



Technology management in China: a global perspective and challenging issues

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China

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Abstract

Purpose – This paper reviews the framework of the management of technology (MOT) field and examines some application cases of technological development and innovation in China. It addresses various crucial issues necessary in the establishment of infrastructure, strategies, mechanisms and systems of technology management in China. It draws upon knowledge acquired from the US experience in this field for the past two decades.

Design/methodology/approach – An overview and conceptual paper based on observations and research experience.

Findings – This paper stresses the importance of keeping-up with the fast pace of technological change and the emerging new global paradigms of the business environment. MOT is an important strategic instrument to improve competitiveness and create prosperity in countries that effectively apply it. The paper draws upon the experience of the US in MOT over the past two decades and projects what may be needed for China to continue its development and economic growth in the future. There is a need for appropriate infrastructures, strategies and mechanism to be established in order to support the diffusion of MOT principles throughout China. Educational institutions offering business and engineering education need to introduce MOT curricula following the US model or develop a new model shaped by the Chinese culture.

Originality/value – This paper presents the crucial tenets of technology management and provides some observations and insights on technology transfer, technology strategy and innovation process in China today. It suggests critical areas that decision makers in government agencies, enterprises and international funding agencies need to address with respect to MOT in China. Understanding the existing gaps in the process of technology management will assist in implementing more sustainable arrangement for successful technology transfer and development.

Keywords China, Change management, International business, Knowledge transfer

Paper type Conceptual paper

Introduction

The main purpose of this paper is to argue that globalisation is beginning to affect international business environment bringing to the forefront the importance of studying management concepts as to their synergies or differences between West and East. It seems that the science and technology of the developed countries of the West, and now also Japan, dominates and controls the whole world. Most technologically based products, carrying Western and Japanese brand, sell all over the world. However, Arnold Toynbee (1889-1975) predicted that countries that are expected to have more influence in the world are not from Europe but China (Zeng, 2005).



Management of technology (MOT) in the West concentrates on how Western businesses should operate to gain competitive edge. Chinese business executives in China seem to be shifting the international business models. Management in China seems old; however, contemporary MOT is a challengeable subject, which has been a focus of considerable interest because it concerns not only Chinese business executives and Chinese government decision makers, but also international investors and funding agencies that operate in China. MOT has been assuming increasing significance in both developed and developing countries. In the age of globalisation, China presents a unique setting for organizations. The unprecedented growth of China's economy, which remains to be the fastest rate of growth in the world, offers significant opportunities for both Chinese and foreign investors. It is not surprising that concepts of technology management, technology transfer, assimilation and development is crucial in the process of international collaboration projects.

Globalisation is seen as offering more opportunity for both developed and developing nations. The developed countries can obtain huge marketplace for their surplus producing power by selling goods, transferring their technology and receiving high return and by acquiring equity in foreign firms by acquisition and setting-up joint ventures. The developing countries can acquire advanced technology and knowledge by opening their market, provide human resources, raw material and in return provide employment to their citizens and improve standards of living. Therefore, technology management and sound technology transfer in the international collaboration endeavours seem evident. As the world celebrates a third millennium, technology assumes a great importance in advancing every aspect of human endeavours. The MOT assumes even greater importance in the ability of countries, companies and individual to embrace technological strategies and changes in order to advance their competitive advantages in a global marketplace (Khalil, 2001). There is no doubt that technology management leverages the economic growth and development in both developed and developing world. It charts the strategic and operational guidance to economic development and wealth creation.

Uniqueness of the Chinese model

The Chinese economy presents a mixture of features of a market economy intertwined with those of a command economy. It was defined, by the Chinese government as "socialist market economy with Chinese characteristics". Since the founding of New China, especially in the last 20 years after the start of reform and opening to the outside world in 1978, China has made great achievements in economic construction and social development. The World Bank (1997) reports that China could meet the new challenges and sustain rapid growth, mainly because of its strengths: relative stability, a remarkably high savings rate, a strong record of pragmatic reforms, a disciplined and literate labour force and growing administrative capacity. These strengths have driven the country's growth for the past two decades and can continue to do so (Li-Hua, 2004). China's continued transformation into a larger, more open economy is likely to have far reaching consequences for other countries. Meanwhile, as China makes the transition into the world economy, it becomes increasingly exposed to external influences.

While China has been highly successful in expanding its economy there has been many failed international joint ventures. This indicates that foreign firms, operating in

China face some risk. Strategic decision makers, practitioners and international organizations increasingly recognize the importance of practical know-how, based on sound theoretical and empirical grounds. They must deal with managing social connections, networks and collaborations, technology and knowledge transfer and managing technology within China. It is against such a background that this paper reviews recent information concerning acquisition of technology and technology transfer in China and then addresses the crucial emerging issues of technology management. The paper also attempts to provide a global perspective of future directions in the MOT that may require adjustments in Chinese or outside investors' decision-making strategies as they pursue either development or investment in China.

