Commercializing Innovation in China

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This article first takes an overview of the commercialization of innovation and the problems it has generally encountered. Then, a conceptual perspective is derived to examine the process of the commercialization of innovation in China in order to show why, until now, it has been problematic. A brief look at a few cases of commercialization in China is taken in this context. This study notes that although there have been successful cases of production of advanced technological military goods, the military does not provide a satisfactory model for commercialization of innovation in the civilian sector. Finally, the article proposes that a potential solution to this problem, based upon the Hong Kong economy's penetration into southern China, is already in progress.

Keywords: Commercialization, innovation, technology, China, R&D, spin-off companies

The Problem

The commercialization of innovation refers to commercializing scientific and technological knowledge, know-how for short. This concerns the ability to convert the ideas of research scientists, technicians, and institutes into marketable products and services. This type of commercialization is crucial to a state's ability to move from an agrarian to an industrial economy. It involves not only economic take-off but sustained economic growth.

Technology transfer since the early 1980's has facilitated the rapid development of a large research establishment in China (Gwynne 1992, p. 19;

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Business Asia 1994, p. 7). Yet, 'although China has thousands of innovative research scientists and engineers, and hundreds of institutes, {it} lacks the ability to' commercialize its know-how (*Business Asia* 1994, p. 6). There have been a number of efforts at innovation but few have been successfully brought to market. This deficiency is due to the scarcity of linkages between enterprises, especially state enterprises, and research institutes (*Business Asia* 1994, p. 7).

The absence of such linkages is a historically conditioned legacy of the pre-reform structure of the research and development (R&D) and production system. 'The process of taking a new item... from the initial R&D stage to the final one of serial production has a certain logical order... . The product must undergo R&D, design, testing, engineering, and finally serial production (Ostrov 1991, p. 13)'. R&D organs ideally should precede factories. During the 1950's, the attempt to establish a high technology base therefore led to the establishment of research institutes prior to factories (Ostrov 1991, p. 13). In the process of making the leap from R&D to production, those research institutes with privileged access to resources exploited their advantages to spawn their own factories. For example, during the Great Leap Forward, research institutes attached to the Chinese Academy of Sciences established 111 factories (Xinhua 1958, p. 17). Should this number of factories established seem somewhat exaggerated, one must recall that at this time the Chinese use of the term 'factory' could apply to anything as minimal as a facility for repairing equipment.

Consequently, factories became collocated with the research institutes that spawned them. The drive for organizational self-sufficiency in resources led to expansion of successful R&D/production organizations. By the same token, it encouraged isolation of factories from research institutes with which they were not collocated. The absence of a free market with the opportunity to form contractual relationships exacerbated this condition of separation of vertically integrated R&D/production units from one another.

One may wonder why the method to take an item from the idea stage to serial production forty years ago cannot be used today. There are a number of factors which account for this. Perhaps the main one is that the goods produced then were predominantly capital goods, not consumer goods and the primary end-user was the State. Marketing was not called for. When high-technology products were required by the State, the assignment would be given to the appropriate R&D/production unit. Linkages to other such units when they occurred at all did so without resort to markets but to

hierarchies. Successful units used the *guanxi* of their leaders and/or the advantages deriving from their positions in state or even party hierarchies to acquire the resources they needed to complete their tasks. Successful organs like the People's Liberation Army's (PLA's) Science and Technology Commission for National Defense did not contract out to other units for needed personnel but simply absorbed such units into an organizational hierarchy subordinate to it (Ostrov 1991).

Today, such measures are no longer applicable. The expanding free market and efforts to institutionalize a legal structure in China prevent units from embarking on the type of organizational conquest in which the Science and Technology Commission for National Defense engaged. This complicates the process of forming linkages between research institutes and factories.

Furthermore, even when such linkages have been made, there are still great difficulties. There are potential end-users other than the State in a growing private sector, and even end-users beyond China. This means that those who wish to produce and sell a product cannot simply aim at one target, the State. Besides, they cannot take for granted any certainty that there will be a guaranteed buyer.

