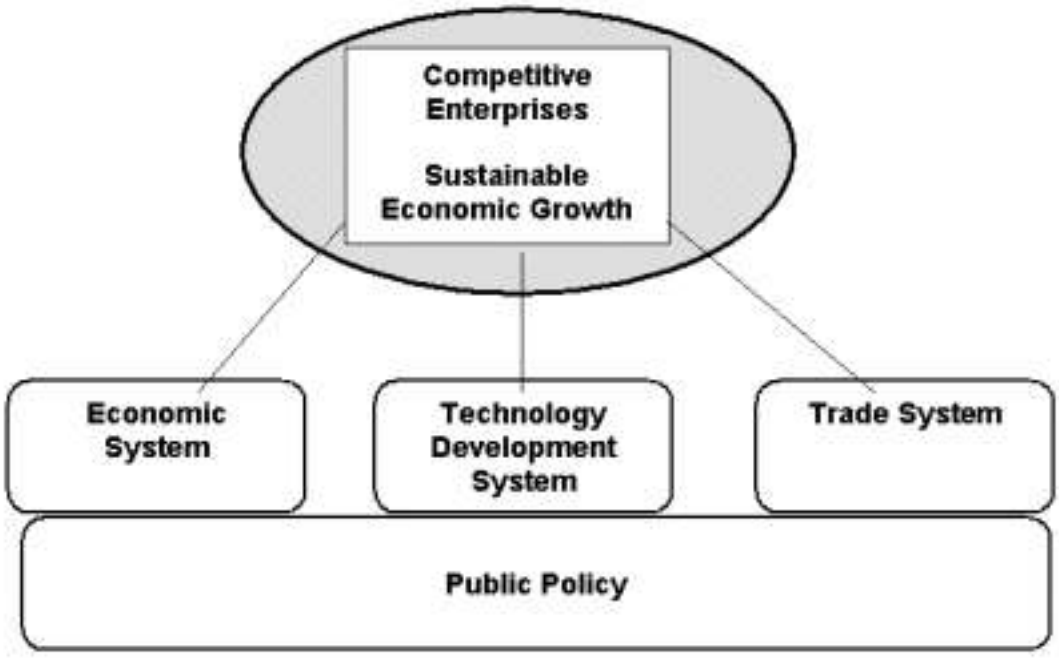
POLICIES IN SUPPORT OF DEVELOPMENT

The proper Management of Technology requires progressive policies in support of technological development. It is a precursor for sustainable economic growth (Berman and Khalil, 1992). The underlying premise is that technology is the most influential factor in a wealth creation system. Wealth creation implies more than just money; it may encompass factors such as enhancement of knowledge, intellectual capital, effective exploitation of resources, preservation of the natural environment, and other factors that may contribute to the well being of government institutions and non-profit organizations. It will also deal with advancing human values, raising the standard of living, and quality of life.

Managing technology implies managing the systems that enable the creation, acquisition, and exploitation of technology. It is assuming responsibility for creating, acquiring, and spinning out technology to aid human endeavor and satisfy customers' needs. Research, innovations, and development are essential components in technology creation and the enhancement of technological progress. However, more important for the creation of wealth is the exploitation or commercialization of technology. It is only when technology is connected with a customer that its benefits are realized. There are other factors that contribute to wealth creation, including capital, labor, and natural resources. For example, capital formation permits investments that form a foundation for economic growth. Labor is another source of economic growth. Social, political, and environmental considerations facilitate or hinder the wealth creating process. Nevertheless, technology is the seed of the wealth creation system. With proper nourishment and good environment, a seed grows to become a healthy tree. Public policy provides the fertile land, environment, and nourishment needed for growth. Management of technology can be considered at two levels: managing at the macro-level of countries or at the micro-level of companies. At the macro-level, it is "concerned with the setting and implementation of policies to deal with technological development and utilization, and the impact of technology on society, organizations, individuals and nature. It aims to stimulate innovation, create economic growth, and to foster responsible use of technology for the benefit of humankind" (Khalil, 1993). At the micro-level of the firm, it is "concerned with the planning, development, and implementation of technological capabilities to shape and accomplish the operational and strategic objectives of an organization" (NRC, 1987).

Economic progress achieved by many countries during the nineteenth and twentieth century, as well as fluctuations in their competitive position with respect to each other, reveals a common thread explaining reasons of successes and failures. Those who had political stability, mustered technology, and properly managed their resources led the pack. A reliance on a three-pronged approach integrating economic, technology, and trade systems gave them a competitive advantage (Figure 2). These three systems can be thought of as the three legs of a stool. Imbalance in any of the legs would create imbalance in the entire system. Effectively managing both the macro aspects and the micro aspects of these three systems is essential. For example, improving the macroeconomic indicators of a country without simultaneous improvement in the microeconomic factors leading to improvement in productivity will not lead to sustainable growth. The same holds true for technology systems and trade systems. Synergy between public policy and the private enterprise system have proved to be very successful in increasing the rate of progress.Economic progress achieved by many countries during the nineteenth and twentieth century, as well as fluctuations in their competitive position with respect to each other, reveals a common thread explaining reasons of successes and failures. Those who had political stability, mustered technology, and properly managed their resources led the pack. A reliance on a three-pronged approach integrating economic, technology, and trade systems gave them a competitive advantage (Figure 2). These three systems can be thought of as the three legs of a stool. Imbalance in any of the legs would create imbalance in the entire system. Effectively managing both the macro aspects and the micro aspects of these three systems is essential. For example, improving the macroeconomic indicators of a country without simultaneous improvement in the microeconomic factors leading to improvement in productivity will not lead to sustainable growth. The same holds true for technology systems and trade systems. Synergy between public policy and the private enterprise system have proved to be very successful in increasing the rate of progress.

Figure 2. System Integration for Economic Growth.



Developing countries striving to improve their economic conditions can learn many lessons from the success of Singapore's effort for economic development. In a speech by Prime Minister Lee Quan Yu during the African Leadership Meeting held in Singapore on November 8-10, 1993, the Prime Minister expressed some of his views pertaining to economic development. Some of the points he made are paraphrased below.

1. Establish/maintain a clean effective government that is well respected by the people. [Officials must have a philosophy based on understanding and appreciation of the development process.] Eliminate corruption and reward officials adequately to protect them from corruption.
2. Avoid internal squabbles for national unity.
3. Build on areas of strength (for example, agriculture or availability of labor force).
4. Encourage savings to increase investment while avoiding external debt.
5. Encourage family projects and local industry to create economic opportunities and keep people from emigrating to large cities.
6. Do not waste spending on huge projects such as maritime, airlines, and perhaps steel, etc.
7. Encourage investment by both small investors and multinationals.
8. Promote education.
9. Develop effective strategies for technology transfer.

Singapore has built its strategy around becoming a regional business services hub in the Southeast Asia region. It serves as a regional marketing and technical support center, a regional financial and business center, and a regional headquarters for multinational companies. It also selected niche industries for specialization, including electronics and computers, ship repair and maintenance, petroleum refining, and aerospace maintenance and repairs (Wong, 1995).

THE ROLE OF GOVERNMENT

The role of government in technological development and economic growth has varied widely based on political and economic ideology. There is no doubt, however, that public policy can facilitate or hinder development effort. The strategic outlook of government agencies, such as the Ministry of International Trade and Industry (MITI) in Japan and the Office Technology Policy (OSTP) and the National Councils on Science and Technology Research of the United States, play a significant role in bringing focus on technological development issues deserving attention by local industry and academic institutions. Governments must formulate national strategy for technology creation, acquisition, absorption, and dissemination throughout its productive sectors of the economy. The individual firm's competitiveness depends on government-enacted rules and regulations in support of business development. These rules and regulations include private investments, tax incentives for technology, transparency of public institutions, government procurement policy, encouragement of indigenous technologies, environmental regulations, and openness to the world information and trade practices. The World Development Report (The World Bank, 1999) discussed in

detail what governments should do in formulating their national strategies. The report indicated that the opportunities for countries and companies to move to better practice for narrowing the knowledge gaps -- within and between countries-- are nothing short of stupendous, and they apply not just to industry but across the entire economy. A very highly influential policy in this regard is that of education and human resource development in general, both at the national level and at the level of the individual firm.

In a training course specially designed by one of the authors for the Egyptian Ministry of Scientific Research, Graham Mitchell, Former Assistant Secretary for Technology Policy at the United States Department of Commerce, suggested that technology policies in developing countries be formulated in three progressive phases as follows.

Phase 1: Development of an Infrastructure Base for Foreign Multinationals -- In this phase, the government should invest in public expenditures on Information Technology, energy supply, and transportation infrastructure. Policies directed towards the creation of attractive investment regimes, including tax incentives, labor incentives, and regulatory investments, are important. Strong effort should be spent in the solicitation of Foreign Direct Investments (FDI).

Phase 2: Building a National Domestic Economy through Foreign Technology Acquisition -- In this phase, public policy should be directed towards formulating appropriate strategies for technology acquisition and setting guidelines for technology transfer. It should also expand tax incentives for technology, provide incentives for use of domestic subcontractors and suppliers, and provide balanced policies for market access.

Phase 3: Development of Indigenous R&D and Commercialization Capability -- In this phase, government funding of R&D can expand including funding of R&D in specific technology sectors. Strong investment in higher education and human resource development is needed. Investment in technology commercialization will also be needed.

In all cases, the formulation of a national technology strategy requires the involvement of well-informed experts and strong integration of all institutions involved in the development effort. Building partnerships with multinational companies, amongst local companies, between companies and universities, and between government, industry, and academia facilitates the creation, acquisition, and absorption of technology.

EDUCATION AND HUMAN RESOURCE DEVELOPMENT

One of the most important elements of an organization's support structure is the quality of education and training its people have access to and are expected to use. Again, policy development in this area has been extensively studied, including the role of public and private schooling, national universities and institutes, technology incubators, etc. We will take this opportunity, however, to emphasize the need for educational systems and curricula, at all levels, that teach students and trainees to analyze, synthesize, and critique. Moreover, students will have to learn how to learn. While this may appear to be a philosophical interjection, it is at the heart of the development of a productive workforce and the change in cultural attitudes and assumptions.

Developing countries, and particularly those in the Middle East and Africa, face the daunting task of having to develop a base of highly qualified men and women who will be able to compete effectively within the newly emerging global market. This is a matter of survival in a competitive world. The competitiveness of a nation will depend, to a great extent, on the brainpower and skills of its population. Human resources development (HRD) assumes a new and crucial role in this environment. Human resource development in less developed countries has to be elevated above the issues of adult illiteracy. It requires a strategy for the acquisition, utilization, improvement, and retention of human resources. It is a strategy that needs to be developed at the national level as well as at the organizational level. At the national level, it requires a strategy to prepare the population to meet the demands of organizations, society, and an improved standard of living. Thus, it involves long-term planning for schools and higher education, vocational education, plans for dropouts, and training needs at the organizational level. It also includes the strategy to meet the needs of an organization in times of changing business environment, increasing complexity, changing technology, skill shortage, migration of the work force, and obsolescence of the work force.

Under the auspices of the Fullbright Commission, the authors conducted two workshops on human resource development in Egypt in June 1998. The workshop objectives were to review current status of human resource development (HRD) in Egypt, to explore new strategies that may be needed to enhance Egypt's HR to ensure sustainable, integrated economic development. Another aim of the workshops was human capacity building as a cornerstone for development. The review included educational, governmental, and business sectors. The following discussion is based on the findings of these workshops and the authors' main experience in the Arab world. Much of this discussion applies to most of the Arab countries.

During the workshops, the following issues were presented as pertinent to the discussion of this subject:

- The changing global business environment and Egypt's challenges in the twenty-first century.
- Industry clusters in Egypt and the growth of the service sector.
- Strategic planning and organization core competency.

- The current practices in HRD in Egypt and the new mandate of human resources in modern and future organizations.
- Intellectual capital and managing professional intellect.
- Productivity and quality improvement.
- HRD for small and medium enterprises.
- The role of distance education in HRD.

The workshop participants included a wide mix of government, public, and private sector representatives as well as representatives from the educational establishment. Attendees were of diversified backgrounds with a good mix of male and female participants. All participants were leaders in their organization's effort to develop human resources.

The workshops were organized to include a series of lectures given by a number of prominent experts and government officials involved in HRD in Egypt and the USA. The speakers came from the highest echelon of government, public sector, and educational institutions. The workshops were also designed to permit full participation by all attendees. Participants were divided into groups and were given defined topics for group discussion. Upon the conclusion of the discussion, each group reported on its findings. All attendees were encouraged to express their opinions and to freely participate in discussions.

Several findings and suggestions came out of the eight days discussions. The following are some of the major areas that seem to require strong attention for developing a competitive workforce in Egypt:

1. The need for a clear vision and a well-defined strategy to deal with HRD.
2. A complete revamping of Egypt's educational system.
3. A strong involvement by the private sector in training for required and necessary skills of the workforce. The skills should be compatible with the needs of the global market as we move into the twenty-first century. Partnership between government and the private sector is essential for the success of the education and training effort.
4. Organizations including government agencies, educational institutions, public, and private industries need a strong reengineering effort in order to be competitive in a global market place.
5. Cultural problems and outmoded concepts that impede the development of competitive HR must be addressed with an intensified national campaign addressing work ethics.
6. Encouragement of creativity, innovation, entrepreneurship, and private-sector initiatives are essential ingredients in any new initiative for HRD.
7. Expanding the use of distance learning and new technologies in education and training must be considered.
8. Government must prioritize its role in investing in people and modern infrastructure while creating a business climate suitable for global competitiveness.

9. There is a need to establish, at the national level, a council to monitor technological changes and to recommend appropriate technology policies in response to these changes.
10. There is a need to establish, at the national and regional levels, centers to conduct research and disseminate information on pressing issues influencing HRD.

The following recommendations pertaining to suitable strategies for HRD came out from participants at the workshops.

Cultural Issues

There are cultural problems and outmoded concepts that impede the development of HR to be competitive in global markets. All potential cultural problems need to be identified. Those should be targeted for programmed interventions through changing educational programs in schools, wide use of the media (TV, newspapers, radio, etc.), and industry training programs.

Examples of areas that need to be addressed are:

- Promoting enjoyment and pride in work.
- Stressing the importance of accepting responsibility.
- Learning to listen and accepting other points of view.
- Promoting creativity and the ability to think freely.
- Removing bureaucracies to accepting change.
- Advocating teamwork.
- Willingness to share, help in promoting organizational objectives, and promoting each other.
- Ensuring fairness in distribution of wealth.
- Following the rules.
- Enforcing the rules.
- Accepting ideas from the bottom-up by managers and top?down by workers.
- Getting out of boxed thinking and preconceived notions.
- Leading by example and starting by improving oneself.
- Educating parents and families in issues of importance to society. Cultural concepts start at home.
- Improving women's education.

Educational Issues

The following recommendations are made to improve the educational system:

- Education should be free from political ideology.
- Educational programs should provide knowledge base and emphasize learning how to learn.

- Student evaluation methodology should be changed. Move towards continuous evaluation and stress the outcome of the learning process, not the exam.
- Move away from memorization-based learning to a free-thinking way of learning.
- Enhance teacher training, remove barriers to change, and restore the dignity of the teaching profession through recognition and incentives.
- Improve school administration. Management training for school administrators is important.
- Move away from heavy curricula and stress quality rather than quantity.
- Promote new methods of delivery, including use of audiovisuals and new technology.
- Enhance resources, including library resources, access to the Internet, etc.
- Execute written policies. Even though many of the problems are known and written in the rulebooks, disconnects exists between written policies and their application.
- Expand extra-curricular activities, including social activities, sports, hobbies, etc.
- Stress science and technology education.
- Stress the importance of languages (English is the dominant language of the Internet).
- Involve parents, industry, and the private sector in sharing the cost burden. Education should not only be a government problem.
- Link higher education to industrial needs and societal needs.
- Evaluate the entire educational system based on outcome.

Organizational Issues

Many issues face organizations in developing countries, and the Arab world in particular, in their attempt to modernize their operations and become competitive on a global scale. Recommendations made in this context are:

- Recognize that people are the most important asset of organizations.
- Expand training programs to enhance skills and permit the workforce to keep up with technological change.
- Partnership should be established between industry and educational institutions for HRD.
- Stress the private sector's strong role in raising the overall skill level of the workforce.
- Management must empower employees and make them feel like partners.
- Organizations need leaders, not only managers.
- Evaluate managers periodically, as is the case with employees, and stress outcome and success of the organization as a measure.
- Make wide use of new technologies and distance education to enhance training programs.
- Reengineer organizations and use established methods for reengineering.

- Decentralize operation whenever possible.
- Include the human resource departments into the strategy formulation and execution of the company.
- Leverage intellectual capital.
- Use human resources to leverage the firm's competencies.
- Training, retraining, and retraining are critical.
- Expand incentive schemes.
- Enhance productivity of workers (through training, incentives, enforcement of rules, etc.).
- Promote investment in people.
- The vision and mission must be clearly established and universally shared across the organization.
- Promote investment in infrastructure.
- Promote investment in technology.
- Train the trainers and the managers.
- Promote creativity and entrepreneurship.
- Small and medium enterprises are a strong vehicle to enhance innovation, create jobs and spin economic growth.
- Use partnerships, alliances, and joint ventures to extend core competencies.
- Multinationals are valuable sources of enhancing the country's HRD effort and for technology transfer.
- Expand training for the service economy.
- Keep track of global changes in the business environment to provide timely response in HRD.
- Organizational structures should provide for flexibility and agility.
- Recognize that technology and its proper management is what create wealth of nations of industry and of individuals.
- Transform the economy from a resource-based, low-tech. economy (minerals, mature technologies, etc.) to a human resource based economy. Use education and training to develop a knowledge-intensive workforce. Expand the value-added service sector (e.g., software, tourism, etc.).

General Policies, Rules, and Regulations

Government's role in promulgating and enforcing rules and regulations is critical to the success of development strategy. In this regard, the following is recommended:

- Simplify rules.
- Reduce government bureaucracy.
- Promulgate rules based on realistic expectations.
- Revamp labor laws, export laws, tax laws, and other regulations related to savings and investments with the objective of promoting competitiveness.
- Establish at the national or regional level centers to conduct research and disseminate information on pressing issues influencing HRD.

Use of the Media

Government should facilitate communication and dissemination of information throughout all regions of the country, including the rural and remote areas. A special effort is needed to make wide use of the media to create a technological society that can compete in the global marketplace.

Identifying the Opportunity

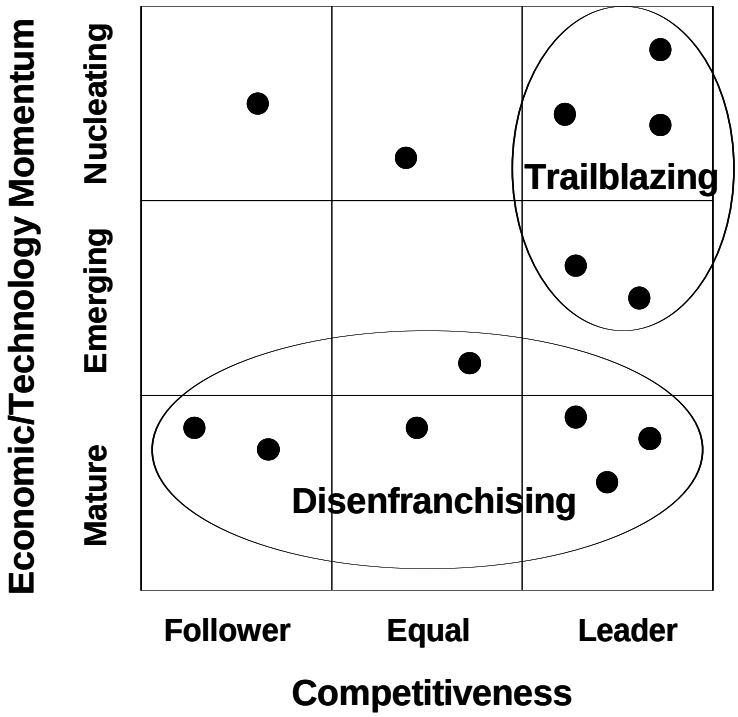
The topic of developing human resources is of vital importance to Egypt and most other developing nations. More similar workshops on this topic should be considered for identification of local issues in individual countries and for human capacity building. However, it is the effective implementation of findings that holds the key to progress in this endeavor.

Many factors come into play as one proceeds into the planning of organizational skills and competencies, and these have been the subject of previous treatments. However, one specifically stands out as worthy of further discussion, particularly when technology is at the very heart of the issue. We refer here to the analysis of the domain of potential opportunities, an approach that happens to fortuitously lend itself to application at different levels of detail and over a fairly broad spectrum.

Such a domain (see Figure 3) can be conveniently divided to reflect economic, technology, social, etc., momentum on the one hand, and organizational, national, or regional competitive posture on the other. For purposes of our discussion, we will view it as a matrix reflecting economic and technology momentum (here being intimately related) and competitive posture. Each of the entries on the matrix (dots) can be viewed as an option, deliberately chosen, to capitalize on. Furthermore, the clustering of the dots can be an indication of (and should reflect) the vision and general strategy of the organization. To exemplify, two clusters are shown. The first indicates a choice of opportunities in which the desire is to be on par or lead in certain areas of mature technology (e.g., focus on innovative applications or the synthesis of solutions to future needs); equally valid is a posture of parity or leadership (even better) in certain economic endeavors (e.g., disenfranchising developed nations of what might appear on their balance sheets as having insufficient added value). Moreover, initiatives which emerge as being followership in mature areas can be identified and discarded, or at a minimum carefully monitored and examined as a potential drain on resources. Furthermore, an occasional "dot" in the emerging or nucleating economy/technology arenas - even as a follower - might provide the core around which future intellectual property and economic prosperity can be grown.

The second cluster, on the other hand, reflects a trailblazing posture, where leadership has become desirable in emerging and nucleating futures. In that situation, and if that is all the choices there are, then one might want to question, because of the risks involved, how viable the short- and mid-term health of the organization will be. The value of profiling the future is that it forces the articulation of the future vision and the current state in clear terms. If benchmarking is used to profile the competition, the process can give insight into their relative strengths and weaknesses, possible strategies, and the formulation of counter-strategies. Equally important, profiling clarifies for all involved what the organization's strategic posture is and how it will evolve, helping to align objectives and harmonize strategies. Taking the process further, one can then determine where in the value chain the organization (national, regional, or global) belongs, where the competency gaps are, and begin evolving the right skills profile and training needed.

Figure 3. Profiling Opportunities.



Responsive Policies are Support Systems

In a fast-changing and fiercely competitive environment, success will rely heavily on effective systems in support of organizational strategies. At the heart of each support system is a set of policies designed to facilitate, regulate, and manage execution and interfaces as the organization is propelled towards its objectives. It is important to note the difference between regulation and control. The former assumes the role of guide and facilitator. The latter is the straight jacket that stifles the organization, invariably becoming the end goal and leading to mediocrity. While clearly some controls need to be in place, the idea is to maintain a delicate balance, keeping in view the final destination and the time of arrival.

SUMMARY

The gap in wealth between developed and developing countries is expected to increase. In order for developing countries to bridge the economic divide, they must develop and adopt appropriate public policies. There are three public policy areas fundamental to the creation of sustainable economic growth: technology, economics, and trade. Responding to the threat of marginalization will require developing countries in general, and the Arab region in particular, to launch concurrent initiatives that will serve as the foundation for formulating these policies.
Policy integration must occur at the highest level of government. The formation of a National Office of Technology Policy reporting to the highest level of government authority is one mechanism to serve in this endeavor. Moreover, priorities will have to be given to the following issues:

Technology Policy

- Technological momentum and competitiveness
- Strategic intent and positioning
- Strengths, weaknesses, and gaps
- Robustness of strategy
- The "right tech" transfer

Economic Policy

- Monetary policy
- Generation of growth capital and participation of local small capital
- Regulation of capital markets
- Selective sector targeting
- Job creation
- Self-sufficiency and vertical integration
- Barriers to entry
- Entrepreneurship

Trade Policy

- Free trade versus protectionism
- Quality as a value
- Intellectual property protection

It is also evident that countries that have inched ahead, at a faster pace, in their development efforts have adopted clear public policies in specific areas known to support economic and societal growth. The Arab Countries must do the same by implementing the following set of actions:

- The countries must heavily invest in education and human resource development
- Improve technology management
- Increase government support for R&D
- Support innovation
- Foment closer coordination among scientists, engineers, and policymakers
- Strengthen universities to be central to the entire research enterprise
- Create an Arab and Afro-Asian common market and seek to increase the lead in the global market
- Eliminate bureaucracy and create an environment facilitating business investments

It is anticipated (almost a certainty) that several iterations will be needed until acceptable closure can be reached on any of the above issues. It will also become essential that the results withstand rigorous tests for internal consistency and alignment. Finally, there are two givens: speed, which is of the utmost importance; and flexibility, which provides opportunities to change to meet changing realities. The one thing that one can conclude with certainty is that the future will be very dynamic and highly nonlinear. This will no doubt place developing countries at the risk of being marginalized within the global order. The serious consequences of such a possibility, however, can be viewed as the opportunity to drive change and hence propel countries and organizations toward growth and prosperity.

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Networking for Technology Acquisition and Transfer

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Contents

Networking for Technology Acquisition and Transfer [1]

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Summary

The importance of technology is widely recognized. World Development Report 1991 states that productivity growth, the best proxy for technology progress, accounted for as much as 30 percent of GDP growth in the East Asian countries. Thus, technology is the engine of growth.