Technology and technology management

The concept of "technology" has to be addressed prior to the explanation of technology management. Technology has a great influence on individuals, business, society and nature (Khalil, 2000). Advances that occur in technology have a major influence on creating national and individual wealth and on improving people's standard of living and quality of life.

What is technology?

Technology represents the combination of human understanding of natural laws and phenomena accumulated since ancient times to make things that fulfil our needs and desires or that perform certain functions (Li-Hua, 2004). In other words, technology has to create things that benefit human beings. Miles (1995) defines technology as the means by which we apply our understanding of the natural world to the solution of practical problems. It is a combination of "hardware" (buildings, plant and equipment), "software" (the way to operate the hardware) and "know-how" (skills, knowledge and experience together with suitable organisational and institutional arrangement).

The UN Conference on Trade and Development (UNCTAD) has provided the following definition:

Technology is bought and sold as capital goods including machinery and productive systems, human labour usually skilled manpower, management and specialised scientists, information of both technical and commercial character, including that which is readily available, and that subject to proprietary rights and restrictions.

Technology cannot merely be considered as a production factor, and it is not socially neutral. It seems much easier for understanding "technology" to consider the concept of "technology" as consisting of four closely inter-linked elements namely, technique, knowledge (normally being considered as "technology" upon its application) and the organisation of the production and the product. However, knowledge does not make sense if the organisation of the relevant production goes without producing meaningful product. Therefore, technology must be applied and maintained, which implies a demand for a further input of a suitable range of human resources and skills. However, it should be noticed that it is this latter input that is at the root of the difficulty in transferring technologies between different environments.

Technique. Technique covers the instruments of labour (machinery and tools), materials and the way they are brought into function by labour in the working process.

Both social dynamic (working process) and social contradictions (e.g. between machinery and labour) are inherent in this element of the technology as in each of the sub-concepts.

Knowledge. Knowledge consists of three principal categories: applied science, skills and intuition. The weighting between these categories of knowledge is changing historically, but in every case an adequate combination of types of knowledge must be present. Knowledge is the “key to control” over technology as a whole, which can be seen both at micro-level (Taylorism) and at higher levels of social aggregation (technological dependency). However, it is helpful for understanding that knowledge can be classified as explicit knowledge and tacit knowledge (see detailed discussion in Li-Hua, 2004).

Organisation. Technique and knowledge must be organised before they can bring results. Organisation is, therefore, an integral part of technology. Organisation of a working process of technique and knowledge into a product may have technical causes, but mostly the actual choice of organisation will rest widely on social-economic causes and reflect the general social structure of society.

Product. The ultimate purpose of bringing technique, knowledge and organisation together is, of course, to obtain a product. Without including this goal, it is in fact, difficult to understand the other three elements properly. It seems natural to include the product in a comprehensive technology concept, not least because in practice, the choice of product often precedes the choice of the technique, knowledge and organisation by which it is going to be produced.

It should be noted that “knowledge” is a key to control technology as a whole. Today, in terms of international business, the involvement of technology and knowledge transfer as a whole in the international collaboration project seems an open secret. Furthermore, knowledge transfer/knowledge sharing has been widely recognised to be strategically significant for international collaboration. Li-Hua (2004) addresses the appropriateness and effectiveness of technology transfer and knowledge transfer in China when foreign and local managers work together on an international joint venture project. The study had identified that without knowledge transfer, technology transfer does not take place in international joint venture projects; therefore, knowledge transfer is a strategic issue when addressing issues of technology management. In this turbulent world, knowledge is widely recognised as the single most important factor in creating and sustaining superior organisational performance. At the same time both public and private sector organisations face an environment characterised by rapid and unpredictable change. Customers and clients are more demanding, and in the private sector, many businesses face hyper-competitive markets and industries. Under such circumstances the only way in which organisations can build and sustain competitive advantage is by creating or accumulating knowledge more rapidly than their competitors.

What is technology management?

According to the 1987 workshop report of the US National Research Council (NRC), “MOT” is the hidden competitive advantage bridging “the knowledge and practice gap” between science, engineering and business management. MOT as a field links “engineering, science and management disciplines to plan, develop, implement technological capabilities to shape and accomplish the strategic and operational

objectives of an organisation". The NRC report summarises important contributions to industry that MOT knowledge can make as how:

- to integrate technology into the overall strategic objectives of the firm;
- to get into and out of technologies faster and more efficiently;
- to assess/evaluate technology more efficiently;
- best to accomplish technology transfer;
- to reduce new product development time;
- to manage large, complex and interdisciplinary or inter-organisational projects/systems;
- to manage the organisation's internal use of technology; and
- to leverage to effectiveness of technical professionals.

Following the competitiveness crisis of the US industry in the 1970s and 1980s, the NRC report recognized that research and education diverted towards satisfying these needs are essential for US industry to regain its leadership position.