The Solution

Since the measures taken in the past to bring a product on-line will no longer apply, new ones must be taken. New linkages between research institutes and factories in the context of a growing free market must be created. Furthermore, these linkages must also include personnel with entrepreneurial skills so that products are not only successfully produced, but are done so at suitable cost and targeted at appropriate market niches. These demands require team-building in an optimal sequential cascade. An optimal sequential cascade involves inputs from individuals in certain organizations in a logical order (Belinko and Large 1995, pp. 16–17). Above all, it is crucial that the team must remained intact until a successful outcome has been achieved.

First, the research institute must have an end-user for the product it intends to bring on-line. Then a product manufacturer must be recruited. Next, a transfer agent is needed to formulate a business and marketing plan. Finally, when all this has been achieved, the plan can be presented to a funding agent. The advantage of such team-building is that the cooperation involved allows 'firms to pursue scale and scope economies in research, finance large costly proposals, share risks, avoid unnecessary duplication... and allow the use of firm specific complementary skills and resources (Tripsas *et al.* 1995, pp. 367–389) cited in (Nakamura *et al.* 1997, p. 153)'.

The team-building process described above, which creates research consortia, is a slow one. Therefore, the problem of maintaining commitment of the personnel involved is incurred (Belinko and Large 1995, pp. 19–20). The problem occurs for various reasons. One is simply the normal movement of personnel to new positions in the course of career development. Another is the problem of motivation. The latter problem can be especially intractable. One might think that financial inducement would be sufficient to retain key personnel in the team. It often is. However, many personnel in the research group within the team may not be swayed by financial inducement. Scholars may be more concerned about teaching and research conditions and the general academic environment. They may be lured out of the team, indeed out of their research institute and university, to another institution offering a more sympathetic setting. Ultimately, scholars subjected to this tension will experience conflicts of values and conflicts of interests between scholarship and entrepreneurship (Bird *et al.* 1993, p. 58).

Sometimes, these problems can be alleviated and the commitment of researchers to the team can be retained by creating spin-off companies from universities. In effect, universities fund business ventures inspired by technology originators among their faculty. Where successful, this has two advantages. The benefit to the university is that those good faculty members who are entrepreneurially inclined will be retained instead of being lured into the private sector. The advantage to the team being built is that the stability of technology originators is enhanced (Tripsas *et al.* 1995, pp. 20–21).

Such spin-offs require great flexibility in the way researchers are incorporated into them. Some primarily retain the interests and values of scholars and are motivated more by intellectual curiosity and peer recognition. To retain their commitment, such spin-offs must allow them to continue their work in this fashion. Others discover entrepreneurial talents and must be allowed to combine the roles of technology innovator and entrepreneur (Roberts and Malone 1996, p. 21).

There are numerous examples of universities in the USA and United Kingdom that have successfully created such spin-offs. Among these are Harvard University, Boston University, the Massachusetts Institute of Technology (MIT), Stanford University, the University of Chicago, the

University of Connecticut, and King's College, London. Typically, these universities have set up technology transfer offices (though they may go by other names like 'technology licensing office') to facilitate spin-offs (Roberts and Malone 1996, pp. 17, 31–39).

When considering the ability to commercialize know-how, looking at the character of individual research institutes or enterprises, or even particular teams is insufficient. Certainly, certain social conditions create opportunities favorable to innovation. Van de Ven suggests that 'technological and institutional innovations reciprocally co-produce each other (1993, p. 25)'. More specifically, he proposes that the success of a technological innovation depends upon how well 'the institutional arrangements, resource endowments, and proprietary components of the social system are established at the industrial community level (Van de Ven 1993, p. 32)'.

The resource endowments and proprietary functions involve features of the team being constructed to bring a new product successfully to market. The institutional arrangements, however, concern the social and political environment in which the team finds itself. They involve legitimation, governance, and technology standards (Van de Ven 1993, pp. 26–27). These arrangements suggest severe limitations to the commercialization of innovation in China due to the social and political environment there.