This technology changes the paradigm of economic activities and networking. Because of the advancement of technologies of information, communication and transportation, technology fusion, the acceleration of technological innovation and science orientation, market competition becomes wider and harder despite easier market entry and networking becomes more international, inter-sectoral and inter-institutional.

Technology also changes the mode of technology transfer and technology strategy. Any entity can easily access to available technology worldwide; and technology transfer becomes easier and more formal since some portion of tacit knowledge is codified and stored using information technology and microelectronics technology. For technology strategy, national strategy places more emphasis on private sector initiative; and corporate strategy becomes more comprehensive including the functions from procurement to marketing and network-oriented.

Technology acquisition from overseas is important especially for developing countries. The means of technology acquisition from overseas ranges from foreign direct investment (FDI), the most comprehensive one, to licensing. A suitable means depends on the condition of a recipient country. To facilitate technology acquisition from overseas, various policy efforts are required from macro economic policy to education policy.

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1 This paper is largely based on Kondo (1998).

Though technology acquisition from overseas is important, it is only one part of technology development. Technology assimilation and domestic diffusion is necessary for full use of acquired technology. It is not easy to assimilate foreign technology. Based on these experiences, a company or a country develops its own technology.

To utilize all technological capability for industrial development, collaboration among industry, universities and public research institutes is necessary. This necessity is stronger these days because technology has become more science-based and the size of corporate laboratories is shrinking. However, changing the culture of universities and public research institutes and their systems is never easy.

Finally, the paper points out that networking is indispensable and that domestic efforts and conditions determine the country performance of networking.

1. Technology as the Engine of Growth

Importance of technology for development is widely recognized. In industrialized economies, many studies have shown that more than 50 percent of long-term economic growth stems from technological changes that improve productivity and lead to new products, processes or industries.[2] In the East Asian countries, productivity growth, the best proxy for technology progress, accounted for as much as 30 percent of gross domestic product (GDP) growth.[3]

Technology progress is the key to international competitiveness and economic growth. Of four inputs to production--capital equipment, raw materials, labor and technology--, technology is the only one that is not physically limited. Though it seems that employing a large quantity of capital equipment increases productivity, it is not necessarily so.

The importance of technology is seen when considering a production function. This function omits raw material as an input and takes value added as an output. Technology is the only source of output increase without increasing capital or labor as inputs. Wealth is increased by technology.

$$dY/Y = dT/T + a\, dK/K + b\, dL/L$$

dT: total factor productivity increase (technology progress)
dY: output (value added) increase
dK: capital increase
dL: labor increase
a, b: coefficients where $a + b = 1$.

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2 See Kim (1997).

3 See The World Bank(1991), page 88.

Technology is also important to think of labor productivity as follows.

$$dy/y = dT/T + a\, dk/k$$
where $y = Y/L$ and $k = K/L$.

Thus, a labor productivity increase rate is determined by a technology progress rate and an increase rate of a capital per labor ratio. As far as capital investment in the form of foreign direct investment (FDI) and others continues, labor productivity increases. However, it will not last long as Paul Krugman warned the East Asian Miracle in his paper.[4]

Technology development is also vitally important for the world from environment consideration. Technology development saves energy and resources through productivity improvement and quality improvement. This will lead to the reduction of green house effect gases and will realize sustainable development. Productivity improvement directly reduces energy and materials used to produce the same amount of products. Quality improvement reduces energy and materials by reducing the number of defects and readjustment in the production process. Quality improvement reduces losses after shipment as well by avoiding the transport of defect products, the check of products at the next customer and the assembling of products containing defect components.

Good news for a country under industrial development is that it has a great potential to make technology progress. Technology progress is rapid at the early stages of economic development. In Japan, a technology progress rate, or a total factor productivity growth rate, was high in the early 1960s when Japan was developing and became lower to one seventh of that in the late 1970s and early 1980s as its economy matured (Figure 1).[5] This fact implies that technology strategy needs to be modified according to the stage of development[6].

2. Paradigm Shifts Caused by Technology

2.1 Economic Activities and Networking

Technology development has, on one hand, changed the mode of market competition. Because of the development of information technology, communication technology and transportation technology, we now live in a borderless economy and face global competition (Figure 2).

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4 See Krugman (1994).

5 See Ministry of International Trade and Industry (1988), pages 11-13.

6 Technology strategy changes as a country develops. See Kim and Dahlman (1992) and Chapter 5 of Kondo (1998).

The mode of technology development has, on the other hand, changed. Technology fusion, such as mechatronics, is occurring. An industry sector needs to work with another industry sector. A competitor may appear from unpredictable industry sectors. This change fosters inter-industry or sectorless competition and collaboration.

The speed of technology development has been accelerated and life cycles of products have become shorter. One company alone cannot afford to conduct R&D (research and development) in various fields speedily. Companies need to find collaborators because of R&D resource limitation.

Technology itself changes as everything changes except changes. Technology has become more science-based especially in high-tech areas. This change compels companies to work with universities and public research institutes.

Thus, technology has changed the paradigm of economic activities. At the economy level, borderless economy appears; at the industry level, sectorless competition and collaboration appear; and at the firm level, corporate boundaryless business appears.

Networking is functioning accordingly. At the economy level, international networking in the area of R&D takes place vigorously (Figure 3)[7]. Except the United States, companies in many countries ally with foreign companies. At the industry level, companies in different industry sectors and researchers in different technology fields collaborate in R&D[8]. At the firm level, companies cooperate with other companies and with universities and public research institutes. Real business takes place in the domain where multiple players work together.

In Japan, a special policy was formulated to facilitate networking among small-and-medium-size enterprises (SMEs) in different industry sectors. This policy is called "Igyoshu Koryu Plaza (Inter-sector Exchange Plaza)" and has been successful (See Box 1).

2.2 Technology Transfer

Technology transfer is largely influenced by the technology development and changes of technology described above. Access to the information of technologies has become much easier thanks to the development of information technology and communication technology worldwide. However, the situation is the same for anyone. We need to learn how to find right information quickly.

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7 See DTI(2000).

8 See Kodama (1991) for inter-industry competition and technology fusion.

Technology is defined as follows. Technology is knowledge necessary to design and/or produce a product or a set of service retained by an individual or an organization. It can be embodied in machinery and other products or service. This knowledge, resulting from accumulating experiences in R&D, design, production and capital investment, is mostly tacit, that is, not made explicit in any collection of blueprints and manuals. Only a part of that knowledge is codified in manuals and blueprints.

Whether knowledge is codified or tacit relates to the characters of that knowledge. As shown in Table 1, knowledge is codified if it is expressed in a digital form or in software or is science-based. It is tacit if it is expressed in an analog form or in hardware, or is skill-based.

These days knowledge has become more codified. Since technology has become more science-based, knowledge to be transferred in technology transfer has become more codified and can be expressed in documents. Since information technology has advanced coupled with microelectronics technology development, knowledge is stored in software or microchips. This phenomenon also makes knowledge more codified.

Thus, technology transfer needs less human involvement nowadays since tacit knowledge transfer requires human involvement. This implies that technology transfer has become easier in a sense and more unified.

However, knowledge related to analog character, hardware or skill-based, tacit knowledge plays an important role. In Japan, technology transfer is carried out through human transfer in many occasions[9]. Tacit knowledge, which is hard to transfer without human involvement, gives a person or a company competitive advantages.

3. Changed Technology Strategy

Technology is changing and innovation means changing. The ever-changing efforts are required for firms and governments to make use of technology and innovation. The accelerated innovation requires quick response and constant "strategy innovations" for firms and "policy innovations" for governments (Figure 4).

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9 See Kusunoki and Numagami (1997).

3.1 National Technology Strategy

3.1.1 From Public Initiative to Private Initiative

In the former days, R&D mission was clear and the public sector took initiative and developed technology itself to some extent. However, the mission is now diversified and it is difficult to determine. The private sector knows market needs better since companies operate in the market and compete each other everyday. Thus, the private sector should be a main player of technology development. Technology development mode needs to be shifted from technology-push to market-pull.

In order to do so a more vigorous national strategy is needed to develop R&D capability in the private sector because R&D capability is concentrated in public sector in most of developing countries. It is needless to say, however, that a public role is definitely important to assist and complement the private sector R&D. The government is responsible for intellectual property right (IPR) protection to facilitate private R&D and technology import, constructing science and technology databases that are public goods, setting standards for facilitating industrial networking and so on.

Though science and technology policy in developing countries places a strong emphasis on public R&D, supporting services are increasing their roles. Though public R&D is surely needed to assess and assimilate technologies acquired and is needed in some areas, such as environment and safety, more resources and policy attention need to be oriented to supporting services such as testing, consulting, information provision and training.

Upgrading the average level of industrial technology of a country is an acute problem. However, supporting institutions to improve technological level are not well developed in developing countries. Even the United States developed extension service organizations through Manufacturing Extension Partnership (MEP) Program, which modeled itself on the Japanese Kosetsushi system (see Box 2).

3.1.2 From 'Research for Research' to 'Assistance for Industry'

It is commonly seen that science and technology policy in developing countries places a strong emphasis on R&D. For R&D, faculty members and researchers, many of whom are trained overseas, have a stronger linkage to international scientific community than to domestic industry and most of research seems to aim at producing papers in academic journals. More resources and attention need to be oriented to industry. A country cannot afford to allow researchers to enjoying a paradise in their circles. Researchers need to contribute to economic development of the country in the age when competition is global and technology is a critical element of competition.

Another common phenomenon seen in the developing countries is emphasis on science. This is partly due to the fact that scientists are respected and influential and the fact that engineers are not influential yet. Science is indeed important for education and a basis for technology development in a long run. However, a country needs to meet more immediate technology development demands to compete in an international market. Policy emphasis needs to be shifted from science to technology since science differs from technology (Figure 5).

Policy emphasis also needs to be shifted in education between science and engineering. Resources need to be shifted from science departments of universities to engineering departments or technology institutes to support technological development of a country, although the demarcation between science and technology is blurred in some areas such as biotechnology.

3.1.3 From General Financing to Tailored-For-Technology Financing

Changes are occurring in financing, too. Conventional loans are risk aversive and technology assets are not safe as collateral. Thus, new risk financing schemes are emerging. One is a form of venture capital. A government needs to assist this new scheme to be developed.

Another is a form of conditional loans. A government needs to provide conditional loans to risky technology development projects in addition to conventional loans. Or a government provides R&D grants such as Small Business Innovation Research (SBIR) Program in the United States.

Moreover, traditional financial institutions do not possess proper capabilities to assess technology assets. It is also needed to establish new financial institutions that are technologically capable and are specially catered for technology-related risk financing.

3.1.4 From Formal Education/Training to Practical Education/Training

Education also needs some changes. In the former days one-time education was enough. Knowledge needed after education could be acquired by individual efforts and on the job experiences. However, as technology increases its speed of development and its knowledge content, it requires more systematic continuing education for people to catch up with ever changing technology. Education is changing from one-time education to lifetime continuous learning. A national strategy needs to assist develop the change of a formal education system and informal training or learning institutions.

Though higher education is important, at the same time, basic education and vocational training are important to secure the basic level of industrial technology of a country as seen in East Asian countries until basic education becomes pervasive.

Training also needs to be changed. Firms know their training needs best. In Japan, in-house training is common and extensive based on a long-term employment practice. Public training may provide generic training but not tailored for each firm or each industry. Moreover, once a public institute is established, its management is rigid. It is not easy to change trainers and machines for training frequently, though technology changes quickly and firms need to equip with up-to-date technology to compete internationally. Thus, training needs to be shifted from public-led training to firm (or industry)-led training. When training is done in firms, their up-to-date machines can be used for training and their senior workers act as trainers. One training institute in Malaysia provides a good example of industry-led training (see Box 3).

3.2 Corporate Technology Strategy

3.2.1 From Self-Reliance to Networking

A major change in corporate technology strategy is from self-reliance to networking. Technology development activities were mostly conducted in-house in the former days. However, in-house development only is not enough to cope with the accelerated speed of technology development and with a new and wide range of technologies. Thus, firms need to seek partners for technology development to complement quantity and quality of engineers. They make strategic alliance with other firms[10], sometimes even with competitors. They also cooperate with universities and government institutes. They need to compete not as an isolated point but as a node of a network. Networking partners are not only domestic partners but also international.

Firms also make an international alliance to establish de facto standards of new products. When a firm develops a new generation product, the industrial standards of that product largely determine the competitiveness of that firm. If the specification of the type of a product that firm is developing is adopted as an international standard, it will give a strong competitive advantage to that firm. Otherwise, that firm will lag behind in an R&D race of that product and needs to pay a large amount of royalty to a firm whose product specification is adopted as an international standard.

Also for production, firms need to compete as a network. This strategy gives flexibility and agility of new product production as far as partners deliver quality products just in time. Subcontract arrangement based on a long-term relation has been largely seen in the Japanese assembling industries. Work specialization and sharing network is seen in the Italian fashion industry. Today, this kind of production network is worldwide. Some firm has only design and marketing function. They are fabrication-less companies.

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[10] See Kondo (1995) for the increase of joint patent application in the 1980s in Japan.

For firms in developing countries, it is quite advantageous to be in the international production network. They may be original equipment manufacturers (OEMs), subcontractors or subsidiaries. They can access to or are exposed to foreign technology, management skills and marketing information constantly.

3.2.2 From Single Approach to Comprehensive Approach

Borderless economy inevitably creates mega-competition; and this mega-competition has changed the mode of competition. Beforehand operational competition was mostly based on price because competitors were basically domestic and their product quality was similar. For timely delivery, old logistics management and transportation did not allow speedy production of ordered products. Thus, competitors pursued competitive advantages through economies of scale or other means to lower price.

Now operational competition is based on speed, quality and function in addition to price. Thanks to the advancement of information network and transportation network, buyers and consumers can obtain product catalogues quickly, order instantly and receive products timely. Since customers are accustomed to getting products that they want quickly, they change their tastes for goods quickly and prefer to have new differentiated goods from others. Thus, the time required from design to delivery also needs to be shortened. In Mauritius and Cyprus, fashion sensitive fabrics are sent by air from Europe.

For quality, many competitors from the world provide different qualities of goods. Then, buyers and consumers are conscious about product quality. In addition, an international market, especially European market, requires suppliers to be certified as ISO 9000 factories. ISO 9000 is a set of industrial standards for quality assurance systems developed by International Organization for Standards (ISO). Thus, quality is an important factor of competition.

Because of accelerated pace of innovation, products with new features and functions appear quickly. In addition, the information of new products travels quickly via Internet and other means. Thus, the function or feature of a product is an important competition factor.

The situation changed for innovative competition, too. Beforehand product development only sufficed in many cases. A new product usually enjoyed its monopoly for a while. However, these days new competitive products quickly appear from some corner of the world and from another industry due to the accelerated pace of innovation and high speed of information diffusion. Thus, a product development cycle of idea creation to market entry needs to be shortened.

Moreover, a total procurement-product-delivery system should be strategically designed from the product development stage. Factors from design to input material procurement and to production and delivery need to be considered to capture profits in a short time and to construct operational competitiveness from the beginning of a new product launch. A business model development is also needed at the time of product development in some areas.

Because of network production and combined usage of products, standards and interfaces are critically important. Firms try to have an initiative in standards setting and interface setting. De fact standards strategy or interface strategy needs to be formulated at the product development stage.

4. Technology Acquisition from Overseas

4.1 Technology Acquisition

Technology acquisition from overseas, technology import, plays a more important role at the early stage of economic development than at the later stages, while domestic technology development increases its importance as an economy develops. Many developing countries largely benefit from importing readily available technologies from abroad to complement their technological capability. As late comers, they can use already-established technologies existing overseas. In Japan, the role of technology import was large at the early stage of its economic development and diminished as it developed. In the early 1960s, technology import payment occupied 14 percent of total technology expenditure, which was the sum of domestic R&D expenditure and technology import payment; however, it decreased to 7 percent in the late 1970s (Figure 1).[11]

To acquire technology, a certain level of technological capability is needed. An entity to acquire technology from abroad first needs to know where to seek candidates of technology to be imported. Then, it must assess each technology and compare those candidates. This kind of capability is often lacking in the firms of developing countries.

In searching technology, there is a structural problem in the market to make the situation worse. Technology market is essentially incomplete. A seller does not want to give details because technology is essentially information. A buyer cannot get enough knowledge of that technology and of required conditions to utilize that technology.

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[11] See JITA (1986), page 9. Technology import payment is only for patent licensing, know-how transfer and technology services.

Technology transfer can occur between various types of entities: from university to university, from research institute to research institute, from firm to firm, from university to research institute, from research institute to firm, from research institute to university, from university to firm, from firm to research institute, and from firm to university. However, commercial industry-related technology transfer occurs from firm to firm. To use imported technology for industrial development speedily, the private sector should take an initiative to acquire technology from overseas. Other routes are mostly non-commercial technology transfer routes. They are academic exchanges and official development aids (ODA). They are rather R&D cooperation rather than technology transfer.

4.2 Technology Acquisition Means

There are various means to acquire technology from abroad (Table 2). A comprehensive form of technology acquisition is FDI. FDI brings in not only technology but also management skills and market connections as well as capital. Similar comprehensive means is build-operate-and-transfer (BOT) arrangement. Foreigners build, manage and operate plants or other large projects until they recover their investment. Means like own equipment manufacturer (OEM) arrangement, own design manufacturer (ODM) arrangement and parts production subcontracting also accompany technology import[12]. Subcontractors supply technical specification at least. They sometimes provide production methods, know-hows and technical assistance and designate exact types of production equipment and input materials.

In China, a variation of OEM, cooperative production is exercised. Chinese firms receive technology from contractors from overseas and produce products for them. Chinese firms also produce products under their brands using the same technology for domestic market and a small number of designated countries. They do not pay royalties but provide products at lower price to the contractors under OEM arrangement. Therefore, this is a combination of OEM and restricted licensing.

For a tangible form of technology acquisition, importing turn-key-plants is the most comprehensive. Importers only need to operate based on manuals. Other tangibles to be imported include capital equipment, products, such as molds, and parts and raw materials. Based on product import, copying and reverse engineering can be performed.

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[12] Subcontracting means a contract to produce some part of an assembled product or the assembled product itself for other company's brand. OEM is a type of subcontracting providing a complete assembled product for other company brand based on a provided design. ODM is similar to OEM except detailed design done by a subcontractor.

For an intangible form of technology acquisition, there are forms of licensing, know-how transfer and technology services. Other intangible forms of technology acquisition are consulting service, information service and subscription of journals and the purchase of other documents. These activities are mostly related to information purchase.

Human exchanges also bring in technology. Foreign experts are hired to transfer technology. In the late 19th century Japan hired many foreign experts; and their salaries were higher than those of ministers in some cases. Studying and training overseas is a good means to absorb technology overseas. Just visiting foreign factories and attending international fairs also provide good opportunities to get to know foreign technology.

To facilitate and promote technology acquisition from overseas using various means described above, policy efforts are required. Policy instruments used depend on an acquisition means. For a comprehensive means, such as FDI, even a macro economic policy is important (Table 3). For a specific means, such as licensing, a particular technology policy, such as IPR protection, is important.

4.3 Comparison of Technology Acquisition Means

To acquire technology from overseas, different countries adopt different means such as FDI, OEM and licensing. For example, Japan mostly used licensing and technology services, Chinese Taipei used OEM and other types of subcontracting and Singapore and Malaysia used FDI.

There are clear differences among those acquisition means. Each of the three means has both advantages and disadvantages (Table 4). FDI requires only basic skills and brings in capital, management skills, market link and technology. To start industrialization, FDI is the easiest way to enter an international market though basic infrastructure and political and macroeconomic stability are needed. However, management decision is entirely in foreigners' hands and may be foot-loose. If labor cost increases, FDI may move to lower labor cost countries. FDI usually does not invest in deepening technological capacity of local subsidiaries unless local subsidiaries become world centers of some products.

OEM or other types of subcontracting are widely used to acquire technology and market. OEM involves various levels of technology transfer from providing blue prints and specification of products only to providing production machinery, know-hows, key input materials and worker training. OEM accompanies licensing in many cases. The subcontracting in Japan sometimes accompanies financing as well as technical assistance. Assembling firms sometimes provide financing for new production equipment to produce parts for them.

OEM requires existing companies to possess capital and management capability including production management capability.[13] Since market is provided, the risk to start business is small but profit margin is also small. Management decision of a subcontractor affects the management of a subcontractee largely. An OEM manufacturer has an incentive to move to ODM and own brand manufacturing (OBM) to increase profit margin and gain management autonomy. The possibility of future growth is fairly large.

Licensing brings just technology. Sometimes licensing is just paying royalties. A firm is capable to produce a certain product without further information but it has to pay royalties because of a patent right owned by the other firm. Licensing requires high management and technology potentials for licensees. Even though licensing provides more elaborate technical assistance, a licensee must have or create a market access and bear the whole business risks. If a licensee markets products successfully, its profit margin is large. Since a licensee possesses management autonomy, it has a great incentive to make efforts to develop technology and a high possibility to grow.

The choice of technology acquisition strategies differs depending on technology capability of a recipient country. As noted above, FDI requires the lowest technology capability and management resources; licensing requires the highest technology capability.

The time a country starts industrial technology development also affects the choice of technology transfer strategies. The earlier the timing was, the role of foreign sources was smaller. In the older days it was easier to protect domestic industries from the view of international political economic environment and it was not easy to find right sources and transport their products quickly because telecommunication and transportation were not well developed. Thus, licensing was a good strategy option provided that a recipient country had certain technological capability to assimilate acquired technology.

Now the situation has changed. A single international market is emerging because of the World Trade Organization (WTO) and the development of telecommunication and transportation; and domestic market protection to foster domestic technology capability is more difficult. At the same time, international market access is needed to acquire information of customer needs, technology and suppliers. Moreover, it is getting more difficult to get license from overseas.[14] Firms in developed countries are, on one hand, reluctant to transfer just technology. They prefer to export their products themselves or to invest overseas to get more profits. Because of a Mega-Competition, it has become easier to manage worldwide trade and operation of business. On the other hand, firms in developing countries prefer to enter the international market quickly. Thus, FDI and OEM and other types of subcontracting are more plausible strategy options these days.

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[13] See Hobday (1997) for benefits and disadvantages of OEM/ODM in South Korea.

[14] See Dahlman et al. (1995).

5. Technology Acquisition and Technology Development

5.1 Three Modes of Technology Development

Three ways can be considered to improve technological level of a country:

(i) Introducing technology abroad,
(ii) Improving existing technology and
(iii) Developing new technology indigenously by formal R&D or production experience.

This section proposes a progressive model of technology development (Figure 6). This model progresses from acquisition to assimilation and diffusion to indigenous development (improvement and innovation). These modes exist at the same time in an economy, though the emphasis on each mode differs from an economy to an economy depending on a development stage and strategy[15].

Though all the three modes of technology development need to exist, at the early stage of development, technology acquisition is most important. That is, technology transferred from overseas is a major source of technology in developing countries. An assimilation mode is also important to fully utilize imported technologies. Then, this technology is utilized in developing countries. Finally, this technology is improved and based on this technology new technology is developed. Of course technology is developed from other sources such as findings in universities.

5.2 Assimilation of Acquired Technology

Assimilation is usually achieved to a certain level if a technology is acquired through comprehensive means. In this case, a technology supplier makes sure that an imported technology work for its own sake. The technology supplier will lose profits or reputation if a transferred technology does not work.

Using imported technology through licensing is, however, not easy. It took a longer time and required higher R&D cost to develop a new product with imported technology than with in-house technology in Japan, though revenues from new products with imported technology were large. It took, on average, 2.50 years and 680 million yen at the 1963 price to develop a new product with imported technology, whereas it took, on average, 2.35 years and 170 million yen with in-house technology (Table 5).[16]

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[15] Dahlman and Brimble (1990) used an analytical framework of acquiring foreign technology, using and diffusing technology, improving and developing technology and investing in technical human capital. Bjerke (2000) says that Japan progressed in the following order: imitation, improver, improviser, innovation and invention.

[16] See Agency for Industrial Science and Technology (1963), page 11.

Japan's experience demonstrated that technology import must be accompanied by domestic R&D to assimilate the imported technology. In Japan, domestic R&D expenditure paralleled the increase of technology import from the early 1950s.[17] Domestic R&D does not mean scientific research conducted in universities or national research institutes. It means, rather, to experiment in firms with what technical documents state, changing some parameters or downsizing the scale of plants to adapt imported technology to domestic conditions. It means to experiment with ideas like Columbus' egg to make incremental innovation based on imported technology.

In the initial industrializing phase, R&D is needed for assessing and selecting foreign technologies to be imported. This role is expected for public research institutes to play making use of their international connections, though they sometimes conduct research for themselves isolated from industry. Public research institutes and universities are expected to assist firms to solve their technical problems or refer some specialists in other places. Equipment suppliers and input material suppliers are also helpful in solving technical problems.

6. Networking among Industry, Universities and Public Research Institutes

Within a country, technology transfer from universities to firms and from research institutes to firms is important to utilize domestic technological capability for industrial development. In these technology transfer activities, universities and research institutes also benefit from collaboration with the industry.

There are various ways to facilitate collaboration among the industry, universities and research institutes. In Japan national projects are organized to develop technology mostly between the industry and public research institutes. The Very-Large-scale Integrated Circuit Research is one of successful examples.