Significance of technology management

It is argued that there are three major factors strategically in modern organisations that underpin the creation of competitive advantages. The first of these is strategic leadership. The effective leadership ensures that the enterprise will develop itself in the right direction and that the production of products will meet demands of the market. The second factor is having a staff with motivation and empowerment. They are the driving forces of the organisation. The third factor is the proper MOT. It is important that the company's technology be properly managed so as to achieve effective and competitive status (Harrison and Samson, 2003).

Leadership and motivation of employees have been widely recognised as success factors. There have been significant additions to theories and practice regarding improvement in the management of people. Therefore, strategically, the remaining battlefield for being competitive depends on proper MOT. To put it differently, the strategic issue will be how a company could develop, acquire, share and manage technology appropriately and effectively.

It is interesting that this argument has been in congruence with the American historical experience. The US experienced an increasing global competition, which resulted in loss of market share in several industry sectors in the 1970s and 1980s. This became a concern not only to industries, but also to government and educational interests. To identify reasons of the decline in US industrial competitiveness and to formulate a response to the challenges within global competition, serious work and efforts had been contributed in the search for explanations and solutions. Discussions were initiated by major establishments such as the NRC, the National Science Foundation (NSF), the American Association of Engineering Societies, the Accreditation Board for engineering and technology, the American Assembly of Collegiate Schools of Business, Oak Ridge associated Universities and others. A series of workshops were organised and attended by experts for the discussion of changing paradigms in business and technology (Khalil and Bayraktar, 1988). A resulting consensus was that great attention and significant amount of efforts should be directed

towards making improvement in the MOT and in conducting research and developing educational programs in this emerging field of knowledge.

Khalil (2001) highlights that efforts to improve the US position in the global economy were being influenced by the understanding that more organisations, including government agencies, high educational institutions, enterprises and founding agencies, become aware of issues involved in the international arena. Today, rapid changes in the technology and business environment continue to occur. These changes require continuous updating of methods and techniques of business practice. For example, measuring the value of a business according to assessment of physical assets or based on traditional accounting or finance formulas are inadequate in the knowledge economy. Education and training institutions need to take into consideration the changing environment in technology and business and respond by changing their programs, accordingly. Khalil (2001) argues that international business and engineering schools need to have consideration of incorporating into their curricula educational modules recognizing the importance of the knowledge era and the technology revolution. The intangible assets such as intellectual capital, intellectual properties, service innovation, information technology and many of today's rapidly growing arenas should be recognized. Furthermore, many of the existing models and the traditional programmes need to take into account the appropriateness and effectiveness of technology and innovation as well as the volatilities of the environment in which the technology is created and applied.

Technology management in China: a historical perspective

Historical antecedents and evidence

Given the four glorious and famous inventions, paper-making, compass, gunpowder and printing, in the splendid Chinese histories, Porter and Forrester (2001) argue that the application of technology in China has evolved from two imperatives: The first imperative was to take into account the agricultural technology and feed the population in the areas where Chinese civilisation was born; the second was the need to provide military hardware and weapons, with which soldiers could keep the peace and secure China's borders against attack from outside. Confucian ideology, the orthodoxy of the traditional state, had little use for technology, while the ethnocentric character of the traditional Chinese state was disinclined to borrow new technology from overseas. The practical approach was to tolerate technology with reluctance, rather than exploit its advantage and to dominate it. However, the very nature of the pressure brought to China was the consequence of superior technology. The industrial revolution in the Western countries had inevitably brought with it great strides in military technology, which had great impact on China. China's experience of modern technology prior to the establishment of PR China in 1949 was of the brutality of foreign armies, and exploitation of its people by largely foreign commercial interests. In China's eyes, this modern technology was the technology of destruction. It was not surprising that after liberation, China's new leaders continued to be wary of modern technology as a principal instrument of self-improvement.

Technology and innovation after the establishment of PR China

In the early year after its establishment, China suffered significant diplomatic isolation. However, talks with the Soviet Union resulted in somewhat China's reluctant decision

to import industrial technology and equipment from the Soviet Bloc. In fact, the actual technology acquired by China through the deal was in many cases derivative and out of date. Russian technical assistance was suddenly withdrawn in 1960 following payment difficulties and ideological splits between China and the Soviet Union (Porter and Forrester, 2001).

Technology and innovation suffered even heavy blow in the 1960s as China entered a period of increased isolation from outside world. During the cultural revolution, the educated and technical professionals were targeted by the campaigners for greater redness, which undermined China's capacity to move forward scientifically and technologically and destroyed China's technology modernization.