For example, Van de Ven suggests that elements of governance, explicitly including the patent system, are important to technological development (Van de Ven 1993, p. 30). One can imagine how the motivation to establish linkages between research institutes and enterprises, and subsequently embark upon the commercialization of innovation depends upon the existence of a strong patent system with its protection of intellectual property rights for a limited time. There should be enough time not only to recoup investment costs but to make sufficient profit (however much that is.) Since it is doubtful China has such a system, in this manner one might account for the low level of commercialization of innovation into high technology products. However, studies have found that patent protection has little bearing on product innovation in most industries. Only in the pharmaceutical and chemical industries is patent protection significant to the development of new products (Mansfield 1986, pp. 174, 180).[1] Besides, in 1998, the Chinese Government announced plans to strengthen patent protection and extend it to cover not only new products but also production, marketing, and business strategies. In addition, China established the Intellectual Property Rights (IPR) Training Centre earlier in the year, with State Council backing, to train officials concerned with intellectual property rights issues (Cui 1998).

However, while the issue of patent protection might not be problematic, other intellectual property issues are. China's Company Law limits the valuation of industrial property rights and non-patent technology to a maximum of 20% of a company's registered funds. This makes potential innovators more dependent on others for funding than they need to be. The potential for profit is reduced and innovation is inhibited (Qiao 1998; *China Daily* 1998a).

One might question the significance of this provision of China's Company Law as an inhibitor of the commercialization of innovation. After all, such regulations are not uniformly applied in China. The recent (early 1999) failures of GITIC and GZITIC are indicative of this. Familiarity with the relevant officials can allow one to get around regulations. Guanxi networks have long been known to be significant in China. However, even though some can evade the regulations, this is not true for all. The rules therefore can have an inhibiting effect upon potential entrepreneurs of innovation. Furthermore, it is not only these potential innovators who can be discouraged. Officials can also be discouraged from either helping businessmen evade the rules or even granting official approval in compliance with regulations to a project. The penalty for alleged corruption, especially during periodic anti-corruption campaigns like now (July 1998 to 2000), can be as severe as capital punishment.

Nakamura, Vertinsky, and Zietsma also suggest that the social and political systems are significant in accounting for how well commercialization of know-how can be carried out in a particular setting. However, they place greater stress than Van de Ven on culture. Elements of culture, such as trust and an individualism/collectivism axis are used to explain how readily research consortia can be formed and how successful they can be. These features can also explain when government intervention may be necessary to make success likely (Nakamura *et al.* 1997, pp. 156, 158–159).

For example, Nakamura, Vertinsky, and Zietsma show that in Japan with its collectivistic orientation, cooperation among units or individuals of equal status is difficult. Unless there is a strong hierarchical structure among units, each will retain their most talented personnel and contribute only mediocre people to any cooperative effort. Thus there are few joint laboratories in Japan. Where there is successful cooperation, MITI has intervened and provided the hierarchy that would otherwise be absent (Nakamura *et al.* 1997, p. 164).

Applicability to China

Some Chinese economists themselves recognize the impact of culture upon institutions conducive to innovation. They suggest that in China culture and institutions inhibit innovation. They then insist that legal reforms are necessary to make property rights and profit-making from innovation secure (*China Daily* 1998b).

The conditions cited above for the establishment of linkages between research institutes and enterprises do not provide grounds for enthusiasm about such possibilities in China. Universities are probably insufficiently autonomous and inadequately funded to launch spin-offs. Premier Zhu Rongji himself recognized the existence of the problem of inadequate development of enterprise spin-offs from universities. He 'cited the need for effective policies to transform institutes involved in applied scientific research into enterprises'. The Premier expressed the view that 'more scientists and technicians from research organizations and universities should be encouraged to work closely with product manufacturing, or otherwise help improve the climate for technological innovations by enterprises through forming different forms of economic entities (Xinhua 1999)'.