These days, Japan makes tremendous efforts to facilitate the collaboration between the industry and universities. The Ministry of Education established "venture business laboratories" to encourage business-oriented research on campus, collaborative research centers to facilitate university-industry research. The Ministry and the Ministry of International Trade and Industry provide research grants to university-industry collaborative R&D projects and assist establishing technology licensing organizations (TLOs) that license university patents to the industry.

Active university-industry collaboration is seen research papers. Co-aurthorship between university researchers and company researchers is increasing[18]. The collaboration is naturally stronger with domestic universities than foreign universities.

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[17] The correlation coefficient was 0.9848. The data were obtained from JITA(1986), pages 6-8.

[18] See Pechter and Kakinuma (1999) for the increase of university-industry coauthored papers in the 1980s and 1990s in Japan.

Now, a new mode is appearing in Japan. As seen in the United States and other countries, some Japanese professors and students start up companies. Also, some researchers of public research institutes start up companies. The government encourages these activities.

Regional initiatives are also seen in Japan. Kochi prefecture is one of the least developed regions in Japan. The governor of Kochi prefecture established a university of technology to develop manufacturing and software industry. Many professors were recruited from industry. The university has a liaison office and rental laboratories on campus to conduct university-industry R&D. To promote university-industry R&D, research parks or incubators are needed to make firms more accessible to universities and research institutes. Research parks provide better environment for firms to establish their research institutes in the vicinity of universities or research institutes. The university also provides entrepreneurship education to graduate students and holds short courses for the public. Several professors and students have started up companies.

Increasingly important aspect of R&D in developing countries is cooperation among R&D institutions. Since R&D capability is weak in the private sector in developing countries, cooperation between firms and public research institutes or universities and cooperation between multinationals and local suppliers are important for technology development.

To encourage the collaboration among the industry, universities and research institutes in developing countries, the mission statements, funding schemes and evaluation criteria of universities and research institutes must be in that way. Developing countries must avoid one of the biggest technology policy pitfalls found in developing countries, that is, science promotion under the name of technology development.

7. Concluding Remarks

We live in the global age and we can exchange information and goods worldwide easily. We also travel easily. Thus, international networking is easier. Because of the change of the character of technology development, inter-industrial-sector networking and inter-institutional networking are also occurring.

Any country or firm can make use of networking to enhance its competitiveness. There are two points to make. One is that this opportunity is open to any country or firm. If a country or a firm does not make use of networking, it will be disadvantageous. Thus, there are no choices whether a country or firm utilizes networking. The other point is that for some networking national or regional networking is more important than international networking as seen in the case of university-industry collaboration in paper writing. Thus, national or regional efforts are critical for networking.

The issue is how to facilitate and support networking. The strategy may differ from country to country. However, there exist a large number of experiences to learn both in developed countries and developing countries. We can access to the valuable information of these experiences thorough networking.

Box 1. Igyoshu Koryu Plaza (Inter-industry-sector Exchange Plaza)

This policy is formulated by Small and Medium Enterprise Agency, the Japanese Ministry of International Trade and Industry, to assist small-and-medium-size enterprises (SMEs) jointly to develop new products or new businesses complimenting each other mainly in the area of technological capability. In 1988, the time-limited Fusion Law was enacted to officially support cooperatives consisting of SMEs from different industry sectors.

This policy was well used. Until the end of 1997, 317 cooperatives with concrete business ideas were established based on this Law and received public assistance. Nearly 3,000 groups consisting of nearly 125,000 SMEs participated in this activity in 1997[19].

These groups are organized locally with some coordinators. Local chambers of commerce and industry could be coordinating agencies. One member from the same industry sector is admitted in one group to avoid conflicts. Members freely discuss issues and ideas they have and sometimes visit their factories. Occasionally, some of members come up with new business ideas and they eventually establish a cooperative to develop new products.

Box 2. Kosetsushi (Public Research Institutes) of Japan

In Japan, all prefectural governments and some municipal governments operate public research institutes called "Kosetsushi", which means public testing laboratories. There exist 602 such laboratories in 1999. Though the majority of them are for agriculture, a substantial number, 185, of them are for the secondary industry.

The main mission of these laboratories used to be testing and measurement to issue certifications. It has shifted to R&D. At the same time, these laboratories consult local small-and-medium-size enterprises (SMEs) and provide solutions to their technical problems.

Also, they function as the information gateway of SMEs. When the laboratories can not provide enough information, they contact national research laboratories and universities. They are in such a network.

The US Federal Government found that the extension service function of Kosetsushi is valuable. It started Manufacturing Extension Partnership (MEP) Program cooperating with State Governments. According to an evaluation study, the survival probability of the SMEs that received MEP service was higher than that of the SMEs that did not receive MEP service.

19 See Small and Medium Enterprise Agency (1998).

Box 3. Penang Skill Development Center (PSDC)[20]

This PSDC is basically managed by large local firms with the supports from a local government. Its land and building are provided by the local government, but the Center is essentially managed by managers of the large local factories. Those managers decide training curricula.

The management is efficient and training fees are around half of those of commercial institutions. Training equipment is leased, sometimes without charge, from equipment vendors to the factories in that region. As the center functions as a showroom of equipment vendors, the newest models are set all the time. For trainers they are hired on a term-by-term basis to meet changing demands from local firms.

This institute meets the needs of local industry at an affordable training fee and keeps flexibility of training curricula through public-private collaboration.

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20 See Kondo (1999).

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TABLES

Table 1. Knowledge Classification

	Codified	**Tacit**
Form	Digital	Analog
Medium	Software	Hardware
Base	Science-based	Skill-based

Table 2. Technology Acquisition Means

	Comprehensive	**Tangible**	**Intangible**
Means	• FDI • BOT • OEM • ODM • Subcontracting	• Surn-key-plants • Capital equipment • Products such as molds • Products for reverse engineering • Parts and raw materials	• Technology import • Licensing • Know-how transfer • Technology service • Information purchase • Consulting service • Information service • Journals • Human exchanges • Attending fairs • Hiring foreign experts • Overseas study and training

Table 3. Policy Instruments For Technology Acquisition

Means	Policy Instruments
FDI (Foreign Direct Investment)	Macroeconomic stability Political stability IPR protection Information service Information centers Information telecommunication network Network creation Promoting agencies for FDI Administrative services One-stop-office (FDI and business start-up) Work permit administration Custom clearance system Business support services Umbrella scheme Ports, airports and roads Industrial estates Lease factories Tax holidays Special economic zones Nno foreign capital ratio regulation No limits on overseas remittance of profits No limits on the ratio of IPR value in equity
BOT (Built, Operate and Transfer)	Macroeconomic stability Political stability No limits on overseas remittance of profits
OEM (Own Equipment Manufacturer) ODM (Own Design Manufacturer) Subcontracting	IPR protection Commercial legal system Training service Training institutes Information service Information Centers Accreditation and certification service National MSTQ system especially for ISO 9000 Networking service Promoting agencies for exports Administrative service Custom clearance system Ausiness support service Information telecommunication network Ports, airports and roads

Technology import Licensing Know-how transfer Technology service Information purchase Consulting service Information service Journals	Market competition IPR protection Commercial legal system Consulting Network creation Public research institutes as technology transfer agents Information service Information Centers Administrative services Proper technology transfer administration Tax incentives including reduced tariff rates Matching grants for information purchase and consulting Royalty rate regulation and remittance overseas
Human exchanges Attending fairs Hiring foreign experts Overseas study and training	Market competition Network creation Export promoting agencies Information service Information centers Administrative services Work permit administration Tax incentives Matching grants for attending fairs, hiring foreign experts and overseas study and training
Tangible imports Turn-key plants Capital equipment Products Input materials	Market competition Network creation Information service Information Centers Administrative services Custom clearance administration Tax incentives including reduced tariff rates Local content regulation

Note. IPR: intellectual property right.
MSTQ: metrology, standards, testing and quality.

Table 4. Comparison of Means of Acquisition

	FDI	OEM and Subcontracting	Licensing
Assets acquired	Capital Management Skills Market link Technology	Market link Technology	Technology
Required capacity	Basic	Middle	Advanced
Risk of entry	None	Low	High
Subordinateness	High	Middle	Low
Profitability	Low	Low	High
Growth possibility	Low	Middle	High

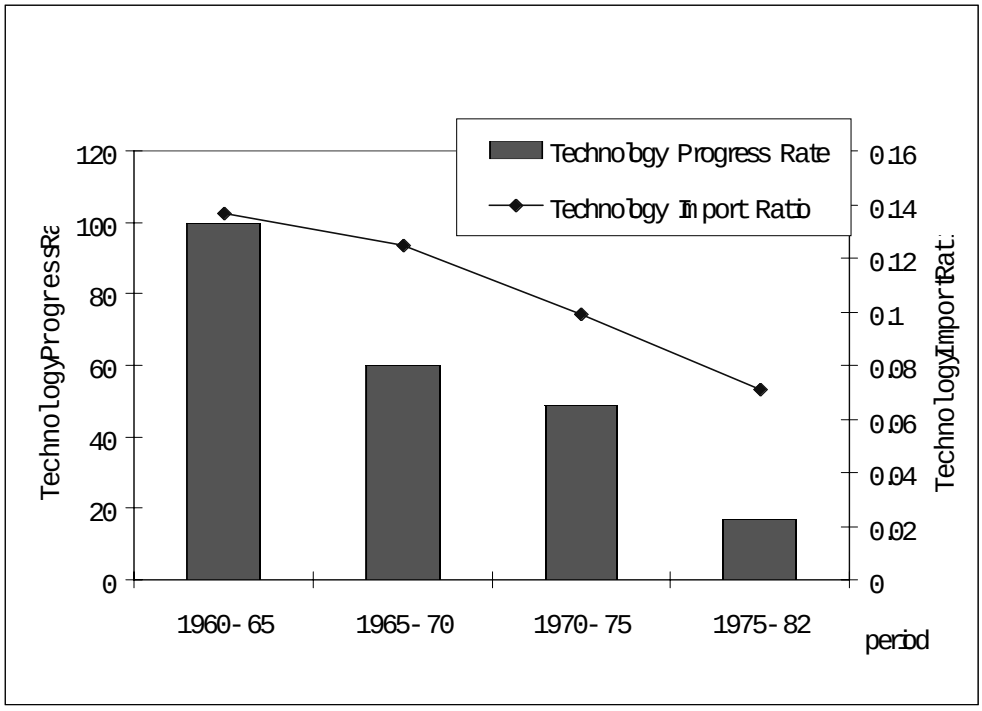
Table 5. Cost to Develop a New Product Using Imported Technology and In-House Technology in 1963

	R&D Expenditure per Product (100 million yen)	Time Required (years)
Imported Technology	6.8	2.50
In-House Technology	1.7	2.35

Source: AIST, White Paper on Industrial Technology (in Japanese), Jitsugyo Kohosha, 1963.

FIGURES

Figure 1. Technology Progress and Technology Import in Japan

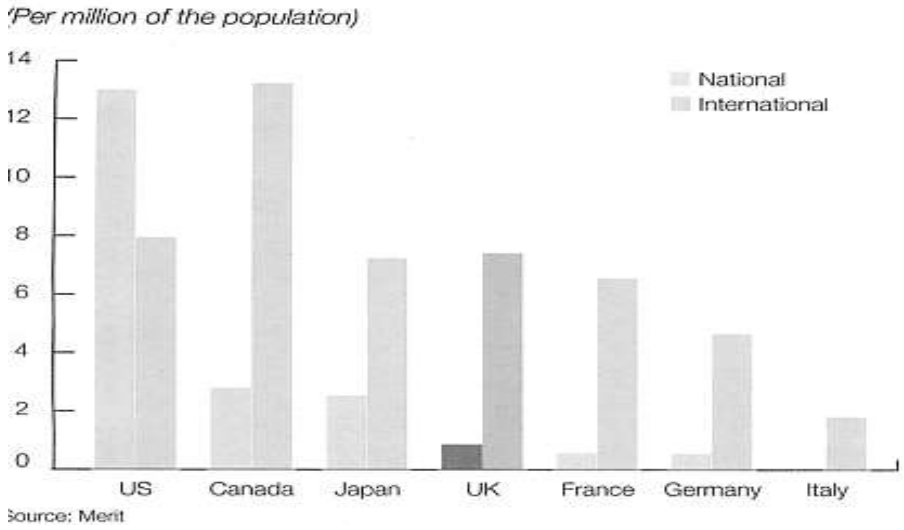


Source. Technology progress rates: MITI (1988).
Technology import ratios: the author.

Figure 2. Technology, Economic Activities and Networking

TECHNOLOGY	ECONOMIC ACTIVITIES	NETWORKING
Development of Information Technology Communication Technology Transportation Technology	Borderless Economy	International
Technology Fusion	Sectorless Competition	Inter-sectoral
Acceleration of Technology institutional Development Science-based Technology	Corporate-boundaryless	Inter- Business

Figure 3. Technological Alliance between Firms (1992-1995)



From: DTI, UK Competitiveness Indicators 1999, Department of Trade and Industry, UK, 2000.

Figure 4. Paradigm Shift of Technology Strategy

National Strategy

From Public Initiative to Private Initiative

Public Technology Development → Private Technology Development
R&D Capability → Infrastructure Building (e.g. IPR Protection, S&T Database, Standards and Metrology)
R&D Focus → Supporting Service (e.g. Consulting, Testing and Information Provision)

From 'Research for Research' to 'Assistance for Industry'

R&D for Journal Papers → R&D for Industry
Science → Technology/Engineering

From General Finance to Tailored-For-Technology Finance

Conventional Loans → Venture Capital and Conditional Loans
Conventional Financial Institutions → Technologically Capable Special Financial Institutions

From Formal Education/Training to Practical Education/Training

One-Time Education → Life-Time Continuous Learning
Higher Education → Primary/Secondary Education and Vocational Training + Higher Education
Public-Led Training → Firm/Industry-Led Training

Corporate Strategy

From Self-Reliance to Networking

Formation
In-House Efforts Only → Network Sourcing
Space
Domestic Network → International Network

From Single Approach to Comprehensive Approach

Operational Phase
Price → Speed, Quality and Function + Price
New Product Development Phase
Product Development → Procurement-Production-Marketing System/ Business Model/Standards or Interfaces + Product Development

Figure 5. Science vs. Technology

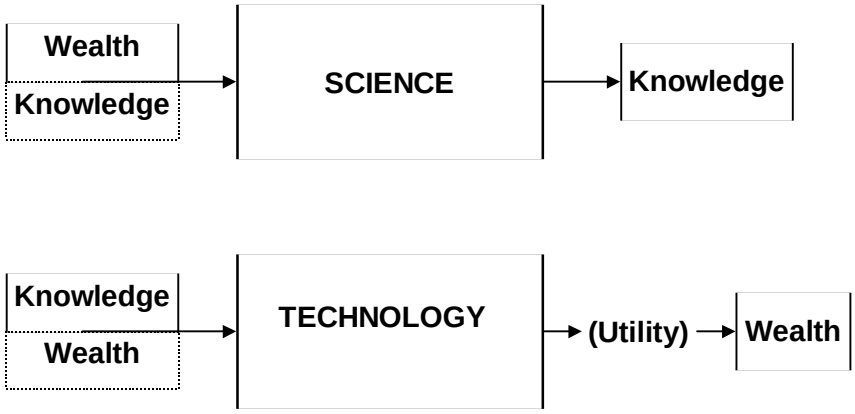
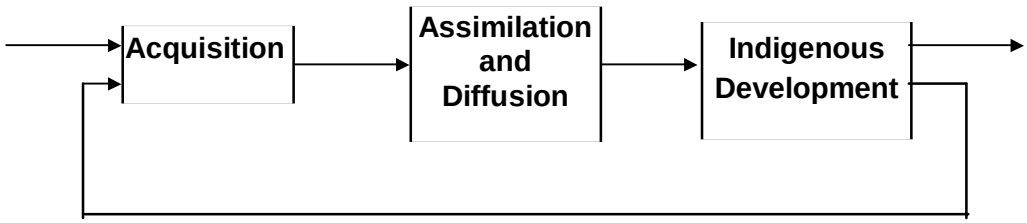


Figure 6. A Progressive Model of Technology Development



FINANCING TECHNOLOGY: AN ASSESSMENT OF THEORY AND PRACTICE

by

Pasquale Lucio Scandizzo

Contents

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1. Innovation and Finance

Finance represents a problem for technology at two different levels: first, research projects have to be funded and their results properly developed to insure effectiveness and applicability; second, these results have to be transferred from universities and research centers to firms in order to foster innovation and growth. For both these stages adequate financing instruments hold a prima facie claim as an important element for economic success.

The importance of finance for technology, in reality, is not easily established and, in spite of its intuitive plausibility, rests on so many different arguments that it is ultimately difficult to ascertain with clarity. A priori arguments for finance as a key determinant of technology success range from its effect on the actual applicability of innovation, to the comparative disadvantage of high tech firms in obtaining capital. For example, no less economist than John Hicks (1969, pp.143-145) claims that the industrial revolution in England did not occur when the main inventions were made, but only, much later, when the financial system was sufficiently developed to offer the appropriate financial instruments to develop and apply the innovations.

From a more micro-economic angle, economists such as Arrow (1962) and Stiglitz (1993) have argued that firms engaging in innovation are likely to be more highly constrained by liquidity, and the financial market imperfections arising from informational asymmetries and moral hazard. Others, such as Bhattacharya and Ritter (1983), have pointed out that innovators may themselves be unreliable as information sources for would-be financiers, because the defense of property rights implies that a crucial part of the information on the projects undertaken remain closely guarded against potential competitors. In 6the United States, for example, patent law cannot be applied unless the invention is considered sufficiently unrelated to "prior art", and even if applied, in many cases "…would be held invalid if ever litigated. Trade secret laws (protection against the theft of ideas) is also difficult to implement because of the strategies used by firms to avoid legal challenges and the difficulty to establish legal proofs."(Anton and Yao, 1994, p.191).

Empirical evidence on the effects of finance on technology has been initially based on the sensitivity of R&D expenditure to the cash flow of the enterprise. The results of these tests have been originally mixed, in spite of the strength of prior arguments, and only recently appear more convincing. Cross sectional studies conducted in the '60s by, among others, Schrer (1965), Hamburg (1966), and Muller (1967) failed to turn up significant effects of the cash flow on R&D. The studies conducted in the '90s and based on panel data, instead, are more successful. For example, Hall (1992) measures a strong effect of the cash flow on R&D over a large panel of US manufacturing firma. Himmelberg and Petersen (1994), by investigating a short panel of high tech firms find also a similar, strong and positive effect and so do Hao and Jafee (1993) on a small and long panel of US firms and Guiso (1997) on a panel of Italian firms. Event studies by Greenwald, Salinger and Stiglitz (1990) point to the same result for the US automotive and airline industry.

The credit instrument, specially for small and medium enterprises (SME), represents by far the main source of finance of technology and innovation. Most of the recent empirical evidence shows that, in spite of the development of financial markets, R&D projects are still financed in order of importance: (1) by the entrepreneur with possible recourse to his family and friends, (2) by a short term credit relation with a Bank, (3) by third party equity investors and venture capitalists (Berger and Udell, 1998).

Because R&D as well as innovation projects are generally affected by high, non diversifiable risks, the financial structure of the firm provides an allocation of risks between the participants to the enterprise. Any change in that structure thus implies subsequent changes in the risk borne by each class of claimants, as well as in the expected value of their claims. By its very nature, however, investment in technology require very specific expertise for expert evaluation, it does not provide collateral because of intangibility and may modify substantially the expected value of the owners (e.g. shareholders') claims in the course of project life.

Not only SMEs may thus face severe constraints in capital scarce countries with low capital labor ratios and undeveloped financial markets (Cobham, 1999), but they may be affected by a specific anti-innovation bias.

Risk transfers between claimants - due to debt financing - may affect shareholders investment incentives in two different ways. On the one hand, shareholders can undertake a negative NPV project if debt financing allows them to capture part of the project gains by transferring part of their risk to debt-holders (over-investment incentive). Conversely, shareholders can reject a positive NPV project if most of the gains accrue to debt-holders (under-investment incentive) without a corresponding increase in the risk level. The resulting sub-optimal investment decisions cause deadweight losses which are commonly referred to as agency costs of debt.

The standard framework of the agency costs of debt assumes that investment decisions go before the firm financing strategy and that operating decisions are taken by shareholders (or managers) in order to maximize the value of equity. When there is no debt in the financial structure, an equity maximizing policy is equivalent to a value

maximizing policy. When debt is present, on the contrary, investment incentives can be distorted by the conflict of interest that originates when the project NPV is shared between claimants according to their relative "seniority". This distortion of incentives induces sub-optimal investment decisions that result in a difference between the levered and unlevered value of the firm (agency costs of debt).

The impact of the agency costs of debt have been envisaged in situations like "asset substitution" (Jensen and Meckling, 1976), "over-investment" and "under-investment" (Myers, 1977; Berkovitch and Kim, 1990). Jensen e Meckling[1] show how the shareholders of a levered firm have incentives to increase the riskyness of a firm's assets, thus increasing the risk for debt-holders, even if the greater risk is associated with lower present values of future cash flows. Shareholders are in fact interested only to the "upper" side of the probability distribution of firm results, that is to the part where cash flows are greater than the face value of debt. Debt-holders, in contrast, receive only the full payment of debt as specified in the contractual provision but nothing of the cash flows greater than the face value of debt. Therefore, they are interested to the "lower" part of the probability distribution of firm results: the addition of risk increasing projects to the firm reduces the expected value of their claim. In this case, the agency cost of debt consists in the increased cost of financing that debt-holders require when they assess the shareholders incentive to accept a risk-increasing investment project.

Myers[2] shows how shareholders of a levered firm can have incentives not to accept a positive NPV project: the "under-investment" incentive arises because existing debt-holders get a share of the project NPV while shareholders suffer the investment cost. In presence of risky debt in the financial structure, debt-holders appropriate the positive results of the project financed with internal funds up to the face value of their claim, leaving to the shareholders only the residual. The agency cost of debt is directly related to the change in firm value that the project would have produced if adopted, but that was lost because of the decision to reject the project.

While in the Myers contribution the agency costs of debt are due to the under-investment incentives that origin from risky debt, Berkovitch e Kim[3] show that also risk-shifting incentives can produce significant deviations from the NPV rule. Using a model based on a different probability level for each state (high and low) and on a project entirely financed with an exogenous specified amount of debt, the authors show how under- and over-investment incentives can arise from the "seniorship" of debt. In particular, the issuance of senior debt to finance a new investment project can have two effects on the shareholders investment incentives. On the one hand, a greater seniority of new debt with respect to existing debt makes the former less risky because increases its probability to be paid back in case of default. This reduces the cost on new debt and makes easier to use senior debt to finance the investment, thus reducing the under-investment incentives. On the other hand, however, the low cost of new

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1 Jensen and Meckling (1976).

2 Myers (1977).

3 Berkovitch and Kim (1990).

debt, if senior to the existing one, can generate incentives for excessive investment expenses and can result in the acceptance of negative NPV projects (over-investment). Also in this case, the agency costs of debt depends on the relative weight of the two incentives and can be defined as the difference between the firm values that originate from the acceptance/rejection of the project.

Scandizzo (1997) shows how this effect is exacerbated in the case of R&D projects. Once a SME has achieved a given threshold of leverage, in fact, it is in the interest of shareholders, i.e. both the owners, partners and venture capitalists, to engage in risky innovation since the debt-holders will bear part of the risk without participating to the possible payoffs. While this effect may partly counteract the under-incentive problem that affect R&D projects for private entrepreneurs, its consequence is that financial institutions will have to step up supervision activities for innovative firms. They will thus be more reluctant to fund projects that concern firms likely to invest in new technology, *even when these projects do not directly involve R&D activities or innovation*.

Traditional managerial economics (e.g. Reekie and Crook, 1995) predicts that financing of the firm will follow a "pecking order" depending on the degree of control of each financing source. Because ownership resists the relinquishing of control and residual rights, internal finance, i.e. the re-investment of profits will be the favored option. This will be followed by debt, which is simply a commi8tmnet to repay without any foregoing of control rights, and only as an extreme ratio, by enlarging the platform of residual and control rights to other equity partners. According to Brouwer and Hendrix (1998), however, this order is reversed in the case for high-tech start-ups, because of actual constraints, rather than a reversal in pecking preferences (Cobham, 1999): "Since internal finance (cash flows) cannot meet (the firm's) capital demands and debt is hard to coma by, equity capital figures as the prime financial resource"(Brouwer and Hendrix, p. 334, 1998).

Financing technology may thus engineer a dilemma for the owner-manager of a SME. His natural preference for debt financing, magnified by the possibility of risk shifting offered by high risk technology projects, in fact, may be frustrated by the unwillingness of banks to grant her credit. According to this approach, high tech firms may be perceived by banks, and also by potential bondholders, as subjects continually threatening to disrupt the basic conditions of credit contracts. This would be accomplished through the shift of the risk burden that innovation could induce by incorporating increasingly riskier projects into the financial structure of the firm.

On the other hand, the reluctance of the potential creditors to supply finance to high-tech start-ups would not be matched by an equal reluctance by management to relinquish control over the firm to equity owners, for two main reasons. In the first place, in fact, the SME - high-tech manager may see debt as a too great commitment, in the face of the uncertainty created by the investment in innovation. Because debt repayment appears dominated by external constraints, owners-managers of small start-ups

may fill less inclined to be fussy about control rights in exchange for the clear risk sharing agreement provided by the equity contract. In the second place, the financial constraints for SME will appear much more stringent in the case of enterprises that are more dependent on innovation for success.