Technological development and innovation since the economic reform

Current literatures concerning technology development and innovation since the economic reform present rather contradictory views (Xu *et al.*, 1998; Wang, 1993; Steward and Li, 1996; Simon and Goldman, 1989). Taken as a whole, these views offer a complicated picture in terms of technology management, technological development and innovation and technology transfer. China to some extent is experiencing significant difficulties, which is manifested in the process of formulating and implementing technology (Porter and Forrester, 2001). The technology development and innovation had strong connection with the command economy. For example, construction industry and other industries in China were arranged in a "block" format before the economic reform (Flanagan and Li, 1997), where they each had the same factories making the same products for the customers with the same demands. The reform from the central planned economy to the market economy saw the break down of these standardized block designs and the Chinese firms were suddenly faced with international competition (Li-Hua, 2004). They had to absorb technology that helps them survive. As a result, technology transfer has become very important and popular in China.

At the 100th anniversary of Communist rule, China's leader, Deng Xiaoping[1], had set targets to achieve a per capita income of US\$4,000 (presumably at 1987 prices) by 2049. This would rank China among the medium-developed countries in the world. To achieve this strategic goal will involve both the importation and absorption of foreign technology on an unprecedented scale. Since economic reform started in 1978, issues of international technology transfer in China have been highly valued and regarded. At present, the priority of this work is to introduce new and advanced technology from developed countries and in the mean time to export the advanced technology as well. In order to promote international technology transfer, several relevant laws and regulations have been enacted, such as, the Technology Contract Law of China adopted in 1987, the Science and Technology Improvement Law of China adopted in 1993, Science and Technology Result Transfer Law of China adopted in 1996 (Yu, 2005). It should be noticed that these laws and policies have a profound influence on technology transfer in China. In addition, technology transfer has been one of the main objectives of China in attracting foreign investment.

The Science and Technology Improvement Law of China encourages enterprises to carry out technological innovation and the renewal of equipment so as to increase the scientific and management competence. The aim of this law is for enterprises to develop new technology and to strengthen the competitive power in the market, in

response to the demand of international and domestic markets. Enterprises are encouraged to import advanced technology and equipment from developed countries through technology consultation, where they can develop new products and high-technology products. By applying new technology enterprises could compete in the international market and promote the internationalisation of high-technology industry (Li-Hua, 2004). The improvement of science and technology in industry, communication, post and telecommunication, geological prospecting, construction and installation promises to increase the economic and social results.

Features of management of technology in China

One of outstanding features in China's MOT was the concept of "self-design" and "self-development", which became important as the core of technological development and innovation since the establishment of PR China. China had made great achievements through the efforts of self-design and self-development in several scientific research fields. For example, the atomic bomb and the rocket were successfully developed and launched and still remain the strength of China's R&D (Xu *et al.*, 1998). It is clear that the philosophy behind the self-design and self-development was to develop indigenous technology capacity.

Another feature was that political ideology of China, which heavily influenced the MOT. Before the current policies of China, technological development and innovation was hindered by the "closed-door" policy, which hampered the acquisition and transfer of the advanced and high technology from the West. No doubt that China's political leaders were aware of the significance of technology development and management; however, it was unknown whether there was appropriate mechanism for technology management after the establishment of the People's Republic of China. Technology and innovation in China in the early years of its establishment were obviously influenced by the political establishment. Top jobs at various levels were often with those who had strong military background in Mao's[2] era, but there was much difference in Deng's time and more in Jiang's[3] time. It was apparent that top leaders appointed to the important posts were those who had technical background with education and research experience in the former Soviet Union. The years of economic reform also witnessed that people who had experience, education and research in the West had been brought to the important posts of the governmental agencies at various levels, in particular, in high education. In fact many of the university presidents have had Western education and research experience and have been awarded advanced degrees in the UK or US.

Technology transfer and acquisition: what is happening in China?

A few cases will be examined in this section that present a picture of what is happening currently and the push for technology transfer and technology acquisition in China. The case of magnetic levitation (Maglev) technology in Shanghai reflects strong influence of technology being transferred from one country to another.

Magnetic levitation technology in Shanghai

The celebration of the Chinese new year of 2003 was filled with the amazing news that the German technology of magnetic train in Shanghai had created the fastest speed (500 km/h), on the first magnetic railway in the world, as the magnetic train from

Shanghai Pudong Longyang to Shanghai Pudong International Airport was officially opened by the Chinese Premier, Zhu Rongji and the German Chancellor, Gerhard Schroeder on 31 December 2002 (Li-Hua, 2004). Known as the Maglev, China's flagship transport system takes eight minutes to hurtle along a 28.5 km track through the paddy fields surrounding Shanghai Pudong International Airport. This journey normally takes up to one hour by car.

The Chinese government is currently considering an extension into the city and possibly further to the neighbouring city of Hangzhou, in time for Shanghai's hosting of the World Expo in 2010. As the German technology being transferred to China has had a positive effect, the Maglev is now having followers across the world. According to Clark (2005), German wants to build one Maglev for an airport link in Munich. The US government is also evaluating Maglev schemes. More realistically the UK government plans to build a Maglev from London to Scotland, which will cost at least £16bn.