In addition, transfer agents with the necessary entrepreneurial skills to formulate business and marketing plans are in short supply in China. Where there have been successful examples of the commercialization of know-how in China, one generally finds that either the process involves organs connected with the military or that expertise is brought in from beyond the Mainland, especially from Hong Kong (Gwynne 1992, p. 19; *Business Asia* 1994, pp. 6–7).

Concerning the latter case, for example, the Hong Kong Institute of Biotechnology at the Chinese University of Hong Kong has brought in biotechnologists from the Mainland and provided the entrepreneurial skills they lack. The outcome is the production of pharmaceutical products from traditional Chinese sources which shall be marketed overseas (Gwynne 1992, pp. 19–20).

Commercialization of know-how leading to a product for the military as opposed to a civilian product is a much simpler process for several reasons. First, there is a single and definite end-user, the PLA. Marketing and procurement of funding are much less of a challenge. Moreover, in this case, the process of commercialization is not initiated by technology originators in research institutes but by the military itself. Until 1999, for nearly the past twenty years, the Commission in Charge of Science, Technology, and Industry for National Defense (COSTIND) had been the engine of this process. It had played the role which Nakamura, Vertinsky, and Zietsma ascribe to MITI in the Japanese context. Considering that while perhaps not as strong as in Japan, the collectivistic orientation also pervades China, the structural introduction of hierarchy among units of equal status is significant.

The COSTIND is responsible to the State Council and the Party Central Committee's Military Commission (State Council of the People's Republic of China 1983a, 1983b). It derives its funding and policy priorities from them. It would annually take guidelines from them, especially the Military Commission, and act to coordinate the development, production, and acquisition of advanced weapons. The COSTIND then would formulate a plan involving R&D and production priorities. Together with the Ministry of Finance and State Planning Commission, it would work out a budget, allocate funds to various units, and examine the budgets of these units. These funds would be placed into different categories and COSTIND would regulate the ratio among them (*Keji ribao* 1987). One of these categories, the 'weapons and equipment development funds', was the channel through which most of the funds allocated by the COSTIND for weapons research and production passed (*Renmin ribao* [overseas edition] 1988). These funds were distributed to military user departments based on the COSTIND's R&D and production priorities. These departments could then contract out to factories and institutes (Yang and Xie 1987).

In the case of other types of funds, the COSTIND could allocate money directly to the developers instead of going through the military user departments. These involved the 'applied and basic research funds' (Xinhua 1983; Zhang and Chen 1987). They also involved funds allocated by the COSTIND to military user departments which had not been used by the end of the year. One-third of these were to be remitted back to the COSTIND to promote 'unified programming of defense research' and fund 'pilot production' (*Keji ribao* 1987). Where the COSTIND allocated funds directly to the developer, it assigned a chief-designer to oversee the project (Xinhua 1983, p. K6). Hower, this year (2000) administrative reforms reduced COSTIND's MITI-like role in the military arena.

Chinese Cases

The following discussion will cover four cases of commercialization of know-how in China. The first two can be considered successful.

However the last two cannot. A comparison among them may yield some insight.

In Shenzhen, the Shangxia Information Technology Company has developed the 'Biyitong' Chinese handwriting recognition personal data assistant (PDA). Besides Chinese characters, the system recognizes Chinese telegraphic codes and pinyin. It also has a number of other features, including English-Chinese and Chinese-English dictionaries. The company has received orders from not only within China, but also Taiwan, Singapore, and Hong Kong (*Keji ribao* 1995a).