Financial constraints prevent external finance from being made available to firms, rather than merely reducing it (Carpenter et al., 1995). They can be summarized under three hypotheses: (1) the collateral hypothesis states that the collateral value of a firm will reduce the discounted value of its expected cash flow, thereby reducing the creditworthiness of firms depending on intangible factors more than proportionally. (2) The bank lending hypothesis states that restrictive monetary policy will cause a reduction of activity for bank dependent firms. (3) The internal finance hypothesis, finally, implies that capital market imperfections and agency costs arising from asymmetric information will cause profit levels, rather than growth to be the main determinant of investments. Given that large corporations (LCs) face themselves finance constraints under these three hypotheses, SMEs, and, even more, SMEs operating in the high-tech sectors can be expected to face more stringent constraints. In support to this contention, we may add the result by Brown (1997) that innovative firms are financially constrained because " the assumption of perfect capital markets is least likely to be satisfied for the class of firms which devote resources towards the development of innovative products or processes ".

2. Risk and creditworthiness for innovation

2.1 The performance of enterprises

What are the signals that creditors can utilize to decide if they may trust debtors? This question is particularly important in the relation between the bank and the high-tech start up, because, due to the intrinsic random nature of the credit contract, the bank is forced to discriminate among firms on the basis of signals predicting their future performance as debtors. What are then the most reliable signals?

In the classical tradition, that can be traced to Joe Bain (1951, 1956), industrial economists regarded the market or the industrial sector as the research unit. Differences among firms were considered transitory or unimportant, unless they were based on scale economies. These, on the other hand were considered non significant, or destined to disappear with the firms expansion. Differences in performance among firms of different sectors, on the other hand, were attributed to differences in the capacity of successful firms to restrict entry and to promote cartels, in order to perpetuate their economic dominance through market power. The degree of concentration of the industry was thus the key variable of the econometric studies aimed at demonstrating the importance of market power in explaining the different performance of firms in different industries (Weiss,1974; Scherer, 1980).

A series of studies in the years '80s challenges this point of view on the basis of an opposite hypothesis: it is not the sector that determines the performance differentials, but at least some industries show significant internal differences in efficiency and innovation. Because market power depends on the relative size of sales (market share) and this is the consequence of the success of the firm, cross sectional studies will tend to reveal a positive correlation between industry concentration and performance of leader enterprises. The causality link, however, is reversed: it is not market power that determines the differences in performance, but the differences in the degree of success among firms that determines the differences in concentration in the various markets. (S.A. Lippman and R.P. Rumelt, 1982; D. Ravenscraft, 1983; R. Schmalensee, 1985).

A further approach to the problem of the differential performance of the firm is the so called managerial school, which claims that the differences are explained by managers' quality. This brings to persistent differences in firms' profitability, even coeteris paribus, with consequences on the budget structure, the equilibrium of development, asset quality and innovation capacity. Studies by D. Muller (1977, 1983), M. Porter (1987), F.R. Lichtenberg (1991, 1992), L.P. Lang e R.M. Stulz (1994) are some examples of the many, interesting studies that reflect this line of thought.

In sum, while belonging to the high-tech sector may be important, the capacity to introduce successful innovation seems to enter only tangentially the consideration of firm performance, as these conclusions drawn from Schmalensee's comprehensive study of the FTC data (1985), suggest:

1) There are no success factors characterizing the firm (i.e., we can reject the hypothesis of the managerial school).

(2) Sector effects exist and are important, as they explain at least 75% of the variability of returns.

(3) Market shares are a statistically significant success factor, but they explain only a minor part of the variability of returns.

(4) The market share effects are negatively correlated wit the sector effects.

2.2 Credit supply and risk evaluation

Let's now look more specifically at the determinants of creditworthiness for the high-tech start-ups and the innovation projects. Because of adverse selection (Stiglitz and Weiss, 1981), banks may not efficiently ration credit through interest rates. Thus, the main element that guides their decision to grant a loan to a firm is evaluating and controlling credit risks.

Once confronted with a loan request, in particular, credit institutions find themselves facing the need of a two-fold evaluation:

(a) Select the enterprises that present a sufficient degree of creditworthiness;

b) Define, for the firms selected, loan conditions in terms of interest, timing and other characteristics of financing.

The concept of creditworthiness has a wider significance than the mere concept of credit capacity (Bottiglia, 1984). In fact, while the former derives from an evaluation of the degree of trust that the bank grants its client, the latter requires an appraisal of the particular situation of the enterprise and of the potential of the project whose funding has been sought. Thus, while creditworthiness may be considered an absolute: i.e. it either exists or it does not, credit capacity may vary instead with the circumstances and the risk embedded in the operation proposed.

The degree of risk created by a loan depends on the characteristics of both the creditor and the debtor. In addition to traditional instruments (debt covenants, maturity, building a relationship with the borrower), financial and technological innovations have in fact made available to credit institutions new instruments that allow a partial or total coverage for risk (e.g. securitizing the loan, swapping, etc.) or greater control (data banks, sophisticated surveillance systems). On the side of the debtor, risk depends on the structure of the balance sheet of the firm, the owner's wealth, the capacity of the enterprise to generate cash flow, thereby insuring that the loan will be repaid and the supply of collateral and guarantees.

Strictly connected with project risk is the interest rate, which plays a many-fold function:

- It is a charge for the risk of default of the borrower,
- Is an instrument for risk sharing,
- Is a premium for loss of liquidity,
- Is a compensation to defer consumption.

Interest rates applied by credit institutions include all the charges corresponding to the functions above plus the coverage of implicit costs (loss of money purchasing power, credit risk), and the production costs (costs of provision, operational and administration expenses). Interest rates are inversely correlated to the price of debt and, as a price-like variable, they summarize market information, in a way, which at least for a given range of rates, contributes to market efficiency. In particular, all other things being equal, the greater the risk of financing, the greater the interest charged by the credit institutions.

There is, however, a threshold of maximum acceptability for project risk (which is a function of the degree of the bank risk aversion and of innovation capacity) beyond which the credit institution will switch to straight out rationing. In this respect, two types of rationing may be distinguished:

a) Type one rationing, when all customers receive a quantity of credit lower than the one desired. In this case the client is considered creditworthy, but her demand is greater than the amount granted.

b) Type two rationing, when some customers are denied credit altogether. In this case the client does not pass the creditworthiness test.

The literature on credit rationing is rather extensive. Initially its interest was focused almost exclusively on the effects of the adjustment lags of the interest rates. Credit rationing was explained through hypotheses of price rigidities determined by exogenous factors, such as market imperfections, upper limits on interest rates, etc. In a second moment, Hodgman (1960), Freimer and Gordon (1965) claimed that the causes for rationing were to be found in factors internal to the bank and linked to the objective of profit maximization. These contributes identified the real cause for rationing in the fact that beyond a certain size of the loan, no increment in the interest rate would be capable to compensate the expected losses from the corresponding increment in bankruptcy risk.

More recent theories have tried to explain rationing from the existence of asymmetric information (Stiglitz and Weiss, 1981) and the hypothesis of multi-period contracts. The asymmetric information thesis[4] demonstrates that the fact that a perspective borrower possesses more information with respect to the banks on the probability of success of a project determines a situation where the banks, in order to avoid adverse selection and lack of incentives, do not finance investment projects that would be willing to pay high interest rates. Small firms seeking finance for high tech projects are clearly among the most difficult to assess and, as a consequence, the most likely targets of credit rationing exclusion.

The second line of thought, based on multi-period credit contracts[5], identifies in the stipulation of one period contracts between the bank and the borrower, a way to provide an incentive to the borrower to be repay her debt. If this does not happen, rationing occurs as a sanction. In other words, the possibility of exclusion from credit, combined with the existence of one period contracts, is used as a disincentive to default.

As I have indicated before, the relationship between the bank and the borrower may be framed by the principal- agent model, which has received much attention in the economic literature. (Arrow, 1970, Borch, 1963, Hart and Holmstrom, 1987). On one hand, in fact, we find the credit institution attempting to maximize the returns to the

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4 Two classes of models refer to asymmetric information to justify credit rationing. They can be represented by the model, respectively, of Jaffee and Russel (1976) and of Stiglitz and Weiss (1981).

5 See Kletzer (1989), and Stiglitz e Weiss (1983).

loan, while, on the other hand, its customers try to exploit as much as possible financial leverage, to maximize the enterprise net worth. Furthermore, the productive firm sends signals on its creditworthiness and credit capacity to the bank to obtain as high a rating as possible. The bank, on its part, tries to perform an effective selection, by denying credit to the unworthy and limit the size of the loans to expected capacity for the worthy ones.

Both the signals sent by the firm and the activities of the banks to assess credit risks are such that, small firms with little track record, involved in high tech products or markets are at comparative disadvantage in obtaining credit. This is particularly true if their projects appear to revolve on untested ideas, require technical expertise and are associated with risks that are difficult to diversify. Furthermore, while adverse selection via interest rate may be limited by rationing, the cost of appraising innovation may itself be correlated with project complexity and success chances. Thus, in a different form, adverse selection may re-enter the scene, since more complex projects may be discriminated against simply because they are more costly to assess. Moral hazard, in the form of the over-investment incentive described in section 3, may also discourage the banks from getting involved with firms and projects that propose to invest in innovation and technology.

In a hypothetical market without informational asymmetries, where both subjects (bank and client) would be able to obtain the same returns from the investments financed, there would be no reason for conflict. The two subjects are put on opposite positions, however, by the uncertainty of the business plans of the perspective borrowers and by their potential use of financial leverage as an instrument to gain value at the expense of the bank. A special form of conflict, in particular, arises for *start ups* and *high tech* projects, where enterprises naturally aim at postponing the production of cash flow favoring long term growth, against the banks' attempt to anticipate as much as possible debt repayment to minimize risk. Possible solutions to this conflict rely on two basic techniques: *monitoring* and *commitment*.

Monitoring activities on the part of the bank may be performed on an *ex ante* or an *ex post* base. *Ex ante* activities aim at improving the portfolio of bank investments, by granting credit on the basis of systematic evaluation of both projects and enterprises. These techniques, which may be rather costly to set up, are not particularly biased for projects involving high or new technology, if they develop methodologies and procedures (such as feasibility studies and expert evaluations) that deal with project merits rather than with the evaluation of corporate capacity for credit.

Ex ante activities thus consist in the more traditional screening and evaluation types and concern the fundamentals of the subjects that are interested or potentially interested by financing, as well as project appraisal. As in all cases where it is necessary to undertake acceptance-rejection decisions, the possibility of error is two-fold. On one hand, it is possible to err by granting loans that should be refused (error of type one). On the other hand, one can incur in the opposite mistake of denying loans that should have been granted (error of type two). The proportion of loans of good and bad quality depends on both error types and not, as it could appear on first sight,

only on the error of type one. An excess of type two error, which is particularly likely for high tech, start ups and innovative projects, may have particularly nefarious consequences on economic growth and competition, and result in high social costs.

A recent literature (Stiglitz and Sah, 1984) has studied the effect on the two errors of the architecture of the economic systems, identifying two extreme typologies of organization: the hierarchy and the poliarchy. In a hierarchical organization, which we may assimilate to a traditional bank, loan proposals are examined at each of the successive levels of a pyramid of decision makers. Credit is eventually granted if and only if the proposal has been considered acceptable at all levels of scrutiny. Type one error is clearly minimized in this decisional structure, while the probability of error of type two is comparatively higher, *coeteris paribus*.

In a poliarchyc structure, on the other hand, we are closer to the case of specialized credit institutions, such as the investment banks and the venture capitalists, since projects proposed for financing are examined by a limited number (some times only one) of decision levels. The project is thus promptly accepted or rejected and does not have to go through a vertical line of positive evaluations to be financed. If it is rejected by one possible financing institution according with this procedure, the project does not receive the stigma that is inevitably associated to a candidate that is solemnly dismissed after a ponderous examination.

This system clearly increases the probability of error of type one, while error of type two is minimized. Specialized institutions should be able, at the cost of a higher risk of being wrong, to capture a greater percentage of the best and most innovative projects.

The upshot of this discussion is thus that ex ante monitoring activities present a clear comparative advantage for projects based on innovation and for specialized institutions. These are called, one could say, to perform a social function, by discriminating among projects, with the objective of not letting the best opportunities escape for lack of sufficient attention to the error of type two. The same activity, on the other hand, is exposed to two different risks, which tend to attenuate its benefits, at least from the point of view of financial agents.

The first risk is the consequence of the fact that financial intermediaries, and specially the larger banks, deprived of the information and of the decision structure adequate to capture the best projects, are tempted to behave as free riders. They can do so by exploiting the monitoring activities of specialized operators, to select part of the projects, thereby avoiding to incur in direct monitoring costs. This risk may imply higher social costs, even though the optimal combination of hierarchy and poliarchy is decided by the interaction of the intermediaries and the market. Specialized operators, in fact, may see their competitive advantage severely compromised by the opportunistic behavior of larger and un-specialized banks, and, as a consequence, scouting and other monitoring activities aimed at finding new project ideas may be hampered.

The second risk concerns the so called "winner's curse", associated with the winner of a competitive auction, who discovers to have bid a higher price than what he should be willing to pay. The financial equivalent of this curse is the fact that the specialized operator, investment bank or venture capitalist, may be financing prevalently those projects which everybody else has rejected because of the excessive risks involved. This financing is apparently the fruit of competition, but at the same time it may be a poisonous fruit, since in the long run it may both do damage to the specialized operators, which will be affected by a higher degree of failures, and the high tech firms, which will find fewer financing opportunities.

Ex post activities aim at improving the performance of firms who have already been granted financing, through supervision and control. Because of the general uncertainty characterizing innovative projects, the often long gestation lags, the tenuous property rights and the prevalence of intangibles in the assets owned by the high tech enterprise, monitoring may be costly and only partially effective. The fact that the bank may try to audit the firm's accounts and to prescribe actions of some sort does not generally help on the front of moral hazard. When it is tied to the possibility of renegotiating loan terms, it may hamper project success by either unduly restricting the firm's impulse to grow (under-investment incentive), or by inciting it to take excessive risks (over-investment incentives) at the expenses of senior lenders who may not be able to renegotiate.

Ex post monitoring activities may be divided in two groups: (a) surveillance and control actions, to collect information on the firm that may be relevant for the bank and, (b) supervision actions. These include assistance, advice and provision of services, thereby involving prevalently information that may be useful to the firm financed. In a regime of financial deepening, with both banks and specialized operators competing to promote the success of the projects financed, both activities of type (a) and (b) should be growing. This would be specially true for start ups and projects that require technical expertise and innovative or at least state of the art technology to be successful. Both activities, however, are linked to a relationship between intermediary and enterprise that may go much beyond unilateral monitoring. Specialized operators may develop a competitive advantage in type (b) activities, but they may not be sufficiently numerous to satisfy the demand for know how and technical capability where innovation and technology is at stake.

The relationship between the intermediary and the enterprise has been recently evolving towards forms of delegated monitoring, where the incentives provided to the two parties constitute the essential elements of the financing relationship. Monitoring activities of type (a) and (b), in fact, tend to eliminate the problems of moral hazard deriving from the fact that the firm and the intermediary may both have an interest to hide information to one another and to operate under conflict of interest. The contract of delegated monitoring with incentives, instead, aims at creating a unity of behavior of the two parties, which may be particularly beneficial for long term performance.

Can we say that the specialized intermediaries hold a competitive advantage, at least a potential one, as agents for monitoring financing in behalf of banks and enterprises. While many activities may be conceivable as part of this type of a relation, it is evident that a contract of delegated monitoring may of great interest for small firms, local banks and operators, such as closed funds, that are also often operating on a local basis. This activity is very difficult to organize, because in most cases both banks and specialized operators are unprepared to go beyond traditional monitoring and control. On the other hand, the experience of capital deepening in the areas of concentration of technological progress, such as many industrial districts and science parks indicate that this may be a most productive area of business.

Commitment activities aim at reducing adverse selection and moral hazard by incorporating incentives in the structure of contracts or of its implementation procedures. They include a panoply of instruments, the most important being collateral, loan agreements, debt covenants and what is generally referred to as "building a relationship" (Cobham, 1999).

Collateral may take the form of a pledge of inside assets, i.e. assets owned by the firm, or outside assets, owned by the shareholders, sponsors or other stakeholders. Because it attenuates the implications of limited responsibility (the value of a failed project is negative rather than zero), collateral reduces both adverse selection and moral hazard. On the other hand, the fact that the bank has required an independent pledge to back the project, significantly reduces the value of the loan as a signal of approval and trust to the enterprise. Nevertheless, collateral is the main instrument to overcome the conflict of interest between the bank and the firm, specially in the case of SMEs, start ups and high techs. In the United States, about 40% of loans (Ang et al., 1995) and 60% of their value (Avery et al., 1998) to small business are backed by outside pledges.

Loan commitments are forward contracts committing lenders to provide loans over a given period, at fixed rates. Lines of credit are "generally pure revolving credits that allow the firm to borrow as much of the line as needed at any given time over the interval time specified" (Berger and Udell, 1998,p.28). Even though these instruments appear to be conceived to provide working capital, they may be used to finance machinery and innovation. It is also typically utilized to open a credit door to the firm by allowing her to slowly upgrade her credit capacity over time. In general, however, the short term and conditional nature of this type of credit, allows the banks to hold an option not to finance the enterprise, and limits its commitment to any longer term venture. While it may mitigate the effects of rationing for small enterprises, it makes them dependent on the credit institutions to the extent that they may not be able to implement a new project without prior consent from the main bank that finances their current operations. Loan commitments and lines of credit, furthermore, are not generally sensitive to positive news, including the favorable characteristics of good innovation projects. They tend to be, in fact, rather dependent on bad news, to deny credit when the firm enters the gray zone of financial difficulties, low cash flow and, depending on the circumstances, temporary low returns due to high growth prospects.

Debt covenants can stipulate that the borrower has to obtain the consensus of the lender before engaging in a new project or in a change of corporate policies. They are specifically designed to reduce the information problem and agency costs and may be rather effective for sufficiently large enterprises. Small firms, however, are more rarely disciplined by this type of instruments, because of the generally low quality of their auditing. In the case of innovative projects, furthermore, restricting the firm's ability to change its financial position may severely hamper management flexibility in the face of uncertainty, including its ability to take advantage of market and technological opportunities. More frequently, small firms are controlled through contracts of short maturity. These contracts enable the banks to monitor changes in the borrower and to renegotiate the terms of the loan if risk conditions have been modified by the evolution of its fundamentals, or by the adoption of riskier expansion policies. In the case of high tech SMEs this adds a further reason to their inability to obtain long term credit on the basis of projects' merits rather than on systemic risks.

The activities that lead to the development of a long term relationship between the lender and the borrower provide more efficient commitment than contractual instruments that restrict in any way the flexibility of one or both parties. Long term relations are particularly desirable because they may drastically reduce agency costs. These costs are due to the fact that the credit contract generally does not satisfy the requisite of time consistency. Efficient ex ante contracts may thus become ex post inefficient, if circumstances occur that determine a divergence in the interest of the two parties as to abiding by the contract terms, renegotiating, defaulting.

Under these conditions, developing a long term relationship between the bank and the firm may allow the bank to build up a credit history for the SME, by accompanying her through her life cycle and providing financing at the appropriate time with sufficient information. In the United States, for example, small business that define a commercial bank as their main financial partner have been receiving financing from the same bank for more than 9 years (Berger and Udell, 1998, from SBIC data). Figure 1, from Bornheim and Herbeck (1998, p.328) illustrates the situation by contrasting gross marginal benefits from the relationship, shown as a curve decreasing with time, to costs, which are instead increasing with the length of the relationship. Costs are mainly due to what has been called the phenomenon of information capture. Marginal gross benefits are mainly due to the reduction of capital costs in response to the private information about borrower quality provided by the relationship. As a consequence the price of the loans falls (Petersen and Rajan, 1994), loan size rises over time and collateral demand also tend to fall (Boot and Thakor,1994).

Information capture shows up as a progressive loss of options for the firm. Once caught in a long term relationship, a small firm may find difficult to turn elsewhere for funding. The broader effect may be lowering competition among banks and higher costs to the firm. On the other hand, a long term relationship does not necessarily imply an exclusive one, both in the sense that the firm may try to build up long term financial ties with several intermediaries and because after a certain number of years it may be advisable to severe one's ties with the main lender.

Relational financing has been defined by Aoki and Dinc (1997) in a way directly dependent on the intermediary expected benefits, as the type of financing that is provided in the expectation of both further financing over time and the exaction of rents. In contrast, ordinary financing is referred to as arm's length. Relational financing is thus particularly important for start ups, high tech projects and SMEs because the prospect of the gain proposed is often sufficiently vague and long term that only the expectation of extracting a rent may provide the incentive to offer financing on a likely repeated basis. Relational financing thus includes commercial banks, investment banks and venture capitalists, but clearly favors specialized intermediaries which can fulfill the needs of growing firms through their more closeness to the firm territory, their expertise in the firm operations, and their know how on the relevant markets.

2.3. Equity financing

The rise of the Internet economy has demonstrated, somewhat spectacularly and not without the danger of a negative feedback, that high tech firms may be almost entirely financed by equity, provided that the prospects for acquiring rents are sufficiently high. In general, however, most innovative businesses have found hard to resort to equity financing. While available empirical research on this topic is almost nil, business angels appear to be the main source of third party financing (TPE), at least in Anglo Saxon economies. Nevertheless, even in the most developed countries, this source of finance, at least at first sight, appears to be of minor importance. In the USA, for example, according to SBIC data, only 3.59% of total finance to small businesses is provided by TPE and only 1.85% by venture capitalists. These figures, however, may give a false impression, since both business angels and venture capitalists "…invest very selectively and target small companies with significant upside potential." (Berger and Udell, 1998, p.15). While a small proportion of the total, therefore, TPEs, venture capital and business angels may account for a much larger share of the outside finance obtained by successful firms.

As for innovation, one may reasonably argue that, because of the comparatively lower incidence of traditional credit, enterprises engaging in riskier projects involving research and new technology would also be more represented among the firms financed by venture capitalists and business angels. This would be the result of mutual signaling of preference for growth, as well as a result of greater competence in evaluating high tech and start up projects. Furthermore, the improved financial management obtained through the involvement of equity partners could have positive results on the performance of the firm. This conjecture has received some support a study of venture capital in the US (Kortum and Lerner, 1998), which shows that, even though it financed only 3% of total R&D, it was associated with 15% of industrial innovation.

Venture capitalists and business angels differ in their objectives in a substantial way. While venture capitalists are interested in capital gain, business angels aim at finding enterprises that can be reliable income sources. Further differences concern the modus operandi in the partnership. Because of their concern with maximizing returns to capital, venture capitalists generally operate through intermediaries (closed funds

or other financial entities), they typically take small equity positions in the firm selected and always combine these positions with carefully designed exit strategies. Among these, the initial private offering (IPO) is the elective one. In contrast, business angels do not operate through intermediaries, are not committed to exit designs and tend to become involved in the management of the companies financed in a major way. Involvement in the company management appears indeed to hold a positive value for angels, to the point of justifying their financing of companies comparatively riskier and less liquid than those that TPEs and venture capitalists would fund.

Business Angels are also characterized by the fact that they tend operate in anonymity, often work in groups, tend to share databases and news about the best companies and generally rely on networks of consultants and special services. These services, which are increasingly on-line, have a matching function and, by combining an application process to a growing database, look for mutuality of preferences between investors and entrepreneurs. According to Marcia Schirmer, who is President of the Colorado Capital Alliance Inc., a Colorado-based angel network, 82% of BA's expect a role in the venture, with investment ranging from $50K up to over $1 million - (Bill Gates is the largest angel of all, and has a slightly higher range) - 18 of 20 investments don't produce a positive return, while investment costs for angels is very high (due diligence - patent attorneys for example). The sectors of involvement are mostly technological, with innovation in the forefront: Hugh tech services companies, telecom, computers, Internet, manufacturing, with financing distributed over project life: 31% seed, 46% early stage, 23% mid-stage or established - 56% have sales.

According with the latest SBIC data, there are more than 2 million angels in the country (of which only 250,000 are investing), who invest $20 billion annually. While angels look for companies that have strong management, they are also interested in very high returns (40% within a few years is a common target). As a consequence, they often seek direct involvement in the company in a way that may allow them to exercise some control on growing strategies, but also effective monitoring of management practices and performance.

2.4 Growth, returns and financial constraints

Growth prospects are not equally important for all enterprises. Start-ups and innovative firms, in particular, are dominated by long term goals, rather than by short term profit maximization. In spite of the fact that the firm is free to formulate its strategy plan, it cannot always do this without taking into account of the needs and prescriptions of some of its most influential stakeholders. Among these, the credit institutions are the main subjects, not formally involved in the governance of the firm, that may nevertheless exhibit some power in evaluating and controlling corporate policies.

Wood's model (1979) analyzes the relationship between development and profitability. The author claims that leverage creates a trade-off between profit margins and development rate. Enterprise growth requires finance to support both new investment and working capital. Finance may be generated within the firm (self-financing) or from outside by shareholders or third parties. A corporate policy aimed at generating high short-term returns to the providers of capital (shareholders as well as creditors) reduces the growth of the firm because of its inevitable recourse to funds that would otherwise be used for self-financing. In contrast, a high rate of investment of the resources generated (a high rate of self-financing) broadens the possibilities for growth and the long-term returns.