Technology acquisition: the giant dragon is awakened

The year 2004 witnessed that "made in china" aroused the curiosity across the world. The *Journal of Economist* expressed confidence that China would be successful in the establishment of world-class companies. *Wall Street Daily* was surprised that from oil to iron mining, from chips to colour television, China goes global and Chinese companies are purchasing the "whole world". *Financial Times* stated that China is a country where the high technology from the first world and the cheap labour and raw material from the third world are combined together.

Legend, a company now known as Lenovo, which was established at Shenzhen in 1984, purchased the PC department of IBM with US\$1.25 billion and intends to move its headquarters to New York in the near future. This enables Lenovo to become the third world largest provider of PC after Dell and HP and increase its market share by the combination of IBM's marketing channels and networks. However, Lenovo will be presented with challenges such as whether the original customers of IBM continue to trust Lenovo and how the 1,000 foreign employees and the original Chinese employees respond to the strategic vision and configuration of the company (China Business, 2004). Huawei, a Chinese telecommunication company, surpassed Ericsson in Netherlands with an overseas income of US\$ 22 billion and achieved its aim to obtain its position in the international market. This has enabled Huawei to have the position of world top 50 telecommunication enterprises with business coverage in 90 countries. Working to secure ownership of British MG Rover, Nanjing Automobile, China's oldest carmaker, planned to develop an R&D and technical facility in the UK. China National Offshore Oil Corporation (CNOOC) is looking to acquire overseas assets and made unsuccessful bid to acquire US Unocal's technology and assets in the Asian region to leverage its own exploration opportunities and reinforce its own technology capacity (Lee and Evan-Jones, 2005). According to investment bankers in Hong Kong, China has probably US\$30 billion in assets which can be deployed quickly now to affect corporate takeover. Chinese companies are able to take a "cocktail" approach to overseas acquisitions, depending on the overseas entity that is the subject of a takeover (Lee and Evan-Jones, 2005). According to Ming-Jer Chen, a business professor at the University of Virginia, the author of a new book *Inside Chinese Business*, among many Chinese companies attempting takeover, Haier, Chinese electronic giant based in

Qingdao is going to be at or near the centre of what is happening in China's economy. In other words, what they do will have a big impact on foreign companies that are looking to succeed in China. Haier has been identified as a company with sophisticated approach and energetic leadership. Haier Group, attempted takeover of Maytag, the US microwave oven and vacuum cleaner conglomerate. The guiding genius behind Haier's success is its chief executive officer, Zhang Ruimin, whose management theories are strongly influenced by ancient Chinese philosophy (Flannery, 2001).

Is Chinese business practice changing international business model?

Early in 2005, the *Journal of Sino-Foreign Management*, through its web site and the distribution of questionnaires during the annual conference, conducted an interesting survey among Chinese entrepreneurs on "whom should Chinese enterprises learn from". The result shows that 57.1 per cent (web site) and 59.4 per cent (conference questionnaires) believe that Chinese enterprises should now "move forward on its own way" while only 28.6 and 33.0 per cent believe that Chinese enterprises "should continue to learn from the West". However, there were different views expressed by three different schools in the consultancy circle and the academia (Deng and Yang, 2005). Chinese business consultants who have education and research experiences and hold Western degrees believed that the Chinese management philosophy is essential to the Chinese enterprises while Western management knowledge is desirable to the Chinese enterprises. Foreign business consultants who work in China believed that Chinese enterprise have not yet been able to establish its own management system within the 20 years since the economic reform. Chinese consultants believed that the prevailing management theory today only benefits and fits well with the Western trans-national enterprises. Therefore, Chinese enterprises should look after themselves and develop indigenous capabilities. These were differing views from Chinese entrepreneurs and the management consultancy circle.

Top jobs in trans-national corporations in China

As established previously, to some extent, Chinese management practice is shifting the international models. International companies are facing tough decisions in managing their operation in China. What were the responses from the trans-national companies who are working in China? It was surprising in 2004 that many trans-national corporations, including Motorola, Nokia, Intel and Siemens, changed their CEOs from foreign nationals into local Chinese, which indicates the significant change of the corporate policy and strategic views. Table I shows that the local Chinese have been currently appointed into the posts of presidents, or deputy presidents or CEOs of their firms.

In the meantime, many other trans-national corporations including Audi, BMW and General Motor, changed their CEOs frequently, which reveals the anxieties and uncertainties of the top management team towards the Chinese market today (Fang, 2005).

Drivers of trends in the management of technology

There may be differences or a large chasm that needs to be bridged between management in China versus managing in western countries. However, some constants will remain as to what is needed to succeed in Technology Management.