There are several factors that can account for the success of this venture. The Shangxia Information Technology Company may be a university spin-off. It included the involvement of professors from Harbin Polytechnical University. Being located in Shenzhen, which is one of China's Special Economic Zones (SEZ's), there are less restrictions on how the firm conducts its business. It also has greater access to personnel from outside the Mainland. Indeed, it has already formed a joint venture with the Hong Kong-based Star Paging Company to develop a new PDA based on the Biyitong which will also include facilities for paging and wireless communication (*Keji ribao* 1995a). Finally, unlike many other commercialization projects, this one had government support. It was bolstered by 'China's "863" Plan, a national high tech program focusing on the commercialization of high-tech product developments (Yu and Huang 1995)'. The plan, begun in 1987, provides for State funding of approved projects through the State Council's Science and Technology Commission. The Commission's financial controller has the duty to correspond with units engaged in developing advanced technology products, working out production targets for approved projects, and arranging financing (Guojia kexue jishu weiyuanhui 1990; Lin 1992).

The Chinese Academy of Sciences' Software Research Institute has established a Parallel Software Research and Development Center. This supersedes the Parallel Computer Studies Research Office set up by one of its research fellows, Sun Jiachang. It is designing a parallel mathematical database for a foreign client and will conduct feasibility studies on the commercialization of petroleum reserve simulation software for Chinese and foreign petroleum firms (*Keji ribao* 1996).

Again, it appears that success depends upon a spin-off. However, in this case, it appears that the spin-off is not from a university but a government organization. The initiating role of the Academy of Sciences in this process appears to have taken an organ that previously had been purely research-oriented, the Parallel Computer Studies Research Office, and transformed it (*Keji ribao* 1996). The result is a series of successful commercialization ventures.

Staff of the Electronic Sensors National Key Lab under the Chinese Academy of Science claimed to have developed a completely newly conceptualized virtual function generator. This device can generate a function from a wave that one inputs as well as reproduce a wave from a mathematical function that is submitted and is compatible with the Graphtools program. It consists of a personal computer which together with appropriate hardware and software and combines the functions of a function generator, oscilloscope (to show the wave) and kymograph (or oscillograph to record the wave.) It is claimed to be inexpensive and user-friendly. The capacity of this device is indicated by the data transmission sampling rate of its AD/DA (analog-digital/digital-analog) card of fifty microseconds and its range of wave frequency from 10^{-4} to 10^{4} Hz (*Zhongguo dianzibao* 1996).

This capacity though is quite low. The waves that can be handled are of very low frequency. Audio waves for CD-ROM's generally begin at 2×10^{4} (20,000) Hz and go on up. The wave range of the device is limited by its slow data transmission rate. Five microseconds is now generally attainable and there are AD/DA cards in the high nanosecond range. (A microsecond is a millionth of a second and a nanosecond is a billionth of a second.) Fifty microseconds would have been state-of-the-art over ten years ago.

The limited capacity of this virtual function generator indicates two problems. First it indicates a lack of awareness of the state-of-the-art in the outside world in this field. Second, there is a question as to the utility of the device. Its speed and power are too limited for audio waves let alone the much higher frequency video waves. One must wonder what use it could have apart from being an educational tool.

There have been a number of projects in China to create computer-aided design (CAD) applications. However, most are not commercially viable. Only 5% have been used outside the units that created them. A typical example is that of the China Architectural Sciences Academy. It has developed software being used by over six thousand of its ten thousand units. According to the CAD Applications Projects Coordination Group, such lack of success can be explained by a lack of trained personnel and funds (*Keji ribao* 1995b).

When comparing the last two cases to the first two, some obvious differences do appear. The CAD Applications Projects Coordination Group appears to have some insight into the problem when it points to a lack of trained personnel and inadequate funds as responsible for the failure to commercialize CAD products. Indeed, 'spending on product development and research in China's large- and medium-sized enterprises accounts for only 0.39% of their sales volume. {This} is merely 0.6% in high-tech enterprises. Such spending is less than 10 per cent of the average of the developed countries (*China Daily* 1999)'.

Besides institutional arrangements and proprietary functions, Van de Ven's social system framework for understanding innovation, development, and industry emergence also includes resource endowments. Among other things, this refers to the human competence pool and financing (Van de Ven 1993, p. 26).