If corporate returns (and, as a consequence, the returns for the providers of capital) is measured with the ratio between operating income and investment (rate of return on investment or ROI), an investment increase determines a short term reduction of ROI. Even though one of the modalities of investment selection is the exclusion of projects presenting a ROI lower than the average ROI of the firm, in fact, the rate of return of the new investment depends critically on the income that will be realized at project maturity. In the start-up phase, therefore, all new investments tend to have a negative impact on the average rate of return of the firm, because an increase in resources committed is not immediately matched by a growth of operating income. If the reduction in ROI deriving from the new projects takes the firm below a threshold level of profitability, credit institutions may reduce the financial flows to the firm, thereby constraining uts potential for growth.

Wood identifies two groups of subjects that may determine the equilibrium point between short term returns and growth. They are, on one hand, the entrepreneurs, who define the efficiency frontier, i.e. the locus of the efficient combinations of expected returns and growth rates. On the other hand, these subjects are the credit institutions which, with their financing policies, set limits to the strategic choices of the entrepreneurs.

In defining the production and organization structure, the entrepreneur determines the level of efficiency and profitability of his firm. This allows him to define the growth rate of the enterprise for each level of short-term return of the investment. Given a certain level of short-term returns necessary to satisfy the needs of the providers of capital, the level of growth will depend on the level of efficiency that can be attained.

If the firm is totally financed with own capital, the entrepreneur may autonomously determine the minimum rate of return in the short-run and, as a consequence, he may freely choose the rate of growth for his firm. If the firm is in debt, on the other hand, or is forced to seek external financing, the short-run level of the rate of return to investment will have to be sufficiently high to satisfy the requests of the capital providers. The financial market (second category of subjects who can determine the equilibrium level between returns and growth) thus defines the "finance constraint" which sets a limit to the entrepreneur's choices on the growth policies to pursue.

Assuming, for example, that an entrepreneur wishes to invest in a new project, he will face, from the financial point of view, two alternatives: risk capital (i.e. common stock or self-financing), or credit. Once the financing is secured, the entrepreneur will be solely responsible of investment choices in the first case, with no external constraint. In the second case, instead, the release of financing may be conditioned upon a continuous positive evaluation on the part of the bank. While in the first case the analysis of investment choices will be only subject to the evaluation of the entrepreneur,

in the second case it will be subordinated to a positive evaluation on the part of the bank. One of the parameters utilized by the bank for granting credit is represented by the capacity of the initiative to create short term wealth. In this respect, the bank tends to appraise the firm's capacity to reimburse the debt contracted by generating a cash flow. It is thus possible to identify different alternatives:

- The project realized generates a cash flow that allows the amortization plan to be respected;
- The cash flow of the project is not deemed sufficient to cover the amortization plan, but it may give the firm the opportunity to grow in a way that ultimately may allow the repayment of the loan;
- The projected cash flow may not be sufficient to repay the loan unless the firm is carefully steered along the construction stage of the project, so that no other projects are undertaken that may interfere with its debt obligations.

The possibility of obtaining external resources depends critically on the risks of the initiative proposed. The greater project risks, the greater the expected variability of the cash flow generated by the project and, therefore, the probability that these may not be sufficient in every moment to assure the reimbursement of debt. Faced with the greater uncertainty surrounding innovative projects and start ups, therefore, banks require higher cash flows, as if higher risks were at stake , thereby excluding from financing projects with inadequate expected cash flows even when, on an ex post basis, these appear to have been credit-worthy and economically valid as expansion options for the enterprise.

In conclusion, the recourse to external sources of financing may force the firms to secure the financier a short term level of cash flow commensurate to the perceived project risks. This requirement may actively discriminate against projects which, even though characterized by a positive net present value, including an allowance for the risk aversion of the entrepreneur, do not insure a sufficiently high short term level of the cash flow. Even though in theory the bank has no control on the firm, its power to discriminate against the projects without a convenient short term profile may in practice severely restrict the firm strategic choices and severely hamper its innovation capacity.

On the basis of Wood's model, therefore, the capacity of the enterprise to grow by enacting an innovative project is constrained by the following variables:

- Project risks (in terms of what is perceived by the banks);
- Capacity of the project to generate adequate cash flows (or to guarantee a mnimum income) in the short run;
- The degree of financial leverage.

3. Risk and credit supply in the Arab countries

3.1 Islamic Banking

Arab countries present an interesting picture of development and finance, in that on one hand they fully participate to world financial integration, and in some cases are even among the protagonists, while, on the other hand, they have been actively seeking viable alternatives to western banking and traditional credit practices. As a consequence, the Arab world does not only present the usual dualism between the banks and the financial markets, but also, within the banking system, a further dualism between western-like banking and Islamic, i.e. interest-free banking. The prohibition of charging interest or holding/trading in interest-bearing instruments, in fact, has determined since 1400 years ago the preference for equity holdings and for a variety of credit substitutes in Islamic countries. Various financing techniques, originally developed by traditional Islamic jurists since the early days of Islam, have evolved into a credit system which is not based in any way on interest charges to recover credit costs and remunerate financial intermediaries. The fact that interest rates have never been used to recover higher risk charges makes credit rationing almost automatic and, even in the most recent evolution of Islamic banking, rather sophisticated in the use of monitoring and commitment techniques to reduce informational asymmetries and moral hazard. Today, Islamic banking is considered the fastest growing sector in the Arab financial services market. Since the beginning of the 70s, the years where active experimentation of the new system started, an estimated $US 70 billion worth of funds are now managed according to Shari'ah. Deposit assets held by Islamic banks were approximately $US5 billion in 1985 but grew over $80 billion in 1999.

The main principles of Islamic Banking may be summarized under the following headings (Nida ' ul Islam Magazine, 1995):

a) Any predetermined payment over and above the actual amount of principal is prohibited.

b) The lender must share in the profits or losses arising out of the enterprise for which the money was lent.

c) Making money from money is not Islamically acceptable.

d) Gharar (Uncertainty, Risk or Speculation) is also prohibited.

e) Investments should only support practices or products that are not forbidden.

The basic credit contract of the Muslim tradition is called Murabaha (or cost plus financing). It consists of a deferred sale in which a bank purchases the goods and sells them to the customer for a pre-arranged price, which can be paid by installments. In this sense Murabaha is similar to the technique of "Build, operate and transfer" (the so called "BOT") of project financing, since credit is used as a devise to share risks over time between the bank (which finances the first stage of the project) and the sponsor (who finances the second stage). The two stage purchase agreement that results from this typology of contracts has proved to be suitable for a variety of financial ventures, such as real estate investment, purchase of machinery and project financing.

In practice, Murabaha is a form of short term credit, that is considered consistent with more specific forms of lending, such as: a) Loans with a service charge, where no interest charges are levied on the loan, but banks cover their expenses by levying a service charge, which may be subjected to a maximum set by the authorities. b) No-cost loans, where each bank is expected to set aside a part of their funds to grant no-cost loans to needy persons such as small farmers, entrepreneurs, producers, etc. and to needy consumers. c) Overdrafts, which may be provided, subject to a certain maximum, free of charge.

In the ten years since the establishment of the first private commercial bank in Dubai, more than 50 interest-free banks have come into being. Though nearly all of them are in Muslim countries, there are some in Western Europe as well: in Denmark, Luxembourg, Switzerland and the UK. Many banks were established in 1983 (11) and 1984 (13). The numbers have declined considerably in the following years.

While in most countries interest-free banking was created by the private sector, in 1981 in both Iran and Pakistan the government introduced legislation aimed at establishing compulsory country-wide interest-free banking. In Pakistan, starting on January 1st, 1981 all domestic commercial banks were allowed to open deposits on the basis of PLS principles. After a series of intermediate steps, from July 1985 PLS was extended to all existing and new deposits. In Iran, starting on February 1981, banks were prohibited from carrying out operations involving interest. Lending was permitted only on a cost plus basis, with a 4 percent maximum service charge and a 4 to 8 percent 'profit' rate depending on the type of economic activity. Banks were also prohibited from paying interest on deposits, but they were allowed to offer a 'guaranteed minimum profit.' By March 1985, after the introduction in August 1983 of the Usury-free Banking Law, the whole credit industry was converted to a no-interest, PLS system.

While the participatory features of interest free banking may be appealing under several aspects, the loss of a key price-like variable such as the interest rate, creates an informational gap that both debtors and creditors find very difficult to fill. Above all, the key problem created by the kind of lending generated in the PLS framework is that there is no specific provision for investment financing. Bank lending, in fact, is limited to either no-cost loans (mainly consumer loans) including overdrafts, or loans with service charges. Both these types of loans may produce income for the bank only to the extent that they mobilize other sources of revenue, either through services, or through the acquisition of deposits. Investment financing may thus be accomplished only through either trade financing or through partnerships, which are both supposed to be carried out by banks only on a profit and loss sharing (PLS) basis. This is where the banks' main income is to come from and this is also from where the holders of investment deposits (a special type of deposits that are equivalent to shares of investment funds) are expected to derive their profits from.

Musharaka is the second basic Islamic financing technique. It consists of a contract of two or more parties on a joint venture where they contribute capital as well as other factors production and agree to share profits and losses according with a predetermined ratio. In technical terms, Islamic scholars have referred to musharaka as shirka (partnership). Within this broad category, they have distinguished two main contract typologies: sharikat mulk (property partnership), which denotes a joint ownership without joint exploitation, and sharikat 'aqd (contractual partnership), which denotes joint ownership and exploitation.

In parallel to what happens in banking and finance outside the Arab countries, most of the Islamic financial institutions are heavily involved in cost plus financing on a short term basis (Murabahah and Bai Bithaman Ajil), rather than in the partnership contract (Mudarabah and Musharakah). This latter form is clearly a more effective way to address the needs of investment financing. Mudarabah is also known as qirad and muqaradah. It consists of a contract between two parties in which one party supplies capital to the other party for the carrying on of some trade on the condition that the resulting profits be distributed in a mutually agreed proportion while all loss is borne by the provider of the capital.

The bulk of technology financing, specially where innovation is incorporated into machinery, equipment and other tangibles, however, takes the form of a sales contract rather than of a financing contract.

Even though cost plus financing may be interpreted as a loan contract where interest is deprived of some of its speculative components, its pure Murabaha version relies too much on the trading aspect to be really equivalent to loan contract. The consequences of the "split personality" of this kind of short term financing on technology projects may be negative. In fact, while this contract may work relatively well in the cases where credit is sought to buy advanced equipment that can be amortized quickly, it is clearly inadequate in all cases where product or process innovation requires

investment in research, development, prototype building and acquisition of know how. The anticipatory nature of the contract, therefore, is likely to impart a distinct bias in favor of imitation (through the purchase of already made equipment) and against the development of new hardware and software.

The concentration on short-term financing through the Murabahah and Bai Bithaman Ajil (BBA) typology has made most Arab institutions accumulate surplus funds. This represents a form of extreme rationing, partly explainable with the failure to use a price-like variable, such as the interest rate, to select borrowers below the threshold of adverse selection. For example, a research conducted by the New Horizon in UK (a magazine which deals with Islamic Banking and Insurance) suggests that by the year 2000, Islamic financial institutions may have developed surplus funds of more than 30 per cent out of total assets exceeding US $100 billion.

Tables A1 - A7 in the appendix show some of the characteristics of Islamic banking in the various countries. Tables A3 and A4, in particular, show that Murabaha is by far the most common form of credit and that manufacturing finance is a relatively minor proportion of the total, except for the single case of Bahrein. Other figures suggest that long term financing may be less than 15% of total lending for the 20 major Islamic banks. In part, these characteristics may derive from the general features of the PLS system. The preoccupation for eliminating interest charges from the loan contract, in fact, has two consequences. First, it prevents the de-coupling of the sources from the uses of funds, by forcing bank management to allocate savings to investments in a way that allows the imputation of profits and losses from specific investments to specific funds. Second, it does not allow ex ante monitoring activities to be carried out in a straightforward manner. Project evaluation under PLS, in fact, requires a detailed appraisal of both the characteristics of the project and of the subjects providing the funds for financing. If a firm needs fresh funds to exploit an expansion option or a market opportunity of some sort, for example, these funds may be provided only if an additional project may be formulated and appraised.

On one hand, therefore, the PLS philosophy challenges the very basis of banking. This relies on the capacity of the bank to create liquid instruments (deposits and other securities), to finance illiquid investment in real estate, machinery, infrastructure and technology. Because savers are reluctant to relinquish the liquidity of their assets for long periods of time, banks achieve, by pooling short term assets, the capacity to transform liquid claims into illiquid ones. This feat is accomplished because savers are unlikely to want simultaneous access to their assets, they are compensated for the limited loss of liquidity with different interest rates, and the banks reduce transaction costs by standardizing and de-personalizing, through intermediation, the contracts between providers and users of funds. By collecting savings, and turning them into a pool of funds, the banks make possible to respond to third parties financing needs without having to report to deposit holders. Eliminating interest rates, an operation that seems innocuous per se, if interests are substituted by service charges, in reality may render the bank unable to provide funds to enterprises and investors, unless viable alternatives are identified to remunerate funds collected from the public. In non

Arab countries, cooperative institutions, such as credit unions, have indeed been operating side by side with regular banks by paying "dividends" to depositors, so that at least this alternative seems already solidly established.

It seems a priori plausible that small scale businesses and innovative firms may have been hit particularly hard in the early stages of the establishment of the PLS system. The observations of Iqbal and Mirakhor (1987) are revealing:

"Given the comprehensive criteria to be followed in granting loans and monitoring their use by banks, small-scale enterprises have, in general encountered greater difficulties in obtaining financing than their large-scale counterparts in the Islamic Republic of Iran. This has been particularly relevant for the construction and service sectors, which have large share in the gross domestic product (GDP). The service sector is made up of many small producers for whom the banking sector has not been able to provide sufficient financing. Many of these small producers, who traditionally were able to obtain interest-based credit facilities on the basis of collateral, are now finding it difficult to raise funds for their operations."

On the other hand, the PLS system does not share the most conspicuous sources of inefficiency of banking credit, such as adverse selection and agency costs. Because interest rates are not used as a rationing variable, even for limited groups of perspective lenders, Islamic banking suffers to a much lower extent of the ex ante informational costs that characterize ordinary banks. As a consequence, it should be able to secure credit to innovative enterprises more quickly and efficiently than ordinary banking. Furthermore, because of the participatory nature of the credit contract, ex post inefficiencies should also be attenuated, with an emphasis naturally taken by built in incentives (commitment) with respect to monitoring, banks' oversight and their unavoidable consequences in terms of bad will, moral hazard and over and underinvestment incentives.

In sum, against more pervasive rationing and more severe credit restrictions for investment and technology, Islamic financing may present some advantages for innovative firms and high technology development. While it is likely that higher risks and transaction costs will be associated with each financing operation, each investment is more likely to be considered on its own merits and a relationship between the bank and the firm may be more easily constructed. Short term requirements on the cash flow, risk aversion considerations and harder rationing, however, may be expected, at least until the institutional arrangements are sufficiently developed. As a consequence, we should expect more stringent restrictions to credit to prevail, and harder life for start ups and innovative enterprises.

3.2 Non banking Intermediaries

In most Arab countries financial intermediaries and investment allocations are subject to direct government influence and control. Only in Jordan and in Egypt, even though government influence remains heavy, public control is indirect and less pervasive. In Egypt, the resources of the social security system are managed by the National Investment Bank, with most financing going to public projects. Malaysia, which follows a similar pattern, has the merit of paying positive real rates of interest to individual accounts. Tunisia and Morocco, on the other hand, require contractual savings institutions to hold low yield government paper and invest in low income social projects.

Table 1. Equity Markets in Selected Countries (% of GDP)

	1980	*1985*	*1990*	*1993*
Netherlands	18.6	38.7	39.2	61.4
Sweden	10.6	32.8	38.6	61.8
Switzerland	44.4	82.0	66.0	117.2
UK	37.1	63.6	79.9	123.3
US	45.7	57.6	56	82.4
Chile		13.9	59.6	103.6
Malaysia		50.7	113.4	365.1
Singapore		60.1	90.4	239.5
South Africa	123.9	115.1	127.6	152.5
Egypt		4.9	5.0	9.7
Jordan		44.7	49.8	87.3
Morocco		1.9	3.7	9.9
Tunisia		6.8	4.3	6.5

Source: International Finance Corporation

Table 2. Value of Equity Trading in Selected Countries (% of GDP)

	1980	*1985*	*1990*	*1993*
Netherlands	3	11	13.2	22.7
Sweden	1.4	8.4	6.6	25.1
UK	6.6	13.3	26.2	45.3
US	15.1	24.7	32.9	55.3
Chile		0.4	2.8	6.5
Malaysia		7.2	25.4	254.7
Singapore		7.6	53.5	147.3
South Africa	6.6	5.8	7.6	11.5
Egypt		0.3	0.2	0.2
Jordan		3.2	10.1	24.6
Morocco		0.1	0.2	1.9
Tunisia		0.1	0.1	0.3

Source: International Finance Corporation

Depressed investment opportunities and infant capital markets thus characterize most Arab countries (Tables 1 and 2), with the notable exception of Jordan, whose equity trading, since 1993, is already comparable to some European countries. As Tables 1 and 2 show, Asian equity markets are much more developed in countries with Islamic traditions, where business conditions and investment opportunities may even be more favorable than in continental Europe or the USA.

According to econometric studies conducted at the World Bank, Levine and Zervos (1995) found that the size of the equity market and the volume of trading are robust indicators of market efficiency, low transaction costs and market liquidity. They further found that countries with more developed equity markets and more intense activities of non banking intermediaries were, coeteris paribus, better performers in terms of capital accumulation, long term growth, and efficiency. While this evidence appears to be convincing and, indeed, compelling, it is difficult to predict whether the current trends of growth of capital markets in Arab countries will proceed in the direction of the development of a vital and productive structure. Although the preference for participatory financing should be strong in a culture which objects to interest lending, the financial resources of domestic origin are still trapped in large bureaucratic institutions (public banks and insurance companies), while foreign capital is subject to discouraging restrictions and controls.

Some countries, however, appear to be moving in the right direction. In Jordan, for example, the Social Security Corporation is a large institutional investor enjoying remarkable freedom from government interference. Even though its investments have been constrained by highly conservative policies by the shortage of attractive investment opportunities, it may be considered a great potential for investing in new companies and financing innovation.

In Egypt, since the early '90s, a number of incisive measures have been taken to revitalize the capital markets, with special emphasis on the market for corporate equities. The development of the stock market has been stimulated by the enactment of new and comprehensive legislation, the strengthening of the CMA (Capital Market Authority), the inflow of foreign capital, and an aggressive privatization policy. New listings and IPOs also showed a remarkable increase, with market capitalization reaching 20% of GDP in 1996, from10% in 1993, and trading activity 3.4% of GDP, from 0.2% in 1993.

As a consequence of the fact that savings are trapped in low yield investments and managed under government interference, venture capital and other sources of business financing have not seen a significant development in Arab countries. In spite of the tradition of PLS financing and of the fact that most of these countries have established the legal framework for the operations of financial intermediaries specialized in risk capital, the development of the private sector and its involvement in finance still requires major changes to exploit the virtuous circle between finance and innovation (Levine and Zervos, 1995). The bulk of Arab countries, in fact, still lacks the basic conditions required for an efficient and stable financial system (Honohan and Vittas (1996) :

(1) an operationally autonomous central bank;
(2) private commercial banks and other financial institutions operating as profit centers and are not captive of their borrowers or the government;
(3) an adequate legal and administrative framework.

4. Financing the "new economy"

4.1 The main features of the new scenario

The so called "new economy" has received much attention as one special type of innovative enterprising both for technology and financing. What is meant by "new economy" is not altogether clear, but three main elements stand out as its characterizing features: (i) the use, at the same time intensive and diffused, of the modern information and telecommunication technologies (the so called ICT's), (ii) the prevalence of the network structure inside and outside the firm, (iii) the absolute importance of knowledge and information in determining competitive advantage. For many aspects, we may interpret the vertiginous changes of industrial organization, by hypothesizing that we face a second post-fordist revolution (PF). This hypothesis is justified by the fact that the so called "internet revolution"(IR) displays, within a broadly different context, numerous elements of similarity with the processes of deverticalizing and reorganizing the firm that have characterized the 80's and the 90's.

The point of departure, in IR as in PF, is given by the exhaustion of some important scale economies. In the PF case, these were mainly directed to the fact that the assembly line could be substituted by more flexible production tools, capable of insuring a larger and more pervasive automation, greater modularity and, as a consequence, an ever increasing recourse to outsourcing. In the IR case, the disappearing scale economies are linked to transaction costs. These costs become so low on the electronic network, that one might possibly state that they threaten the very existence of the firm (at least as a nexus of standardized contracts in the Coasian tradition). Entry barriers shrink, since they depended on the fact that the firm was forced to put together, to start its business, a critical mass of resources, precisely to exploit the scale economies generated by its functioning as a broker of contracts on various markets.

The loss of the traditional scale economies, in IR as in PF, appears to translate itself into a push towards a reduction of the size of the firm and the increase of outsourcing. Here, however, some important differences emerge. In PF, the reduction of firm size was aimed at transforming the old firm into a network, with the so called "core business" at its center and, around it, a series of more or less captive subcontractors. The PF organizational model is similar to a small solar system, dominated of what is left of the traditional firm (transformed into a center irradiating strategic knowledge), with many planets and satellites. These are situated at various distances from the center, according to their strategic importance, the degree of captivity and other characteristics. The PF mode of production has thus been associated with *de-localizing*

and *de-centralizing* phenomena, since the traditional firm, in addition to perceiving the end of scale economies, is stimulated by the possibility of exploiting the economies of scope through outsourcing, and, by using a plurality of subcontractors, of optimizing a sort of extended location, given the space structure of prices, wages and transportation costs.

On the whole, the post-fordist revolution, even though it has signed a fundamental step forward in the conquest of new spaces to increase the productivity of the firm, at the same time has been an organizational revolution based an exploiting inequality across laborers and geographical areas. It has primarily concerned the firms that were already operating, and, by differentiating the workers by the degree of strategic knowledge, has created new classes of insiders and outsiders. It has also stratified the firm over space, creating new classes of areas less developed, depressed and trapped within low level equilibria (many "local Koreas"). It has been limited, in its capacity to de-verticalize the firm, by the persistence of scale economies in the distribution, publicity, marketing and finance. Finally, it has created company networks, but has not affected the traditional structure of the market, except in a minor form: almost always the subcontractors remain "captive" of one or more mother companies, and outsourcing networks mostly remain both vertically and horizontally small.

In some regions of the world, in particular, PF has given some impulse to a new process of "light" industrialization. It has mostly done so, however, by dissolving the traditional firms, too large and inefficient, and exploiting characteristics such as low salaries, fiscal evasion, the availability of low cost skills in the areas of craftsmen and non specialized intellectual labor. The construction of penetrating networks for outsourcing, which has concerned many Mediterranean countries, for example, has been associated with a new development of the "underground economy" in all its different shades (from the gray to the black. This has occurred with a sort of "unholy" pact among the firms of Northern and Central Europe. These firms remained in the formal economy, prosperous and law abiding in the control of the "superior" phases of the production cycle. At the same time, they were amenable to de-localize in the less developed areas of Europe and in the Middle East, North Africa the "lower end" production phases, without being too fussy on the ways that the subcontractors used to reconcile the quality of the products requested with the prices paid.

The activity of enterprise creation, furthermore, even though notable in size and dynamics, showed two main negative characters. First, the competitive advantage of the new firms often depended on their capacity to evade taxes and elude labor legislation to survive. Second, both from the point of view of marketing and credit, the firms created were completely dependent on the mother companies, with very limited perspectives of growing out of such dependence. This process and these characteristics are emblematic in the Mediterranean countries such as Tunisia and Morocco, that constitutes a sort of enclave within an industrial economy such as the European Union.

In partial contrast with these characteristics, the IR appears to have found an angle of success based on additional economies with much greater potential and, what is more important, with end results much more virtuous on the industrial structure of the less developed areas. In the first instance, in fact, the reduction of firm size, which is linked, but not totally identified with deverticalization, in the case of IR is based on the disappearance of barriers to entry. The network is in fact available to all, practically at zero cost. Furthermore, it is increasingly easier to find financing for the new firms and the present euforia renders this financing even more attractive. The development of e-commerce and of its interbusiness components (the so called b2b) will make possible a network of subcontractors to outsource any business. This implies that the degree of captivity of the small subcontractors will diminish drastically. But also the scale economies linked to marketing and the related entry barriers appear destined to dissolve. The possibility thus transpires of a global network constituted of small firms, with very low entry costs and highly competitive with one another on both products and processes: something very similar to the paradigm of perfect competition dear to the heart of the neoclassical economists.

The characteristics of the network are, in effects, the most interesting elements of this new revolution. As we have already mentioned, the IR network is different from the PF network mainly because, instead of being a network embedding a plurality of independent networks, it tends to integrate even the smallest unit as a full member of the total network. The emerging structure thus tends to be a network whose constituent parts are individual subjects, and where everybody tend to develop connections and is potentially connected with everybody else. The scale economies (the so called "network" economies) of such a network are thus the largest possible ones: they are of the same type of the other single largest individual network that we have experienced, that is, the telecommunication network. Not surprisingly, telecommunications are the basis of Internet, which is, however, a much more complex and dynamic graph, where knots and links display an intensity of proliferation an intrinsic stability, greatly transcending the pattern of fixed or mobile telephone connections.