Zhou Hong	President of Yahoo
Sun Zhenyao	Vice President of HP Global and President of HP China
Guo Zunhua	President of VERITAS China
Yi Guoxiang	General Manager of Southern China, EMC
Lu Lei	President of NEC China Telecommunication
Zhou Xiaoyang	General Manager of Samsung China Radio
Zhang Yue	President of Philip China
He Qingyuan	President of Nokia China
Shi Dakuan	President of Motorola China
Zhang Zhiqiang	President and CEO of China Siemens Automobile and Electronic Group
Wu Yuzhang	Acting President of Volvo Asia and President and CEO of Volvo China
Ye Ying	Deputy President of Kodak
Su Jingshi	President of China Beisheng Food Group
Wei Zhe	President of B&Q
Peng Zhiyi	President of P&G China Media
Chen Ling	President of Bearing Point Management Consultancy China
Huang Jincai	CEO of Italian Zhongli Insurance Southeast Asia

Table I.

Today, the accelerating rate of progress in science and technology creates both tremendous opportunities and significant risk for developing countries. A lack of capacity among some developing countries to even access and utilize advances in science and technology has prevented them from capturing the benefit of science and technology that become commonplace in the rest of the world (The World Bank, 2002). Sustainable development will increasingly depend on a country's ability to understand, interpret, select, adapt, use, transmit, diffuse, produce and commercialize scientific and technological knowledge in ways appropriate and effective to its ambition and level of development. No doubt that the MOT plays vigorous role and assumes a great importance in advancing every aspect of human endeavours. The interest in MOT has mushroomed globally since its introduction as a new field of study and research in the 1980s. In fact, the application of MOT has made a significant impact on the wealth creation ability of the US and many other countries. MOT is an important strategic instrument to create competitiveness, which still holds the promise of creating prosperity in countries that effectively apply this instrument in the world.

Sustaining economic growth

There are three pillars that are essential to support the competitiveness of enterprises and sustain economic growth of a nation. These are: the technology development system, the financial system and the trading system. The technology development system includes the development of such important sectors as: education, training and human resource development; R&D policies; development of production facilities such as factories and service enterprises; support for creativity, innovation, technology acquisition and transfer. The financial system pillar includes such important sectors as banking, stock exchanges, venture capital firms and central control institution such as a Central Bank or Federal Reserve. The trading system pillar include trading globally, interacting with the World Trade Organization (WTO), building a global network of partners and supporting activities of entrepreneurs and small and medium enterprises (SME).

In a totally free economic system, the government act as a facilitator and supportive of the private business enterprises. The private sector is almost totally in charge of

driving the engine of the economy. In more centrally controlled economies, similar to those existing in many developing countries, government assumes a larger role in central planning and control and may own or be a partner in productive enterprises. In both models the three pillars supporting competitiveness of enterprises, as mentioned here, must be built. The difference among winners and losers of the race to improve a country's share of the global ranking, as measured by GDP and GDP growth, lie in the strategies formulated at the macro level of government and the micro level of enterprises and how well these strategies are executed.

Critical factors in management of technology

There are several key factors in technology management that must be considered by business executives and policy makers alike. These include issues of technology transfer, changes in the global environment, harnessing communication and information technology, organizational structure, business finance and education and training.

Effectiveness of technology transfer

MOT considers technology as the primary engine of economic growth and wealth creation. Technology is an expression of human creativity and depends on harnessing information into knowledge and applying this knowledge to the betterment of human conditions. The question for China and other developing nations is how to acquire the technology and how to permit the population to deploy this technology to improve economic and social conditions. For a country such as China, where human creativity has not been well managed for years, the existing system was not in a position to create technology capable of competing in the global market place. It was necessary to acquire technology by transfer mechanisms from international sources. This is possible by preparing the infrastructure, the business environment and the human resources needed to absorb the transferred technology. It is accelerated by permitting investments, by international firms, local organizations and Chinese entrepreneurs, in productive enterprises in China. China was able to and can continue to build on the strength of its population as a source of labour and huge market to attract such investments. Indeed, China was very successful by all measures in implementing this first phase of technology transfer. In this first phase emphasis is on transferring low and to some extent middle technologies that are in the mature stage of development. Examples of these are manufacturing and process technologies used to produce household products, consumer products, appliances, garment industry and simple electronic gadgets. Competitiveness of these levels of technology is dependent on the cost of element of production, i.e. material, labour, Overheads, administrative and marketing costs. China certainly has a good competitive advantage in cost structures in these elements. The challenges are, however, still formidable in moving to the next phases needed to make the technology transfer and development effort a true success. Countries that have been successful in transferring technology such as Japan have moved in logical progressive stages of technology acquisition, to assimilation and diffusion to indigenous development through improvement and innovation (Dahlman and Brimble, 1990; Bjerke, 2000; Kondo, 2005). This sequential transition remains to be the challenge of Chinese industry today.

The changing global business environment

MOT must be conducted within the context of the business environment. This global business environment has been drastically changing over the past decade with continuous changes expected for the future. Innovation of products and business processes will be a dominant factor in determining business success.

Another change in the business environment is the emergence of multiple stakeholders for the business enterprise. Beside the owners, investors and employees of the firm, the stakeholders now include suppliers, customers, government regulators, environmentalists and the community. This leads to the need for managers who are able to deal with demands of a diverse array of issues as well as diverse stakeholders.