Information on the Parallel Software Research and Development Center is sketchy but a number of favorable features regarding the Shangxia Information Technology Company are clear. It does not lack expertise, drawing scholars from Harbin Polytechnical University. Its location in the Shenzhen SEZ suggests it will also have access to expertise — and funding — from outside the Mainland. Indeed, its joint venture with Hong Kong's Star Paging Company bears this out. The economically freer and relatively more autonomous context of the Shenzhen SEZ is also more conducive to successful economic activity. Finally, it enjoys the unusual advantage of government support and presumably receives some financing. However this does not always guarantee a successful outcome. Presumably, since it is under the Chinese Academy of Science, the Electronic Sensors National Key Lab also enjoys government support and financing. Yet it has manufactured a product of limited utility and marketability.

Conclusion

This study tentatively suggests that a return to a policy of self-reliance would inhibit the commercialization of know-how into high technology products in the civilian sector. China cannot do it on its own. The entrepreneurial and marketing expertise provided by transfer agents must be found outside the Mainland. Indeed, the case of the Shangxia Information Technology Company is indicative of an ongoing and intensifying trend that is making such transfer agents more readily accessible to Mainland research institutes and enterprises. This process is the economic penetration of the Mainland by Hong Kong. Hong Kong entrepreneurs have been introducing their skills and capital first into Guangdong Province, especially Shenzhen, and then more distant areas of China. One indication of this is that 'eight out of every ten Hong Kong manufacturers operate in China, employing five million mainland workers, more than Hong Kong's entire labor force'. Another is that 'Hong Kong investors have poured $100 billion into China and own $40 billion in Chinese-backed companies' stock (Brauchli 1997)'.

Indeed, judging from advice which the new Chief Executive of the Hong Kong SAR, Tung Chee Hwa, is receiving, this process of economic penetration and integration will now accelerate in the aftermath of the transfer of sovereignty over Hong Kong from Britain to China. George Siu-kay Leung, economic adviser at Hongkong & Shanghai Banking Corp., rejects the notion that the new SAR government should create a MITI-like organ to promote manufacturing in Hong Kong. Instead, noting that 'manufacturers moved most of their operations to southern China in the 1980's' and that industry has declined from 37% in the early 1970's to about 16% of output now, Leung recognizes that Hong Kong's strength now is in financial services (Hagerty 1997). This represents expertise lacking in the Mainland and it is where Hong Kong should lay emphasis. In so doing, Hong Kong can be the 'bridge to the commercial world' for scientists on the Mainland who by themselves cannot find commercial applications for their research (Hagerty 1997).

While the increasing role of Hong Kong entrepreneurship in southern China's economy seems encouraging for the prospects of commercialization of know-how there, other factors make this less certain. Although a patent system is not essential to commercialization, the social environment in China does suggest some problems in this area. As in Japan, cooperation among equals is difficult due to a collectivistic orientation, uncertainty, and issues of trust. Where hierarchy is introduced, as in projects initiated by the Academy of Sciences or COSTIND, the chances of success are greater.

In addition, there are highly influential voices in sharp disagreement with Leung's assignment of priority to financial services. In 1999, Richard Li successfully gained the Hong Kong Government's backing for the development of a cyberport. The aim is to make Hong Kong a leading hi-tech center in its own right, passessing its own scientists, technicians, and entrepreneurially-skilled individuals. This might detract from the contribution of Hong Kong entrepreneurial skill to the commercialization of innovation on the Chinese Mainland.

These conclusions are not fixed in granite. Social systems and knowledge are dynamic, not static. Conditions in China have been changing and will

certainly continue to change, ultimately how is beyond the scope of this article. However, such change will alter the prospects for commercialization of know-how within China.

Notes

1. Unlike other industries, these two require a very long time, normally around ten years for product development. This explains the reliance on patents peculiar to these two. In other industries like software, product development is so rapid that the time and expense involved in seeking patents is not economical. These insights come from Jerry Tse whom I must thank for his comments at the Conference on Public Sector Management Reform in China, held on June 6 and 7, 1997 at the Hong Kong Polytechnic University.

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