The PF revolution has been, for many aspects, a computer revolution: numerical control machines, automation and development of programming and control have all conspired to give the computer a crucial role in re-organizing the firm. The computer technology has led the process of de-verticalizing the Fordist company, by forming a network of firms integrated by a virtual texture of computerized programs and controls. In this phase, the role of Internet has been, everything considered, marginal, while intranets and the other tools of enterprise integration have proliferated. It is not thus surprising that this phase of industrial transformation has also been characterized by an expansion of computing capacity, the personal computer has taken off, becoming ever more powerful, lighter and inexpensive.

In an economy characterized by a global network, however, the computing power of the individual units is less important, because it is the network itself that presents the greater potential to contain and elaborate information. Communication capacity becomes thus critical. A reasonable prediction, even though not agreed on by everybody, is thus that IR, in spite of having based its take off on the development of "computing power" and of personal computers, will be itself the main cause of obsolescence of the present combination of computing power and communication capacity. Computers will become increasingly "stupid", even though smaller and lighter, and will instead develop capacity for speedy interaction, which they lack now. The network, in turn, will grow like an enormous super-computer capable of utilizing the power of the million (billion?) machines permanently connected. Together with the development of new "speed" telecommunication methods, based on a pletora of new technologies that are just entering now the scene, Internet could evolve, and this is the right word, because of the unpredictable and mutation-like character of these developments, into the ultimate communication technology. Something that, like language, connects all men, instantly, but is infinitely less constrained than language by linguistic and geographical barriers. The battle for the new standard, the so called "wide band", has to be understood in this perspective: a telematic network of permanent connection, like the electrical network, where, however, marginal connection and communication costs are truly zero.

4.2 The financing sources

As a spectacular example of inversion of the traditional financing "pecking order", Internet companies have resorted to conventional credit in very limited amounts and, at least during the "boom" years, were mostly financed by venture capitalists, with IPOs coming very fast after the first deal between the financial partners was struck. The venture capitalists responsible for most of financing were a handful of financial houses and investment banks that still dominate the market, and the risk, of the new business. These firms, who were often strategic partners for the new ventures ranged from VC kingpin Kleiner Perkins Caufield & Byers to Japanese renegade Softbank and built networks of companies that are often referred to as Keiretsu.

Kleiner Perkins is perhaps the most important venture capitalist on the Internet market, with a record of financing that includes, among others, Netscape, Amazon, AtHome, Excite and many others. Others that can be cited are: Benchmark Capital, with investments in companies like eBay, Ariba and Critical Path, Sequoia Capital that invested in Yahoo, Vulcan Ventures, Idealab and Softbank and few more worth mentioning.

These venture capitalists (VC's), however, do not work alone. While they specialize in identifying the firms with highest potential and helping them developing their strategies, they have to resort to different specialists when the time is come to bring the new born to the market. Goldman Sachs and Morgan Stanley Dean Witter are the top investment banks to back and advise the best Web companies that want to go public. Just behind them is Credit Suisse First Boston and, as the best "technology" financial boutique Hambrecht & Quist.

The role of venture capitalists in financing the Internet firms has been critical for more than one reason. First, VC's have played a broad function for "picking the winners". This has been achieved by actively searching for ideas and companies with the highest potential, by investing in networks and strategic partnerships, and by developing imaginative ways to combine venture capital with different and new forms of financing.

The main indicator of success in these different strategies is the exit of the IPO's. Some of the most spectacular deals occurred in the summer of 1999. For example, Benchmark Capital , one of the leading VCs based in Menlo Park, California, in 1999 scored two peaks: Red Hat, whose IPO in August offered shares at $14 and closed its first day of trading at $52.06 a share, and Ariba, which in June offered 5 million shares at $23 each and saw them close at $90 the same day. In July, the public sale of Net2Phone shares, handled by H&Q, from an offering price of $15 a share scored $26.50 on the first day of trading, with shares soaring afterwards as high as $92.63. handled. In June and July, juniper Networks and Drugstore.com, both backed by Kleiner, respectively soared from a $34 opening price to $98.88 at the close of the day; and from $18 per share to $50.25 at the close of the first day of trading.

More successes and special deals followed through the rest of 1999 and the first part of 2000. At the end of this year, and in the first three months of 2001, however, the bubble burst, with Internet stock prices falling at rates and speed which were almost as spectacular as the earlier rise. Much of this fall was due to the growing evidence of companies under-performing in terms of growth and revenues with respect to investors' expectations. Financing appears to have played a role, however, since the earlier euphoria had been based on the belief that companies might almost do away with credit financing. As the price of the stocks fell, Internet companies found that they had very hard time in obtaining credit from ordinary credit sources. Extraordinary sources, such as corporate bonds and other market-linked deals were precluded by the loss of reputation created by the revenue warnings and the fall in the prices of their previously overvalued stock. A significant part of earlier financing, on the other hand, had been obtained through convertible bonds and other types of options, which, once left unexercised by investors, turned into further loads for their income accounts and balance sheets.

5. Government policies

5.1 Principles of Government Support

Partly through the credit system, partly through subsidies and direct interventions, Governments attempt to support technological innovation through several policy instruments. These may be grouped into three main categories (Lamborghini, Sacchi,1990):

- Direct support
- Indirect support
- Support of research structures.

In the first group we can comprise: (i) non selective incentives through subsidized credit, (2) the selective incentives in special sectors or technologies and in particular areas or enterprises through credit and capital subsidies, (3) the public purchase of technology services. Among the instruments of indirect support, on the other hand, we find: (1) fiscal incentives, (2) patents and protection of intellectual property rights, (3) technical and organizational advise and assistance. Finally, intervention on research structures include the support of a network of national R&D institutions, the setting up and the financing of grants for research and development, and other policies to promote and support research centers.

From the point of view of their modus operandi, support policies may be classified into three different categories:

- *Financial policies:* i.e. the financing or the co-financing of R&D expenses, acquisition of innovative machinery, introducing innovative processes.
- *Innovation services:* i.e. direct interventions to assist or advise the firms in the adoption of innovative processes, or the planning of innovative strategies.
- *Network creation strategies:* i.e. developing services to support the creation of networks of enterprises to share communication, information and stimulate the dialogue on new technologies.

The analysis of the innovation policies utilized by the European industrial countries reveals two different approaches: Italy and Great Britain on one hand, who have for long time favored policies of financial incentives, and France and Germany on the other hand, who have given much more emphasis to innovation networks.

In this respect, the French structure is notable, since the network service model dominates local and central agencies. The national structure is organized as a central agency called ANVAR (Agence Nationale de Valorization de la Recherche) and local agencies denominated CRITT (Centre Regionale d'Innovation e transferiment de technologies) and Technological Parks.

ANVAR supplies existent and new enterprises with technological know how. In particular, ANVAR provides assistance in elaborating business plans and evaluation for innovative technologies, it develops research activities and helps arranging special loans credit for the development of process and product innovation. These loans are granted without interest and are re-payd only in case of commercial success of the innovation. The role of ANVAR is thus to reduce the financial risk of the innovation project, by making the relation between risk and return more favorable to the SME.

The local agencies, called CRITT, are organisms participated by the State, the local governments and the enterprise associations. They usually specialize on given sectors, and operate mainly to favor the linkage between research centers and enterprises. Their greatest resource is a wide data base, containing all the characteristics and technological needs of the firms, the research projects under way and the products developed by the research centers. This data base, which is updated every six months through direct surveys and visits of specialists, is a key factor in establishing contact between demand and supply of innovation.

A networking role is finally played by the Technology Parks. These are areas where different subjects, such as universities, research centers, financial agencies of various sorts, firms, public bodies, meet to promote and coordinate the development and diffusion of technological innovation.

Unlike the French case, the financial approach is the main emphasis of British innovation support policies. In Great Britain, in addition to several financial programs through the government agencies and the commercial banking system, the main operator for the broader support of innovation is a non-profit entity, denominated PERA (Production Engineering Research Association). This entity supplies services in the different area of relevance for the development and the adoption of new technology (research, development, consulting services, information and training).

5.2. The experience of science and technology parks

The experience of the science and technology parks (STP) originated in The United States in the 50's, the first example being the structure realized in Stanford (California) in an originally unused area owned by the university. In response to a policy of open access on the part of the university, enterprises started by ex students or professors were located in the area. As an out-fall of that experience, in the early 70's, the so called Silicon Valley emerged, as a concentrated of enterprises, university and research centers, unique in the world for the sheer size of the phenomenon, in terms of quantity and quality, and for its capacity to attract new research and production forces.

The concept of STP has been followed by several countries and has been adapted to the needs and the characteristics of the reference area, giving rise to many structures. These were often very different from each other, in terms of organization, instruments utilized and operational strategies. While they all share the goal to encourage and facilitate the processes of innovation and technological transfer, their development has caused an intensive activity of analysis of the alternative models emerged, with the intent of discovering the most successful patterns of organization.

The OECDE defines STP's as "territorial concentrations including contiguous areas where technology related activities are carried out, such as research, development, protype production, jointly with all direct support services". According to an alternative definition, due to Rowe, an STP is an initiative of tertiary development that:

- Has formal and operational linkages with a university, an institute of high level education or an important research center;

- Is designed to promote the creation and the growth of productive activities and organizations, normally localized in the area, based on knowledge;

- Benefits of a management function actively engaged in the transfer of technology and management capacities needed for local enterprises.

The European Union, on its part, has tried to generate an official classification of the various bodies sharing the goal of research and technology transfer, by focusing on their core business. The following subspecies have thus been identified (UN Official Bulletin NC 186/51, July 27th 1990):

- The *Science Park* is generally located in a University campus and essentially specializes in activities of research, development, product design and development of prototypes. In such a structure only rarely the production and marketing phases appear.

- The *Research Park* is also located in a University campus, but is characterized for the absolute commitment to research and the exclusion of any production related activity.

- The *Technology Park* is composed of enterprises engaged in the commercial application of advanced technology. It is committed to activities of research, development, and production, marketing and technical assistance. The production activity is thus primarily important, while the presence of the University is not essential.

- The *Innovation Center*, through financial, technical and administrative assistance, promotes the creation of advanced technology SMEs.

- The Business Park, which does not require the presence of a university, is engaged in producing, assembling, selling and managing activities, with the goal of creating a high quality environment for enterprise creation and growth.

- The Business Incubation Center (BIC) is a center housing, in a limited space, new enterprises. It offers them material (physical space, common facilities, network resources) and immaterial infrastructure (technical services, marketing support, management advise, financial counseling).

Scheme 1. UE Classification of STPsi

A. Science Park:

A science park is an initiative that:

- *is located in geographic proximity of high education institutes or advanced research centers and displays operational links with these organisms;*

- *is committed to encourage creation and growth of enterprises based on new technology;*

- *actively promotes the transfer of technology from academic and research institutions to the enterprises located in the park.*

- *It often includes a real estate development, which, by virtue of its proximity to a university or a research center, or simply of its pleasant setting, is attractive to new or existing activities with a technological resource base, or to R&D departments of large corporations (LC's). ScienceParks main functions are research activities, development and project design, invention, experimentation and development of new products up to the production phase.*

- *The R&D work implemented in the park is often limited to elaborating prototypes, while production is carried out elsewhere. In a few cases, however, some advanced technology components are produced within the park.*

B. Research Park:

A research park is normally located near a university or a research center, Its activities are mainly research rather than development, while the characterizing element is constituted by the link university-research with elements of absolute excellence in science and technology.

Scheme 1 (cont.)

C. Technology Park:

A technology park comprises firms engaged in commercial application of advanced technology, with activities including R&D, production, sale and assistance. A technology park differs from a science or a research park for the importance of manufacturing activities. Participation of academic institutions is not crucially important. The park satisfies specific infrastructural needs of high technology enterprises, with prevalence of non productive with respect to productive activities. The academic link is generally less important than for science and research parks. Admission to the park may be conditional to developing production and/or high technology activities.

D. Innovation centers:

An innovation center is aimed at satisfying the needs of new enterprises engaged in developing and marketing new products and technological processes. These will be characterized by relatively high market risk and will need, for a successful development, not only assistance and advice, but also a local network of financial, assistance and research institutions. The main purpose of an innovation center is to promote the creation of advanced technology enterprises. The services provided include consulting on finance, marketing and technology, as well as technical services (for example secretary). The innovation centers are specially aimed at promoting SME's. Sometime they are part of wider projects, such as science parks.

E. Business incubators:

A business incubator is a center which concentrates, within a limited space and for a limited period of time, new enterprises. Its objective is to increase development possibilities and survival rates of new enterprises through by supplying them facilities and real services. Its main goal is to favor local development and job creation. The technology component may be marginal.

F. Business parks:

Business parks provide a high quality environment, for a wide range of activities such as manufacturing, assembling, sales/ expositions and many administrative activities. They do not based on the proximity with academic institutions.

Source: Salvio, 1993.

STPs historical origin is also very diverse. In the USA, in fact, the main technology parks (Stanford Research Park, California, Silicon Valley, California, Research Triangle Park, North Carolina and Route 128, Boston, Massachusetts) originated in the 50's from private business ventures. In Europe, instead, the public sector has been in the forefront. In Great Britain the most important parks (the Aston Science Park in Birmingham, the Cambridge Science Park in Cambridge, the Heriot-Watt University Research Park in Edinburgh) were created by a public policy that encouraged the enterprises, through financial subsidies, to start R&D activities in the high technology sectors. A characteristic of British parks, which distinguishes them from other European parks, is the active presence of financial institutions, such as the Lloyds Bank and the Barklay Bank. These institutions have granted credit to R&D operations, on the basis of criteria that differ from those generally applied for other business loans. These criteria take into account the higher risk and longer pay out period of research ventures.

6. Conclusions

Financing technology poses a special challenge to economic institutions for several reasons. First, the uncertainty surrounding all the investment decisions is particularly acute and pervasive in the case of R&D, as well as developing and testing process and product innovation. Greater uncertainty spurs more highly asymmetric information on both sides of the financial deal, thus rendering contracts more difficult to negotiate, enforce and take successfully to completion. Further problems arise from lack of credit history for innovators, weak property rights and difficulty of supervising and monitoring increasingly intangible technologies.

Secondly, while the banks appear to have an important role to play, for many types of innovative businesses, they cannot be the sole source of financing. Indeed, in all advanced countries, regardless of the prevalence of the banking or the equity markets in their tradition, several operators have evolved that specialize in providing risk capital, combined with management skills and financial advise, to start ups and high tech ventures. Among these operators venture capitalists and business angels figure prominently and, unlike banks, do not approach financing with their "hands off", but rather with "hands on " and "gloves off". They appear to be a critical element of success in the difficult and risky enterprise of recovering and providing fresh resources to finance innovation.

Thirdly, technology ventures appear to face a basic trade off between profit and growth, which may be exacerbated by a difficult relationship with a credit institution. For this reason, combined with the harder rationing of credit on the part of the bank, innovators generally prefer to invert the traditional order of financing sources. They thus favor resorting to equity over debt financing, even though this may involve loss of control or, at the very least, heavy interference in managing the firm on the part of outside financiers. It is indicative, in this respect, that most of new capital in the US equity market has come in recent years in technology stocks. In this framework, the

financing of Internet firms, at least in the first, most euphoric phase of growth of the NASDAQ, has been accomplished with risk capital and only a minimum resort to debt.

On the other hand, the high tech financing story is still unfolding and it is difficult to predict its end. The most recent fall in equity values of technology stocks has brought traditional debt on the forefront again, but imaginative financial innovation may be needed to savage the "new economy".

Fourtly, the US market still appears to be leading as a financial center capable to provide imaginative solutions to provide funds to start ups and innovation. These solutions are being adopted by all countries in the world both because they are effective and because, in a context of globalized financial markets, the leading country is rightly or wrongly regarded as an example of best practices. Even in the USA, however, financing technology poses dificult problems in terms of adequacy and diversification of supply. Traditional credit problems such as adverse selection and agency costs appear magnified and recurrent crises spurred by financial bubbles and over-inventive intermediaries also seem to be endemic. While equity financing certainly holds the bigger promise for high technology and new products, its incarnation for small business and start ups still leaves much to be desired.

What are the conditions of the Arab countries in this context of development, difficulty and partial disarray? On the one hand, because of the traditional Islamic attitude towards interest bearing credit, debt financing was not, to begin with, popular with them even when few alternatives were available. Profit and loss sharing (PLS) does provide an alternative which may be attractive, in addition to its ethical features, because it may be free from some of the distortions that prevent traditional banking from providing efficient financing to innovative business ventures. On the other hand, while Islamic banking remains an interesting challenge, neither its variations, nor traditional banking appear todate to give adequate support to enterprise creation and technology investment. Capital markets, even though very unequally developed in different countries and often handicapped by government intrusiveness, seem to be more promising. Establishing the economic and the legal framework to develop these markets, however, does involve a fully functioning financial system, with an autonomous central bank and commercial banks and industrial business in the hands of the private sector.

From a policy point of view, it is important to enphasize that the hystorical experience shows that a market system requires a critical mass of financial institutions and that a certain degree of diversification and specialization is not only desirable, but, probably, necessary. Large monopolistic institutions, that derive their power to collect funds from a publicly endowed position in the national welfare system may be a drag on financial markets and an obstacle at developing the critical number of actors needed to put in motion the economy. Barriers to risk taking in the form of norms and regulations to maintain a minimum degree of asset liquidity may be justified for lenders of last resort, but act as disincentives to innovative business when they are applied to banks or pension funds. Similar stifling effects derive from forcing holdings of government paper on a less than autonomous central bank and the related banking system.

Does the government have a role in this respect, in addition to the obvious one of engineering the reforms, privatizing and liberalizing the economy and providing those "market friendly " policies that should help the economy to find its new course? The experience of developed countries shows that technology is perhaps the one sector where the government may exercise, without fear of going wrong in a major way, imaginative policies to promote and support innovation. While it is hard to draw a final account, the experience of government support of R&D, for example, has produced a number of centers of excellence, valuable technology transfers, active financing, and a series of structured interventions that appear, by and large, both successful and promising.

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APPENDIX 1

SOME DATA ON ISLAMIC BANKING

Source: *Sudin Haron, A Comparative Study of Islamic Banking Practices, School of Management, University Utara, Malaysia, 1999*

Table A1: List of Sharia Principles Practiced in Selected Islamic Countries.

Category Countries	(A)	(B)	(C)	(D)
Bahrain	*Musharaka*	*Morabaha* Commission Service charges	*Qard hassan*	
Bangladesh	*Al-mudaraba* *Musharaka*	*Bai-mua'zzal* *Bai-salam* Hire-purchase *Ijara* *Murabaha* Commission Service charges	*Qurd-e-hasana*	*Wadiah*
Iran	Civil partnership Legal partnership Direct Investment *Modarabah* *Mozaarah* *Mosaqat*	Forward delivery Transaction Instalment sales *Jo'alah* Debt trading Hire-purchase	*Qard al-asanah*	
Jordan	*Mudaraba* *Musharaka*	*Morabaha* Commission Service charges	*Al-qird al-hassan*	*Wadiah*
Kuwait	*Mudaraba* *Musharaka*	*Morabaha* Commission Service charges *Istisna* Leasing	*Qard-hassan*	
Malaysia	*Al-mudharabah* *Al-musyarakah*	*Al-murabahah* *Bai bithaman ajil* *Bai al-dayn* *Al-ijarah* *Al-ijarah thumma al-bai* *Al-wakalah* *Al-kafalah* *Al-hiwalah* *Al-ujr*	*Al-qardhul hasan*	*Ar-rahn* *Al-wadiah yad dhamanah*

Table A 1 (Cont'd)

Category Countries	(A)	(B)	(C)	(D)
Pakistan	*Mushrika* Equity participa-tion and purchase of share Participation term certificate (PTC) *Modarabah* certificate Rent sharing	Mark-up Purchase of trade Bills Buy-back arrangement Leasing Hire-purchase Development charges Loan with service Charges	*Qard-e-hasna*	
Sudan	*Mudaraba* *Musharaka*	*Morabaha* *Ijara* Commission Service charges	*Qard hassan*	
Tunisia	*Mudaraba* *Musharaka*	*Morabaha* *Taajir* Commission Instalment sales	Interest free	
Turkey	*Mudaraba* *Musharaka*	*Morabaha* *Ijara* *Irara wa-iktina* Commission Service charges	Interest free	Trust
UAE	*Mudaraba* *Musharaka*	*Morabahat* Service charges	*Qard hassan*	

Notes:

(A) Profit and loss sharing principles,
(B) Fees or charges based principles,
(C) Fees services principles,
(D) Ancillary principles.

Sources: Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's CAD letter dated 21 March 1994, Iran: The Law for Usury-Free Banking 1983; Jordan JIB's 1993 Annual Report; Kuwait: KFH's 1993 Annual Report; Malaysia: Money and Banking, Bank Negara Malaysia 1994; Pakistan: State Bank of Pakistan's BCD Circular no 13, 20th June 1984; Sudan: Ahmed, 1990; Tunisia: B.E.S.T Bank's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

Table A 2: Deposit Facilities Available at Islamic Banks in Selected Countries

Bahrain	Current accounts Inv. accounts Saving accounts Fixed term
Bangladesh	Current accounts PLS accounts: Saving Term deposit Short notice Inter-bank deposits
Iran	QH Current accounts QH Savings accounts Time or investment deposits Inter-bank deposits
Jordan	Trust accounts: Current Demand Joint inv. account: Saving accounts Notice accounts Fixed accounts Specific inv. accounts Inter-bank deposits
Kuwait	Current accounts Inv. accounts Saving accounts Limited period Unlimited period
Malaysia	Current accounts Saving accounts Investment deposits Other deposits Inter-bank deposits
Pakistan	Current accounts Savings deposits Fixed deposits Other deposits
Sudan	Current accounts Saving accounts Inv. deposits
Tunisia	Account at call Inv. accounts: PDA Saving (*tawfir*) Time deposits

Table A 2 (Cont'd)

Turkey	Special current account PLS *"Modaraba"* accounts
UAE	Current accounts Saving accounts Inv. deposits: *Muddharabah* Specified

Notes:

Inv. : Profit and loss sharing principles,
QH : Fees or charges based principles,
PLS : Fees services principles,
PDA : Ancillary principles.
CPD : Committed participating deposit.

Sources: Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Iran: BMI's 1992 Annual Report & Hedayati (1993); Jordan JIB's 1993 Annual Report; Kuwait: KFH's 1993 Annual Report; Malaysia: BIMB's 1994 Annual Report; Pakistan: MCB's 1993 Annual Report; Sudan: El Gharb's 1993 Annual Report; Tunisia: BEST's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

Table A3: The Modes of Financing and its Composition by Islamic Banks in Selected Countries.

Country		%	Total	%TA
Bahrain	*Musharaka* *Murabaha* *Qard hassan*	4 96 *	100	88
Bangladesh	**Musharaka** Hire-purchase *Murabaha* *Bai mua'zzal* *Qard hassan* Others	3 13 51 19 4 10	100	57
Jordan	**Musharaka &** *Mudaraba* *Murabaha* Promissory Note *Qard hassan* ***Others***	3 44 11 * 42	100	58
Malaysia	**Musharaka** *Mudaraba* *Ijraa* *Murabaha* *Bai mua'zzal* *Qard hassan* ***Others***	2 * 9 18 68 * 3	100	33
Tunisia	**Musharaka** Leasing *Murabaha* Installment sales ***Others***	7 19 54 20 *	100	68
Turkey	**Musharaka** *Ijarah* *Murabaha* *Qard hassan* ***Others***	1 17 61 * 21	100	87
U.A.E	**Musharaka** **Mudaraba** *Murabaha* **Others**	2 2 85 11	100	70

Notes:

1 : TA: Total assets
2 : * Less than 0.5 percent
3 : No figures available MBI of Iran, KFH of Kuwait, MCB of Pakistan, and El Gharb of Suda.

Sources: Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Malaysia: BIMB's 1994 Annual Report; Tunisia: BEST's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

Table A4: The Distribution of Financing by Sector of Islamic Banks in Selected Countries.

Country		%	Total
Bahrain	Trading	6	100
	Manufacturing	58	
	Real estate	16	
	Agricultural	2	
	Services	1	
	Financial Insts.	17	
Bangladesh	***Commercial***	65	100
	Industrial	28	
	Real estate	3	
	Agricultural	*	
	Transport	2	
	Others	5	
Iran	***Commercial & Services***	43	100
	Industry & Mining	18	
	Construction & Housing	27	
	Agricultural	7	
	Others	5	
Jordan	***General trade***	28	100
	Industry & Mining	9	
	Construction	10	
	Agricultural	1	
	Transport	2	
	Miscllaneous	50	
Malaysia	***Wholesale & retail trade***	6	100
	Manufacturing	24	
	Construction	8	
	Real Estate	9	
	Agriculture	4	
	Transport & storage	1	
	Miscellaneous	45	
	Business services	2	
	Others	1	
Turkey	Metals	21	100
	Petro-chem	6	
	Textile	13	
	Constructions	5	
	Machinery	10	
	Agricultural	21	
	Paper-pulp	3	
	Food	11	
	Chemicals	8	
	Others	2	

Notes:

1. Sectoral breakdown of loans are not available for IBB of Bahrain, KFH of Kuwait, MCB of Pakistan, El Gharb of Sudan, BEST of Tunisia and DIB of United Arab Emirates.
2. Figures taken from the Fisal Islamic Bank of Bahrain's 1993 Annual Report are used to represent Bahrain.