Enterprises must continue to ensure that the systems responsible for the generation of knowledge and acquisition of new technologies are effective. Knowledge generation is always a key entry-point for effectively managing technology, and must be supported by innovative policy development and an infusion of research funding in the development of new technology. Newer methods of technology acquisition including global alliances, mergers and cross boundaries research are emerging.

Global stakeholders and competition encourage more global alliances. A dynamic global marketplace creates the need to educate members of the organization in international business practices. And parallel to this is the increasing trend in industry towards greater dependence on the outsourcing of some aspects of technology or product components to small and midsize companies. Worldwide this fosters greater collaboration, mergers and joint ventures in order for companies to compete effectively. Thus multiple parties are becoming involved in the innovation process, creating multiple ownerships by competitive corporations working in the same business.

The production of non-physical products and services continue to grow in importance. At the heart of all are the advancements in information and communication technologies. Knowledge integration continues to be the driver behind supply chain strategies, driving innovations in products, service, production, distribution and marketing. Yet, even in this global environment, how and what a corporation does will continue to be influenced by cultural influences. Global competition dictates new need to adopt policies leading away from parochialism and ethnocentric trends.

Harnessing information and communication technologies

There is a major upheaval in information and communication arena. Changes in business environments are being greatly influenced by the new information communication technologies. The new information technologies continue to drive a kind of imperative that it must be deployed different areas of the business. Finance, marketing, accounting, R&D, engineering and public relations all must rely on information technology as the common core to compete.

Owing to the growth in flow of information across the globe, which has been fuelled by the growth of the internet, intellectual property rights (IPR) has become a serious issue to deal with. It has become a challenging and multifaceted area from legal and logistic points of view. This emphasizes need for better intellectual property protection strategies and better-structured agreements. Parallel to this, new and enhanced security drive the need for a change in corporate records and information systems. The need for corporations to master communications technology is particularly important because of the quantity of corporate records available in cyberspace.

The explosive use of the internet has caused a “bottom-up” revolution, where communication within companies and communication between the business and the customer has been utilized in order to foster business growth. Accordingly, collaboration, communication and integration among departments and organizations are increasingly important. Collaboration among companies consists of increased global alliances, joint research and development and production projects. New technology continues to fuel entrepreneurial activities and lead to growth of small businesses. The proper integration or spin-off of these small businesses can contribute to the overall growth of technology and wealth.

Organizational structure

There is a growing trend to move away from fixed, permanent, bureaucratic organizational structure to a more temporary and flexible structure. 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 internet. The integration of departments within the organization needs to build synergy and create a unified organization working collaboratively around an end product. Hollow and virtual corporations are emerging as powerful new forms of organizations' structures.

Organizations must recognize intellectual capital and tacit knowledge. The strategic planning process will help to define the culture of the organization and those of employees and customers. Organizations must embrace entrepreneurial activities; rapid changes in technology have made it important to begin replacement or improvement technology immediately following the development of new products. Shorter business and technology phases are creating a greater need to closely integrate the business and the technology strategies. This process is facilitated by proper structure of the organization.

Financial issues

Financial opportunities which use the creation of mergers/acquisitions, particularly in organizations dealing with mature technology, continue to occur as corporations realize the benefits to combining technological expertise, economies of scale and the elimination of organizational duplications. Another interaction of technology and finance occurs because of the need for the formulation of mechanisms to finance complex technology. This is forcing corporations to change their models of financing technology in order to justify investment in technology. Joint R&D efforts, alliances and joint ventures for technology development are increasing in order to share the financial risk of technological development. Venture capital and technology funds are needed to fund innovative risky ideas and to promote entrepreneurship. While China now may have been providing capital resources to entrepreneurs and industry through government and institutional support, this policy may not be sustainable on the long run and alternative financing methods will need to be developed.

Knowledge needed for MOT education

Based on a survey of members of the International Association for Management of Technology (IAMOT) respondents strongly affirmed that there is a definite paradigm shift in industries which requires specially educated and trained human resources. They indicated that current undergraduates are not prepared for the new business environment and that current MBA programs are more suitable for a static environment than for the dynamic environment of the new century.

MOT trained individual should be versed in technology base of the enterprise, understand the impact of technological change, develop good communication skills, excellent computer skills, be able to work in teams, have strong ethics and values, understand global cultures, appreciate diversity, receive cross disciplinary course work, understand organizational structure to develop a wide view of the company, be able to integrate knowledge and resources, be able to think “out of the box”, understand the macro and micro view of the business world, understand the sociology and the context of MOT, appreciates the need for strategic thinking and operational efficiency, know technical methodologies that enhance competitiveness, receive practical training to develop tacit knowledge and much more (Khalil, 2001). Business leadership to run companies of the future must focus on knowledge acquisition, innovation, integration and collaboration.