Sources:
Bahrain: FIBB's 1993 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Iran: BMI's 1992 Annual Report; Jordan: JIB's annual reprot; Malaysia: BIMB's 1994 Annual Report; Turkey: FFI's 1993 Annual Report.

Table A5: The Contingent Liabilities of Islamic Banks of Selected Countries.

Country		%	Total	%TA
Bahrain	***LC & LG***	100	100	3
Bangladesh	***LC*** LG BFC Others	90 3 5 2	100	38
Iran	LC LG IC Others	66 18 11 5	100	13
Jordan	LC LG Others	69 28 3	100	4
Kuwait	LC LG FExc	25 40 35	100	10
Malaysia	LC LG FExc BFC Others	13 35 9 18 25	100	36
Pakistan	LC LG FExc BFC Others	43 28 16 12 1	100	3
Sudan	LC LG BFC Others	12 7 55 26	100	89
Tunisia	CA	100	100	5
Turkey	LC & LG	100	100	99
U.A.E	LC LG	40 40	100	12

Notes:

1. : LC: Letters of credit, LG: Letters of Guarantee. IC : Islamic contracts, FExc : Foreign exchange contract, BFC : Bill for collection, CA : Contra accounts
2. : Islamic contracts which is used in Iran is actually a foreign exchange contracts facility.

Sources:

Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Iran : BMI's 1992 Annual Report; Jordan: JIB's 1993 Annual Report; Kuwait : KFH's 1993 Annual Report; Malaysia: BIMB's 1994 Annual Report; Pakistan: MCB's 1993 Annual Report; Sudan: El Gharb's 1993 Annual Report; Tunisia: BEST's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

Table A6: The Composition of Deposit Facilities and Total Sources of Funds of Islamic Banks in Selected Countries.

Country		%	*Total %*	%TL	Sources of Funds			
					Deposits	SH	Others	Total %
Bahrain	CA IA: SA TD	10 33 57	100	91	91	6	3	100
Bangladesh	CA & ConA PLS: SA TD SND	19 45 32 4	100	84	84	3	13	100
Iran	QH CA QH SA ID IDB	34 5 52 9	100	92	92	*	8	100
Jordan	TrA JIA: SA F&NA IDB	20 8 71 1	100	81	81	7	10	100
Kuwait	CA IA: SA LP UP IDB	14 58 * 26 2	100	85	85	5	10	100
Malaysia	CA SA IA IDB OD	17 15 50 * 18	100	87	87	7	6	100
Pakistan	CA& ConA PLS: SA TD IDB	20 45 24 11	100	89	89	3	8	100
Sudan	CA SA ID OD	57 2 10 31	100	59	59	7	6	100

Table A6(Cont'd): The Composition of Deposit Facilities and Total Sources of Funds of Islamic Banks in Selected Countries.

Country		%	*Total %*	%TL	Sources of Funds			
					Deposits	SH	Others	Total %
Tunisia	CA SA ID: UD CD	11 13 49 27	100	74	74	17	9	100
Turkey	CA: Turkish Foreign PLS: Turkish Foreign	4 6 11 79	100	87	87	7	6	100
UAE	CA SA IA IDB OA	21 18 59 1 1	100	83	83	5	12	100

Notes:

1. QH: Qard hassan, CA: Current accounts, SA: Saving account, ID: Investment deposits, IBD: Inter-bank deposits, OD: Other deposits, ConA: Contingency accounts, TD: Term deposits, SND: Short notice deposits, IA: Investment accounts, LP: Limited period, UP: Unlimited period, TrA: Trust accounts, F&NA: Fixed & notice accounts, UD: Uncommitted deposits, CD: Committed deposits, TL: Total liabilities, SH: Shareholder funds.
2. * Less than 0.5 percent.
3. Contingency accounts which are available at MCB of Pakistan and IBBL of Bangladesh comprise of marginal deposits placed by customers for using acilities such as letters of credit and bank guaranees.

Sources:
Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Iran : BMI's 1992 Annual Report; Jordan: JIB's 1993 Annual Report; Kuwait : KFH's 1993 Annual Report; Malaysia: BIMB's 1994 Annual Report; Pakistan: MCB's 1993 Annual Report; Sudan: El Gharb's 1993 Annual Report; Tunisia: BEST's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

Table A7: The Composition of Assets and its Ranking among the Islamic Banks of Selected Countries.

Country	Cash		Financing		Invest-ment		Other assets		Fixed assets		Total assets %
	%	r	%	r	%	r	%	r	%	r	
Bahrain	4	3	83	1	6	2	6	2	1	4	100
Bangladesh	33	2	58	1	*	5	8	3	1	4	100
Iran	21	2	65	1	11	3	2	4	1	5	100
Jordan	34	2	58	1	4	3	2	4	2	4	100
Kuwait	11	3	40	2	47	1	1	4	1	4	100
Malaysia	11	3	33	2	53	1	2	4	1	5	100
Pakistan	12	3	41	1	39	2	7	4	1	5	100
Sudan	16	3	25	2	31	1	15	4	13	5	100
Tunisia	14	2	78	1	-	-	4	3	4	3	100
Turkey	11	2	84	1	1	4	2	3	2	3	100
UAE	23	2	74	1	2	3	*	5	1	4	100

Notes:
1. * Less than 0.5 percent.
2. r: rank

Sources:
Bahrain: IBB's 1994 Annual Report; Bangladesh: IBBL's 1993 Annual Report, Iran : BMI's 1992 Annual Report; Jordan: JIB's 1993 Annual Report; Kuwait : KFH's 1993 Annual Report; Malaysia: BIMB's 1994 Annual Report; Pakistan: MCB's 1993 Annual Report; Sudan: El Gharb's 1993 Annual Report; Tunisia: BEST's 1992 Annual Report; Turkey: FFI's 1993 Annual Report; United Arab Emirates: DIB's 1992 Annual Report.

From Information and Communication Technology to Bio-digital Technology - Capacity Building Challenge

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From Information and Communication Technology to Bio-digital Technology - Capacity Building challenge

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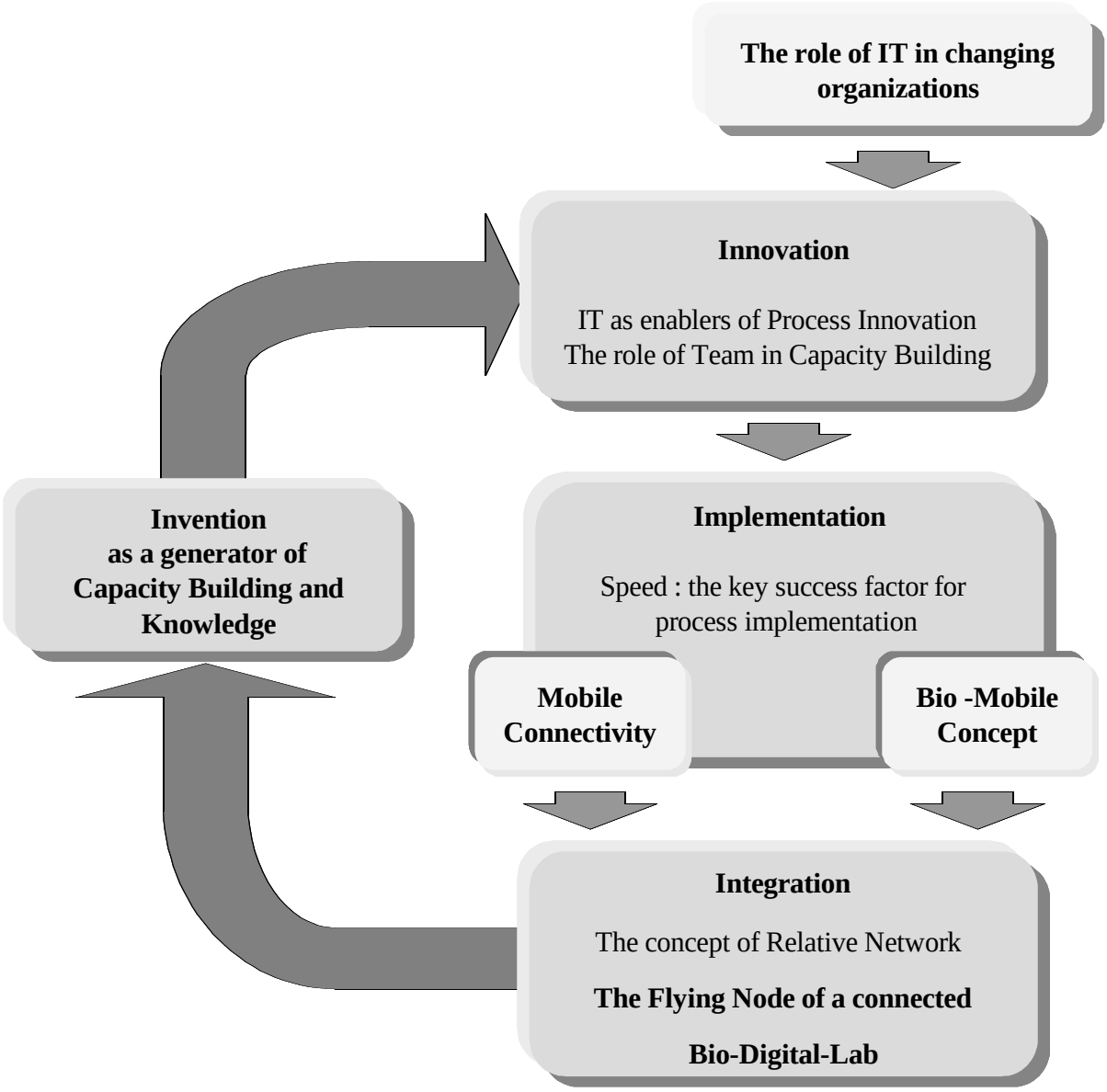
INTRODUCTION

When I was asked to develop the subject matter I had to rely on two very important team projects I had the pleasure of directing. One was how information technology is changing organizations and the second focused on speed in developing an idea from conception to implementation. The idea of course was the development of re-circulating water shower for use in the Boeing Business Jet that promises to revolutionize executive and business travel. Indeed the BBJ concept including the development and execution of an international competition for new idea utilization provided the impetus for an integrated network concept of Business Education Design and Research (BEDR) that may serve as a model for capacity building in information and bio-digital technology in an integrative manner. The challenge of course is centered in becoming part of a network on a global scale while maintaining control and influence on a local (regional) environment. The use of technology (both informational and biological) coupled to time and place on a relative basis may indeed provide the foundation for such a paradoxical concept that can be used by different cultural and organizational entities.

Figure 1- Schematic of 4I's (Invention Innovation Implementation Integration) Application of the subject matter

The underlying logic : Synoptic of the paper



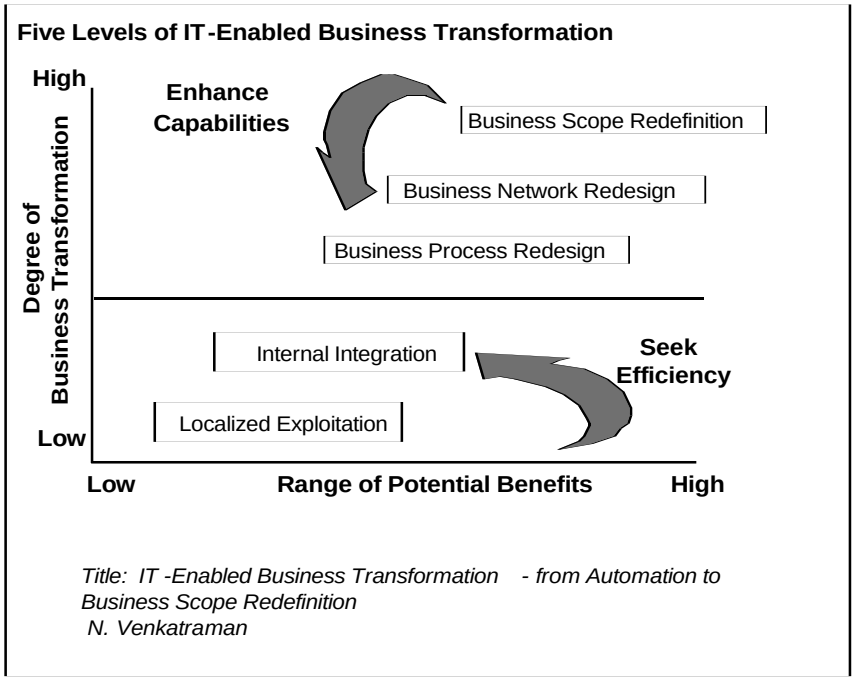
INFORMATION TECHNOLOGY BACKGROUND

The Information Age is defined by the inter-dependencies of companies and economies around the globe. Only rare companies are vertically integrated. Many firms at the hub of the supply chain, who would once have been described as manufacturers, are now better described as integrators or assemblers. These companies combine the products of other firms to create a finished good and take it to market. This distributed nature of production creates significant shifts in organizational design. Companies must have employees that are able to work in cross-functional teams, both within their company and across their partners. It is the combination of these factors that lead to the creation of the Supply Chain Organizational Systems Team (SCOS) under the auspices of the Team Certificate Program of the University of Washington that I chair (whose aim is to teach individuals to work in global cross-functional and cross-business teams). The purpose was to determine the inter-relation between information technology (IT), particularly open systems, and organizational structure [1].

The SCOS team was formed around a broad subject area-technology and communication-and focused its efforts on investigating the relationship of technologies enhancing communications in supply chain organizational systems. Logistics was chosen because it is a discrete area of supply chains requiring the highest level of coordination among companies. Thus, it can act as an identifiable area for study of the principles of technology and large, open organizational systems. The hypothesis of the team was that existing corporate organizational structures were unable to cope with the rapid flow of information created by burgeoning open technology systems. As a result, companies were unable to realize the full value of the technology and were in fact suffering organizational tensions as a result. The purpose of the team was to evaluate how organizational systems and technology could be brought into harmony.

The SCOS Team expended on the work of Venkatraman who yielded creative structures that defined what range of capabilities could be achieved through the application of different strategic IT initiatives. For example, Figure 1 illustrates the differences between using IT as a builder of efficiency or creator of new capability [2].

Figure 2 : Five Levels of IT Business Transformation after Venkatraman [2]



This work is particularly significant because it provided five levels or scales of change that management could select on the basis of business need.

With enabling IT strategies defined by the late 1990s, the maturity and growth move into an analysis of what resources, capabilities, assets and skills are required to effectively execute new strategies. By this time, the advent of new technology had given rise to the .coms of the world and enabled the creation of new business capabilities, relationships and processes. In order to build IT capabilities for competitive advantage (levels 3-5) three assets were required:

- Employees
- Technology
- Relationships

IT strategies are looking into combining processes for integrating business and IT visions. In total, there are nine core IS capabilities projected that require variable time horizons, and motivating values. They reflect a refinement from how to make it happen for the first time to a process that is repeatable and predictable.

1. Leadership
2. Business systems thinking
3. Relationship building
4. Architecture planning
5. Making technology work
6. Informed buying
7. Contract facilitation

8. Contract monitoring
9. Vendor development

Enabling technology (if done correctly) can contribute to an organization's ability to change and dominate new business areas as has been seen as both new and traditional businesses have embraced the Web.

On a supply chain viewpoint, there is a common perspective that IT should facilitate change by expanding the logistics process. Companies are increasing their focus on comprehensive planning and coordination systems to enhance their ability to manage resources on a supply chain wide basis. Logistics planning and coordination systems include forecasting, production planning, inventory planning and transportation planning. Hence new concepts such as CPFR (Collaborative Planning Forecasting Replenishment) allow suppliers, manufacturers and customers to share the same information and to collaborate in order to develop common plans and being able to anticipate events.

The result is that companies are developing integrated computer-based supply chain models that rationalize decisions regarding supplier, production, and distribution facility use, in order to plan least cost or highest profit alternatives.

Moreover as IT encourages firms to develop more external relationships, firms linked together through strategic alliances and supply chain arrangements will begin in the future to make joint investments in information capabilities and systems. In addition, the rapid development of interconnected information systems and companies' desire to focus on their business strengths are creating an important logistics phenomenon: the outsourcing of all or major portions of logistics activity to outside specialists.

Companies that can develop and implement integrated global logistics systems will outperform companies that manage the process in a business as usual and country focused manner. Sophisticated software, hardware, and telecommunications capabilities allow the connection of worldwide business activities in a web of computer-to-computer links. These links will generate cost savings (in procurement, distribution/logistics, and material use) as well as benefits that can be shared by all.

However to be successful in building up more capacities with information technology, the key word is focus. Focus on your strategies, your customers, your core competencies, and focus on your network.

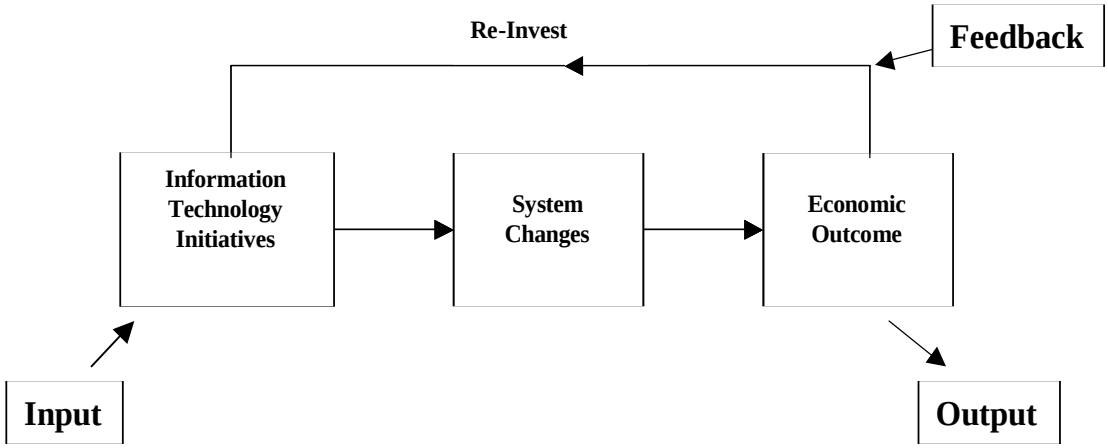
PROCESS INNOVATION

Information technology has not improved productivity for businesses, industry or the national economy. The likely cause of this was a failure to take full advantage of the full capacity of information technology to change the way work is done. American businesses have spent hundred of billions of dollars on computers, but white-collar productivity is no higher than it was in the late 1960s. Getting results usually entails changing the way work is done and that takes an understanding of the options available to assist in this area.

Process improvement and innovation are two key elements for getting greater value out of vast information technology expenditures, yet neither researchers nor practitioners have rigorously focused on business process change as an intermediary between information technology initiatives and economic outcomes and/or investments. The implicit assumption that information technology enables existing processes to be speeded up and/or performed with fewer resources has undoubtedly been correct in some environments, but the lack of visible macroeconomic benefit from information technology suggests that the assumption needs to be made explicit and tested [3].

If the overall importance of process thinking is to establish a firm understanding of how processes change, it can be possible to include process innovation and improvement as key intermediate factors in studies of the benefits of information technology investments. This can be seen in
Figure 3 In other words, to understand and maximize the benefits of information technology business must begin to think of process change as a mediating factor between the information technology initiative and economic return as seen Figure 3. No longer would people expect investments in information technology alone, to provide economic return.

Figure 3 : The Information Technology, Process, Productivity Relationship in systemic environment



In order for companies to be successful and industries to grow they must recognize that only change in their current processes will make new process designs possible through the use of information technology. Managers seeking returns on information technology investments must strive to ensure that process changes are realized. If nothing changes about the way work is currently conducted the role of information technology is simply to automate an existing process and economic benefits are likely to be minimal.

If the relationship between information technology and performance is affected by process change it is likely that it is affected by the presence or absence of other enablers of process change. Few firms think to deploy information technology in conjunction with another key change lever, new approaches to human resource management. A quantitative analysis of information technology investment in the automobile industry found that the investments yielded no productivity or quality gains unless matched by similar levels of human resource innovation.

The identification of change enablers must consider both what is possible and the constraints imposed by current technology and organization. Change enablers must then be analysed to determine the degree of freedom a company has in implementing new technologies and organizational forms given its current state. This is essential for cost / benefit analysis and migration planning. Opportunities and constraints have to be identified in order to understand which enablers will become part of the process vision and how they will be employed in the process. Opportunities must be researched to determine how the technological or human innovation might be employed in the process. Constraints, on the other hand, are usually more thoroughly examined through discussion rather than research.

With everything that has been said before, information technology must be viewed as an enabler of process innovation. Yet, information technology is only one of several enablers that typically work in concert to bring about change in a process. Here the focus will be information technology due to the high demand from consumers for information technology in their lives. The conventional wisdom is that the process should be designed before investigating enabling technology or systems. In other words, first think about the process, and then think about the system establishing a common vocabulary among the two.

People often focus on systems and technology that help to implement, rather than enable, a process. The goal of information engineering is to describe an already-conceptualised process in informational (or, more accurately, data-oriented) terms so that a system can be rapidly and rigorously constructed to support the new process design. But information technology can play an even more important role in process innovation.

When people understand how companies in many industries have used technology in innovative ways to improve their process, people can improve the design of new process. Major process in which information technology has not been used by some firm somewhere to achieve radical improvement. To suggest that process designs be developed independently of information technology or other enablers is to ignore valuable tools for shaping processes. A sculptor does not take a design very far before considering whether to work in bronze, wood, or stone. A process designer pursuing innovation should consider all the tools that can help to shape or enable the process, and information technology and the information it provides are among the most powerful. Indeed it is with the concept of innovation that we can transition to bio digital technology.

1. SPEED AND BIO-DIGITAL-TECHNOLOGY

In his book Business @ the Speed of Thought, Bill Gates says "Business is going to change more in the next ten years than it has in the last fifty". The name of the game is speed, companies which are willing to stay in business have to drastically reduce the time to market for their product and shrink the period of time of the Return On Investment (ROI). He also tries to inspire managers on how to get more from technology, enabling them and their company to respond faster to customers, adapt to changing business demands, and prosper in the digital economy [4]

"If the 1980s were about quality and the 1990s were about reengineering, then the 2000s will be about velocity. About how quickly the nature of business will change. About how quickly business itself will be transacted. About how information access will alter the lifestyle of consumers and their expectations of business. Quality improvements and business process improvements will occur far faster" [4]. One of the example of biotechnological company using the new technology to develop their business is ICOS, a product-driven company that has expertise in both protein-based and small molecule therapeutics Bill Gates is the major investor in ICOS. This company combine their capabilities in molecular, cellular and structural biology, high throughput drug screening, medicinal chemistry and genomics to develop highly innovative products with significant commercial potential. Applying its integrated approach to specific target areas where they have expertise. They include erectile dysfunction, female sexual dysfunction, sepsis, pulmonary hypertension and other cardiovascular diseases".

2. FROM THE HUMAN GENOME TO FUZZY TECHNOLOGY

A challenge facing researchers today is the ability to piece together and analyze the multitudes of data currently being generated through the human genome study.

Rapid progress in genome science and a glimpse into its potential applications have spurred observers to predict that biology will be the foremost science of the 21st century [4]. Technology and resources generated through the research on human genome and other genomics research are already having a major impact on research across the life sciences.

The potential for commercial development of genomics research presents U.S. industries with a wealth of opportunities, and sales of DNA-based products and technologies in the biotechnology industry are projected to exceed $45 billion by 2009 [6].

Some current and potential applications of genome research include (1) molecular medicine, (2) microbial genomics, (3) risk assessment, (4) bio archaeology, anthropology, evolution, and human migration, (5) DNA forensics (identification) (6) and agriculture, livestock breeding, and bio processing.

"The human body contain approximately 100 trillion (million million) CELLS, most of which are less than a tenth of millimeter across. Inside each cell there is a black bolb called a NUCLEUS. Inside the nucleus are two complete sets of the human GENOME. One set of the genome come from the mother and one from the father. In principle, each set includes the same 30,000-80,000 GENES on the same twenty three CHROMOSOMES". I like very much the image offered by Matt Ridley in the book "The Human Genome" that we can imagine the genome as a book schematized bellow [4]:

With 23 ***Chapters***	***Chromosomes***
Each chapter has several thousand ***Stories***	***Genes***
Each story is made up of ***Paragraphs***	***Exons***
Paragraphs are interpreted by ***Advertisements***	***Introns***
And are made up of ***Words***	***Codons***
Words are written in ***Letters***	***Bases***

Fuzzy logic

The modern marketplace relies increasingly heavily on the transfer of information from one point to another in amazingly large amounts and short times. The vast majority of this information in transmitted digitally. Digital information transfer is inherently inflexible, relying on a system of ones and zeros to represent the data being exchanged. These ones and zeros are derived from physical quantities such as voltage in a chip or illumination in a fiber-optic cable. A voltage or light intensity value above a certain quantity is translated into a one and a corresponding value below a given point is converted into a zero. However, there is a range of signals that fall in between these two extremes that must be analyzed by some algorithm to decide if they are a one or a zero. It quickly becomes apparent that a "fuzzy" intermediate region exists in the superficially distinct and compartmentalized world of digital information transfer.

The fuzziness of this information is not necessarily a liability and can be used to maximize the amount of data contained in a given signal. This is a simplified representation of the concept known as "fuzzy logic". For example, people can be characterized as young or old. One could develop an algorithm that states that if a person is under 20 years of age they are young. Similarly, if they were over 70 years of age they would be considered old. There exists a considerable fuzzy area in between these two distinctions where the person in question has varying degrees of age or youth. If "young" is designated by a zero and a one designates "old" a simple linear formula can be used to quantify the age or youth of a person. Figure 4 shows a diagram of this type of formula.

Figure 4: Fuzzy distinction between young and old

This is a fairly simple example, but it serves to demonstrate the wealth of information that can be found between the delimitation of ones and zeros. This concept of fuzziness is readily apparent in bio-digital technology. Biological systems are not digital and operate on a different system than nearly all modern modes of information transfer and processing. Fuzzy logic provides a way to adapt digital systems to use the

flexibility of biological systems. This flexibility can greatly increase the rate of information transfer and the amount of information that can be exchanged. Speed is crucial in the modern marketplace, and fuzzy logic allows digital systems the flexibility and capacity to meet the constantly developing demands of information technology. However both concept of information and biological technology require the use of diverse team of individuals and organization in an unprecedented manner. Accordingly, I believe that future development depend on forming effective teams.

3. TEAM SPIRIT

The past two years I was able to put to practice my teaming experience by organizing an interactive competition for interior concepts of the Boeing Business Jet: I personally saw the competition as an opportunity to expand my design knowledge beyond traditional territories of engineering, education, and business into the realm of art and perception. Focusing on issues of boundaries, frontiers and borders, I had been teaching a class on "boundaryless leadership" at various campuses across Europe, USA, and Asia, based on my experience in leading business and technical teams consisting of students, professionals, and executives. The concept for the competition came at the same time I established the BEDR (Business Education Design Research) network, an idea that was collectively arrived at during a seminar for business and academic leaders in Seattle see Figure 5. I had also already started to teach a final process design class to chemical engineering students (a well grounded process discipline), admitting business majors and other disciplines of the academic environment, as well as 'life-long learners' - people with existing professional careers.

My first involvement with BBJ and the interiors of executive jets came as a result of this design class, which had successfully developed a water recirculating concept for a shower for use on airplanes and had managed to build a working prototype in record time. This innovation went on to become a viable business venture -Aquajet -again in record time. The design class also worked on other BBJ innovations including its distinctive winglets. Indeed, while analyzing BBJ innovations under Mr. Borge Boeskov's leadership as President of Business Jets, it was uncovered that the concept of selling 'green' airplanes was the major driving force behind such leaps in technical evolution. This practice had encouraged the forming of collaborative teaming arrangements - especially with the completion centers, and it was actually during a visit to a completion center that the idea to call an international competition finally matured.
It quickly became apparent that the publishing world, Domus being the most obvious candidate, also had to become a partner in the competition process. Prof. Burkhard, editor of Domus magazine at that time, embraced the idea from the start.

Dr Giovanna Mazzocchi of Domus Editoriale, and proprietor of both Domus and Volare magazines, was also a keen supporter of the project, and was able to combine her love and knowledge of both aviation and design to the benefit of the competition. With the magazine's capabilities at our disposal, we were able to reach a community of possible participants far beyond the traditional borders of aviation. Also, my position as adviser to Mr. Borge Boeskov, with assignments to assess innovations in composite materials and in general aviation, ensured from the start high level support.

In the spirit of B.E.D.R. as a global group network, the competition not only produced significant and impressive innovations of design, but also acted as a vehicle to connect people and organizations in seemingly diverse networks. One of the jurors in the competition remarked how impressed he was with how the world of publishing had come together with the worlds of executive jets and academia to create a network that promoted business, education, and communication. Normally, the boundaries between these disciplines are well defined and provide for separate closed systems. However, the competition brought people and organizations into contact that, if left alone, would never have worked together. Furthermore, the competition clearly occurred at a unique moment - Boeing's entry into the executive aircraft market with the BBJ.

The Domus-BBJ design competition was an endeavor that took me beyond the comfort zone of an engineer and business consultant into the role of a learner. However, as a professor, I was still able to provide my well-established support structure of people and organizations to help set up the Senior Advisory Board of the competition, which was on hand to help enrich the experiences of all those involved in this endeavor. For example, it helped to have Stelios Hadzioannou, the founder of easyJet, within the same network as the president of Korean Air and the vice-president of engineering for Lufthansa Technik, along with the owner and publisher of The Japan Times. My role was that of a master catalyst and resource trustee, a role I had never played before, but one that I enjoyed immensely and hopefully fulfilled well enough. (To find out more about the competition's history and its unique judging panel, as well as the final results, please see the Web site address listed at the end of this article.).

Once the design competition was completed, the question was what the follow-up should be. Should the quality and innovation of the winning designs actually be implemented? However, as I hope this article proves, the real success of the competition was its design process methodology, which was defined through the integration of different network structures of people and organizations.

The following provide some examples involving a cross-section of the organizations involved.

Domus has already launched another design competition with BMW along the principles we have established. Mr. Boeskov, Mrs. Corcos, and I recently led a "Four I" workshop analyzing and utilizing the innovation cycle (invention, innovation, implementation and integration) with all the winners of the competition, as well as some of its jurors, where the potential of collaborating and developing a mock-up of their ideas was proposed and met with enthusiasm.

Using the expanded network of my advisory board and my core expertise in composite materials, manufacturing, and management processes, I am currently developing strategies to promote better integration between airports and aircraft by focusing on interior design schemes using independent processes, systems, and teams. The TORAYCA light roof concept by Toray Industries of Japan (a B.E.D.R. node), is a good example of what can be achieved in this area.

Furthermore, some of us are currently building F.R.E.E.D.O.M. (Foundation for Research Experiential Educational Developmental Operational Management) - a non-profit organization that owns the rights of the designs submitted to the Domus-BBJ competition. FREEDOM has been approached by the National Building Museum in Washington, D.C., to use the results of the competition and go beyond the original concept by building a connection of "small spaces" on the ground and in the air.
Clearly, we have inspired not only designers, but also a whole new community that has been formed by breaking down traditional boundaries and borders of existing work systems. What I believe we have clearly established through this Domus BBJ competition is that through processes, systems, and teams, design can be holistically pursued from the perspectives of art to engineering on a global network environment, combining elements for profit and non-profit endeavors [7].

Figure 5-1: A cross section of BEDR as Global Group Network, showing profit as well as non-profit organizations endeavors

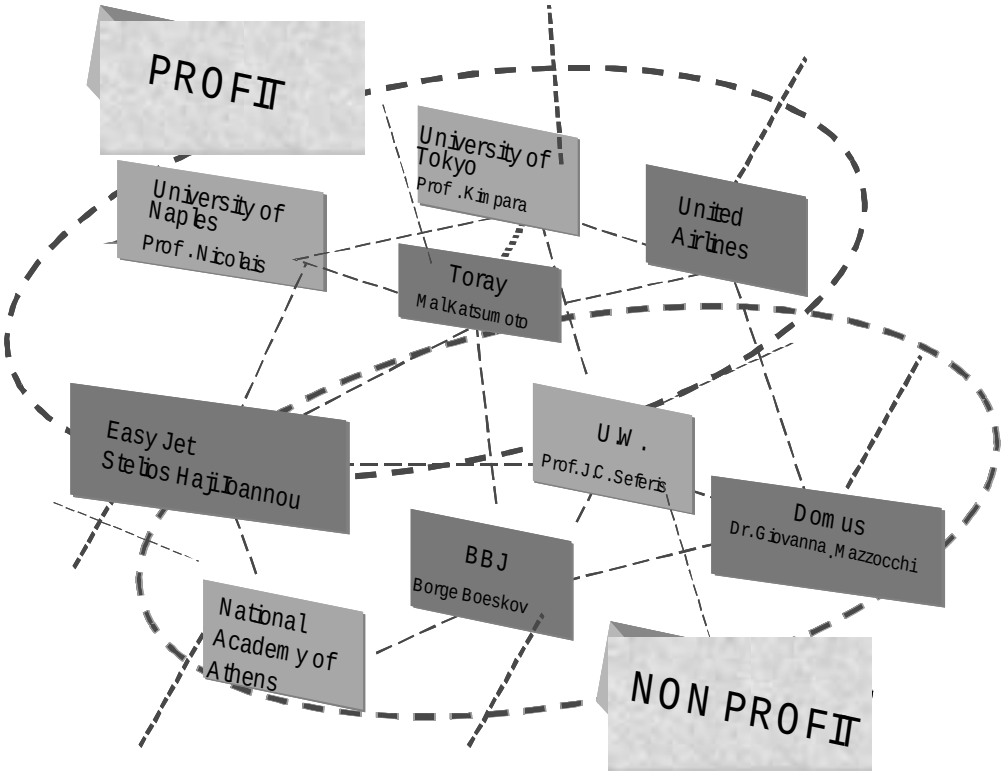
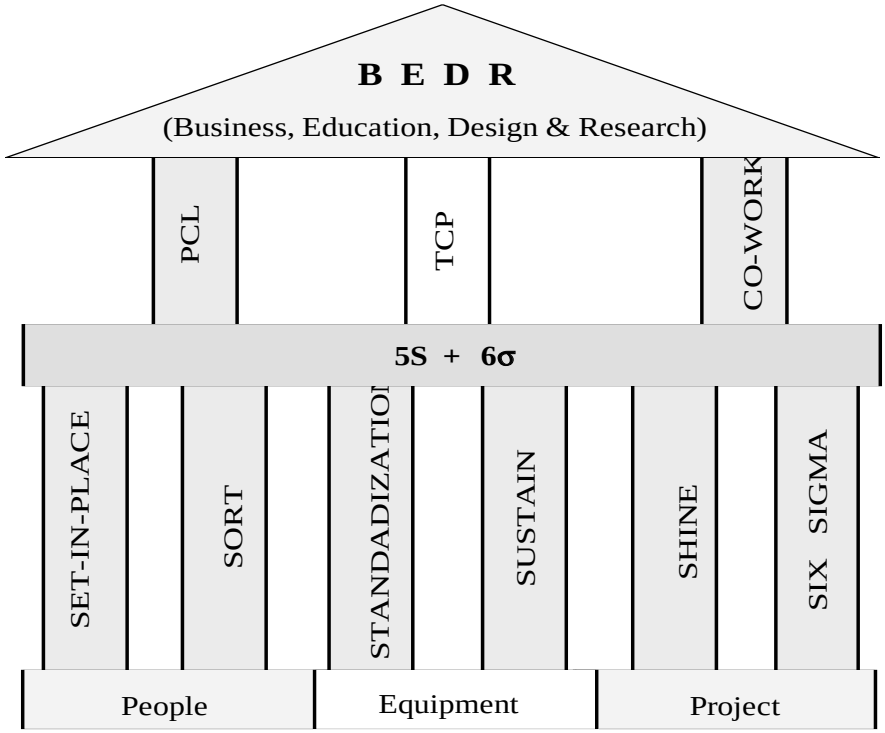


Figure 5-2 : Structure of BEDR from R&D and Program to World connecting network



Clearly, the Boeing Business Jet is an innovative concept that has spurred a variety of innovations not only in the field of aviation, but also in a diverse environment that includes information technology and new ways of working utilizing the BBJ as a modern executive tool. It is interesting to note that one of the winning designs by Sebastian Zimmerman of Germany proposed a bio-hazard protection jet where the concept was to provide on-site a fully functional facility with laboratory, communications in areas of the world where biological hazards develop. Accordingly, during this thesis, I will attempt to utilize some of the concepts that indeed have been developed for the Boeing Business Jet and integrate them in a proposal that can be utilized in this symposium. My philosophy of 4Is, Invention Innovation Implementation Integration, is a circular one making little distinction of the beginning and an end. Accordingly, as I will attempt to demonstrate implementation on some of the concepts that have taken place in the BBJ, I will also provide a proposal for integrating these concepts as a foundation for information and communication technology and bio-digital technology. By using these concepts as "off-the-shelf" experiences, I hope that my proposed integrated concept of a flying node of a connected bio-digital laboratory spurs the reader to an invention that will generate capacity building challenge and knowledge. Of course, the process of implementation should be focused on speed and I will start by describing our accomplishments in the Speed Team that was chartered in August 1998 and concluded its educational function in December 1999. The Speed Team pushed forward the creation of Aquajet, a new company whose mission is to implement and integrate the idea of a re-circulating shower in the Boeing

Business Jet and beyond. What we learned from this exercise was that, in order to maintain speed in any implementation process, leadership is of paramount importance, but not in the traditional sense of command and control. My role in leading this team was more of that of a catalyst and an enabler rather than that of a visionary and a hard-driving inventor who needs to succeed. What I consider key learning from this team that involved competencies beyond my area of expertise was the utilization of individuals and organizations that belonged to seemingly diverse networks but who were coherently integrated. The key, of course, was to move with lightning speed from innovation to implementation. It is, I believe, at this point where separation of academia from the "real world" should take place. If the innovation is connected to academia, a mechanism of implementation that involves academia, but at arms length, should be established. Furthermore, individuals involving projects, at that point, should decide whether they will remain in academia and continue to focus through other or similar projects in the world of innovation or jump to the world of implementation.

As a side issue which probably reflects my philosophy as an educator with long-term experience in interacting with industry, I would say it is of extreme importance to separate and integrate the roles of industry, academia, and government in a network environment that functions at the local as well as global scale. I believe that clearly in the intellectual 4I process of Invention Innovation Implementation, Integration, the business world should clearly own the intellectual property while the academic world should excel at the intellectual process. Collectively, then, they should agree, with the help of a publicly-influenced organization on the intellectual structure of collaboration. As we move forward in describing the implementation phase of the topics I am developing, I will clearly attempt to demonstrate this distinction.

PROCESS IMPLEMENTATION

4. MOBILE CONNECTIVITY

Once the Boeing Business Jet concept was established as a joint venture between the Boeing Co. and General Electric, trying to satisfy a need for individuals in the upper echelon category of society, i.e., chief executives, heads of state, and high network individuals, it became clear that real time communication for the BBJ was of paramount importance for success as a business tool. Accordingly, the BBJ group scouted for available technology that could be implemented with speed in establishing live communication for the BBJ. They found technology inside the parent corporation as well as outside and implemented with speed the capability of connecting through the Internet. In short order, the demonstration of the technology and implementation to the BBJ with speed spurred Boeing to create Connexionâ that promises now to be a viable business. It promises to maximize productivity while traveling not only in executive aviation, but also in commercial aviation as well. It also establishes groundwork where air communication can be as efficient and, of course, more controlled than ground communication. It is this concept that I would like to use in proposing packaging information technology with the physical world and demands of

biotechnology to create a flying node in a network that involves both physical and information connection. Of course, the other piece I would like to base my proposal on is on the bio-hazard jet that was proposed in the Domus/BBJ competition by a German team led by Mr. Sebastian Zimmerman.

5. MOBILE BIOLOGICAL CONCEPT

The idea of the mobile biological concept of Mr. Zimmerman and co-workers was to create a movable laboratory that could address virological and bacteriological issues as a blend of state of the art hospital in combination with the state of the art laboratory that could literally fly directly to any place on the planet where there was immediate need for action. Accordingly, the design team aimed at preserving the uniqueness of flying while creating an area of functioning business/laboratory type of atmosphere. Central to this concept was, of course, high-level communication that needed to be accomplished with a vast network of virological and bacteriological databases. Its intention clearly demonstrated that such a concept not only is feasible, but also could easily be implemented with technology currently available around the globe. What really caught the attention of the jury involved in the selection process in the Domus/BBJ competition was that clearly tight control of the environment was needed. The proposal includes elaborate schemes for air locks and infection protection that clearly could only be achieved in a controlled environment of an airplane. However, once inside the airplane information, technology and communication to worldwide networks were available on site, no matter how remote the location would be. Clearly, then, one can envision that a mobile laboratory could be constructed that would allow connectivity to existing networks while tapping resources from information technology networks. It is interesting at this point to consider how one would integrate to existing activities by building capacity in regions and countries of the world that either through cultural, investment policies or in general economic development have not been able to participate in information technology and bio-technology networks. It is no secret that especially these two networks of information and bio-technology are developing with lightning speed with no apparent controls in either direction or content. It is clear that, if one has ideological objections in the development of bio-digital technology, the only effect, so far, would be blocking localized development and their own participation. Accordingly, I believe, in regions and countries that cannot fully participate in the development of these fast-moving networks, a new concept is needed to participate in the technological development not as an observer, but a full-fledged participating member. Thus, as we move into a phase of integration, I am proposing a concept where truly a flying information/bio-technology laboratory can participate in developments and integrate in existing networks without tight controls that sometimes must be placed in regional environments. As I move to describe this integrated concept, one has to keep in mind the element of speed and focusing in building capacity through integration.

PROCESS INTEGRATION

In the physical world, there is a concept that one can draw upon when attempts to describe phenomena in liquid flow. The mathematical concept is known as the substantial derivative, which has the observer moving with the speed of the flow [7]. It is indeed this concept that I am proposing the integration of the mobile connectivity capability with a mobile bio-digital laboratory to create a node in a global network that is now stationary and can move both in the physical and information world. Imagine for the moment with existing technology and capability if a country that has resources but not established capability in either the information world or the bio-digital world is able to connect selected individuals with specialized as well as generalized knowledge on-site to active areas like Seattle, Washington; Cambridge, England; and Paris, France. These individuals not only will be able to be in their working environment interacting as active participants to these fast-developing networks, but also be able to offer to the visitors a unique environment for interaction they can literally move with the speed of thought from one place to another if the physical situations demands it or if they can provide a unique environment where special interactions can take place. There is no question that such technology is available now in different areas of the world and, of course, in major technologically advanced countries especially relating to issues of national defense. However, if one integrates networks from seemingly diverse areas that appear to be unrelated to the untrained integrator, one can accomplish with speed a capacity building capability with relatively few resources while at the same time minimizing the high risk of invention. Most often than not as we are all aware in our daily lives, an idea takes time to gestate mature, and implement. However, if one can demonstrate that elements of these ideas and concepts are currently in use and successfully functioning in different environments, one can shorten the cycle from invention to implementation and build capacity at lightning speeds. This, of course, leads to my concluding remarks that, hopefully, will summarize for the reader not only my philosophical underpinnings but also their backing through successful implementations.

PROCESS INVENTION AND CONCLUSIONS

It probably appears strange to the reader that I conclude my topic by addressing the process of invention. Most of us are used to ideas being haphazardly created and by brute force implemented to commercialization. However, I hope I have been able to develop in this thesis the concept that even invention is a process that in a networked world can be developed in an organized and systemic manner. I believe we still need an individual to indeed create an invention, but the process no longer can happen in a vacuum. Like the creation of a pearl in an oyster, we need a catalyst or an irritant to create this valuable jewel. I believe in a connected world such an irritant and catalyst is not controlled, but harnessed from the environment around us and is a necessary, but not sufficient condition for successful innovation. If one, however, constructed a dictatable invention process, it is guaranteed to fail. Furthermore, if one expects that an invention guarantees success to implementation and integration, I suggest that the odds are more likely to succeed by gambling in a lottery process

rather than creating an environment that scientifically develops inventions. In regions of the world, where they are not currently leading in information and bio-digital technology, to participate in such developments one cannot do it in isolation or under controlled environments. If one also considers the element of speed, the issue of control truly comes into question. Indeed, one has to consider giving up control in order to participate and build capacity in these fast and fascinating developing networks. In closing, I would like to borrow some of the concepts that I have been using in both teaching and research in my chosen field (which is neither information technology or bio-digital technology) which is the world of long molecules that can be harnessed to shape physical parts like wings of airplanes. In the physical world and business, the concept of game theory has now been well established. Indeed, the best way to describe this concept which is applicable to our subject matter is by theory developed by Adam M. Brandenburger, Harvard Business School, and Barry J. Nalebuff, Yale School of Management, in the book Co-opetition that can be summarized by the acronym of PARTS [9]. P stands for players, A for added value, R for rules, T for tactics, and S, in my view, for strategy. It is within this context that I believe invention should take place if human and other resources are to be used with efficiency. It is also, in my view, imperative that the game in whatever form it is played is considered to be global, and inherent in its makeup should be a high degree of diversity that should be designed to include political, social, and religious diversity. Only when all of these conditions and more are met can we hope to be able to participate with velocity in current developments that from a top view appear to be out of our control.

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Introduction

The Global Forum on Management of Technology with Focus on the Arab Region was organized by UNIDO on 29-30 May 2001 in Vienna and discussed issues for developing countries and the Arab Region. The forum attracted ministerial and official level participation from the Arab countries, international experts and experts from the Arab Region. The International Association for Management of Technology (IAMOT) actively participated in the conference. The permanent missions based in Vienna from the region also took part in the discussions.

Mr. Carlos Magariños, Director-General, UNIDO inaugurated the forum, stressing the role of technology innovation as a key factor in economic growth, and encouraged the participants to present practical solutions on technology management and technology development to meet the challenges faced by developing countries.

Dr. Tarek M. Khalil, Professor of Industrial Engineering, University of Miami and President of IAMOT gave the keynote address. He discussed the main factors leading to competitiveness in the global economy and highlighted the role of technology in creating wealth. He also presented today's issues in managing technology, emphasizing the need for the Arab countries to develop national technology strategies and implement integrated public polices in support of technological development.

There was extensive coverage and discussion on the subject. The distinguished speakers and panelists participating in the conference led the discussion on various critical issues necessary for promoting greater technological development in developing countries in general and the Arab Region in particular.

The meeting has come up with conclusions and recommendations for promoting management of technology in the Arab Region, for strengthening competitiveness of enterprises, and accelerating economic development.

Objectives

The objectives of the forum were to highlight the issues relating to management of technology and how to deal with the critical issues relevant to developing countries and the Arab Region. These aimed at identifying the driving forces of technological development, sharing experiences on the management of technology in the present context and suggesting a course of action to meet the specific problems of the Arab Region.

Main Issues

The conference examined some of the important issues in using and promoting technology and innovation to foster growth in the developing countries, namely:

- The public policies needed for development and implementation of technology
- The infrastructure that supports adoption and promotion of innovation
- Meeting the technology needs of enterprises
- Developing Human Resources
- Financing growth through Technology Development
- Technology networking and leverage

Conclusions and Recommendations

A. Conclusions

- The distinction between developed and developing economies lies primarily in the ability to effectively manage resources and technological assets. In order to avoid being marginalized, countries must formulate strong public policy, and their companies must improve the way they manage technology and innovation.

- Technological globalization has to occur in a harmonious and equitable fashion. Equitable technological globalization can occur through international technology transfer. However, the host receiver of the transfer has to be well prepared to receive the technology, absorb it, and advance it through innovation.

- Financing technology poses special challenges because of uncertainty of outcome and related asymmetry in information. Therefore, governments are called upon to provide financing to technology development in addition to supporting financial institutions, capital markets and the private sector.

- The experience of developed countries shows that innovative technology policies have produced a number of centres of excellence, valuable technology transfers, active financing and a series of structured interventions like technology and research parks and incubators.

- A sound system of technological and scientific education and knowledge acquisition is needed to develop human resources capable of dealing with technological changes.

- Firms do not develop competitiveness in isolation but they are bound to external linkages and environment: competitors, complementary industries, support institutions, national innovative system and regulatory public agencies.

- Technological capability, capacity to innovate and the ability to commercialize the technology are key aspects of the organizational knowledge of a firm enabling core competencies and competitive advantage.

- Technology acquisition is an indispensable element to build up technological capabilities of developing countries and can be achieved through different ways ranging from FDI to licensing. However, the receiver of technology has to be able to make the right technology choice and has to be well prepared to receive it, absorb and advance it through innovation.

- Because of weak R&D capability in the private sector in developing countries, an increasingly important aspect is networking and cooperation among R&D institutions, between firms and public research institutes or technology centers or universities as well as between multinationals and local enterprises.

B. Recommendations

Role of Governments:

- Develop national technology policies and implementation strategies consistent with national needs and resources.

- Establish technology policy coordinating units reporting to the highest level of government authority.

- Give high priority to funding critical technologies, investing in human resource development and supporting technology commercialization.

- Support the development of national innovation system and infrastructure.

- Strengthen the national education system in order to enable the industrial sector to cope with the challenges brought about by the knowledge-based economy.

- Encourage and facilitate linkages and cooperation schemes between firms and supporting institutions at regional and international levels as one of the main instruments to build technological competences and foster competitiveness.

Role of UNIDO:

- Promote and develop capability in the field of Management of Technology through training programmes, national and regional seminars as well as other types of awareness raising programmes.

- Monitor global technological trends and provide support in identifying, planning and implementing recommended technologies to the various countries in the Arab region.

- Assist Arab countries in developing core skills and competencies in support of strategic technologies.

- Examine, assess and recommend synergies and opportunities as well as best practices within the countries in the region, through:

    - Investigation of actual technology management and innovation practices used by successful and competitive enterprises;

    - Preparation of case studies and implementation of demonstration projects based on the results of such research;

- Assist the countries in the Arab Region in building up their institutional capabilities to manage technology acquisition and transfer process including the technology choice, absorption and advancement through innovation.

- Promote the Technology Foresight activities in the Arab Region for analysis of technology and industry trends and formulating regional and national technology policies and strategies.

- Develop a virtual platform for sharing technology, experiences, assessments and application mechanisms applicable to the Arab Region.

- Support and promote cooperation between scientific and technological research centres and productive sectors through the establishment of technology parks, incubators, and linkages with international technology centers.

- Cooperate with other international institutions, NGO's and professional bodies like the International Association for Management of Technology (IAMOT) for strengthening competence in technology management in the Arab Region.

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29 to 30 May 2001, Vienna, Austria

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