Industry has been heavily engaged in transforming their structures and management styles to permit organizational flexibility necessary for survival in the twenty-first century. For industry to be competitive, the need for pertinent technological and managerial education for all managers is imperative. Universities and academic institutions have been slower in responding with the needed curricula to prepare the future generation of engineers and managers that will serve as agents of change. There was a strong sentiment expressed by many of the respondents to the IAMOT conducted survey that academic institutions need to re-engineer their academic procedures, develop MOT faculty, change institutional structure, reward systems, permit stronger interdisciplinary and cross disciplinary interactions. Moreover, excellent opportunities exist in facilitating the delivery of educational material through the emerging channels of distance learning and electronic delivery methods.

IAMOT is now undertaking a major initiative to create guidelines for academic programs in MOT and certification/accreditation guidelines to recognize the quality of academic programs. This promises to be a strong step towards establishing formal MOT education globally on a sound academic basis.

Discussion and conclusion

This paper has attempted to review the changes taking place in China from a MOT perspective. It presents the tenets and critical considerations required for the implementation of principles of MOT. These could be used to establish and to explore opportunities for improving the effectiveness and efficiency of technology transfer and technology development in China. The critical factors in MOT presented in this paper are based on the US research and education experience over the past two decades. It might not be directly relevant to China as there are differences in many respects. These include political structures, cultural background, historical perspective, social value, etc. however, it is expected that China can learn from the US experience where

many industries lost market share and competitive advantages in the 1970s and 1980s and roared back to restore their competitive advantage in the 1990s.

The review of the literature reveals that it is unknown at this time whether there is appropriate infrastructure to support diffusion of the MOT principles throughout China, and it is debatable whether business and engineering school need to introduce MOT curricula following the US model or develop a new model shaped by the Chinese culture. It is, however, evident that current situation in China in terms of MOT presents both opportunities and challenges not only to Chinese business, but also to the Western business. Today, increased levels of competition in the wake of China's entry into the WTO have resulted in experimentation and risk-taking as ways of doing business in China. The complexities of technology and knowledge transfer across international boundaries have led to misunderstanding in the operation and the implementation of international joint venture projects in China. The uncertainties and ambiguities prevalent in the Chinese business environment, in particular, in the area of technology management, are neither well understood nor effectively negotiated by the international investment community. Therefore, as to the international investors, China's business environment continues to present many challenges, particularly in how to manage effective business networks, ensure smooth knowledge transfer and protect IPR. In the meantime, the Chinese investors are facing even more severe competition, both the internal and external business environment presents to them double edged sword with China's access into the WTO and having to compete under its provisions. The challengeable question will be: what is the way forward?

In the 1950s the American style management was prevailing across the world. And in the 1970s, the Japanese style management, which had created the amazing economic wonder, emerged as the most popular in the world. How did Japanese style management become known? The answer is that Japanese style management would not have been known without the wonder of Japanese economic development in the 1970s and 1980s. The Chinese style management is now under scrutiny. The Chinese style management emerged in the 1980s, as the economic reform started in the late-1970s. China's legend is that China has become second only to the US in GDP as expressed in purchasing power parity (PPP). This is a result of the radical economic reform introduced only in the last 20 years. So, is there a newly emerging style of management coming from China? Zeng (2005) has made interesting comparison between American style management and Chinese style management. It has been understood that the American style management is embedded in the process of self-actualisation. For example, it focuses on "management by objectives" and "management by result". However, the Chinese style management concentrates on the philosophy of "self-disciplinary first and then managing people" under the Confucius philosophy. With the current strong influence of government central involvement in technological and business development, the character and effectiveness of the Chinese style of management is yet to be fully understood or tested.

There is no doubt that Chinese style management will have an important position in the management field in the twenty-first century. However, this does not mean that Western style management will be replaced by Chinese style management. There is also little doubt that the twenty-first century is the century of those who are armed with Western management knowledge, but in the meantime it may have to be modified by emerging Chinese management philosophy. The recent success of the Chinese

economy is forcing a new look into strategies of managing technological resources in the twenty-first century. It is an era where people may need to understand Chinese philosophy and Western management science and may need to integrate Chinese management wisdom and Western management ideology.

Notes

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1. Deng Xiaoping (1904-1997), Chinese Communist leader who served as the de facto ruler of China from 1976 to 1997. Under Deng, who survived two purges before he succeeded Mao Zedong, China developed into one of the fastest-growing economies in the world.
2. Mao Zedong, Chinese political leader, poet and statesman, founder of People's Republic of China. Mao Zedong's ideas varied between flexible pragmatism and utopian visions, exemplified in the great leap forward and the cultural revolution. His literary production contains mainly speeches, essays and poems. Mao published some 40 poems written in classical tradition with political message.
3. Jiang Zemin, Chinese political leader after Deng Xiaoping, a shrewd survivor, a veteran of the epic leadership battles in the Chinese Communist Party and an economic reformer intent on shaking up China's massive state-run industries.

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