Evolution of the Academy-run Enterprises in China:
An Organizational Approach

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Abstract

Academy-run Enterprises (AREs), which are defined as the firms owned or controlled by academic institutions (universities, public research institutes), are ubiquitous in China. There are thousands of AREs across the country and several dozen of them are already listed on the stock markets in Mainland China and Hong Kong. However, previous studies have inadequately addressed the AREs either by simply regarding them in the same light with spin-offs or private companies in the Western countries or by excessively emphasizing their Chinese-specific nature. We insist that the AREs are "spin-arounds" rather than spin-offs in that they maintain much stronger relationship with mother institutions. Also, we argue that ARE is an alternative governance form of "knowledge industrialization" that can be chosen when the market for S&T knowledge is underdeveloped and academic institutions are highly entrepreneurial. By modifying the firm boundary theories with an extra consideration of "historically formed social contract" on academy-industry relationship, we build up macro- and micro-level theoretical frameworks of knowledge industrialization. For empirical evidences, we conducted questionnaire analysis on 102 sample firms. Using the frameworks and survey results, we explain the evolution of AREs in China and compare the Chinese mode of development with other developing countries' ones.

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1. Introduction

One commonality across the top three PC makers in China is the fact that they are all established by academic institutions, such as the Chinese Academy of Science (CAS), Peking University, and Tsinghua University respectively. Besides these in PC industry, the first listed software company in China is also a university-run enterprise, Dongruan from the Dongbei University in Shenyang, the capital city of Liaoning province. Let us name them as the "Academy-Run Enterprises" or AREs (i.e. enterprises founded and run or managerially controlled by academic institutions, which include universities and research institutes).

Actually, academy-run enterprises are ubiquitous[1] in China. According to the statistics of the Chinese Ministry of Education, there are 5,039 university-run enterprises (a subset of AREs) in China by the end of 2001. And about 40 university-run enterprises are now listed on the stock markets in Mainland China and Hong Kong.

The firms, which are AREs in our view, have been the objects of many studies with different focuses and disciplines. However, many of the existing studies identified them with well-known (especially in developed Western countries) concepts, for instance, "spin-off firms" (Gu, 1999, Francis, 1999), "private (or privately-run) companies" (Segal, 2000), "regional cluster" (Segal, 2000; Wang, 1999) etc.

In fact, however, the AREs have much stronger links with their academic mother institutions than ordinary spin-off firms. The AREs use the mother institutions' resources[2] "exclusively" or at least in very preferential terms compared with other firms. This is true even in cases of national or public universities[3]. Thus, we would say the Chinese academy-run enterprises are linked up with the mother institutions by an "umbilical cord." In short, the Chinese academy-run enterprises don't

[1] There is no province without university-run enterprises.
[2] For instance, S&T knowledge generated by the mother institution, S&T personnel, the mother institution's popularity (i.e. brand power), and real estate etc.
[3] Actually, almost all major universities in "socialist" China are national or public universities.

actually spin "off" from their mother institutions. They just spin "around" or even spin "in" their mother institutions. At similar vein, it is very hard to regard AREs as purely "private firms". In addition, according to our preliminary observation, it is the exclusive linkage with the mother institutions rather than the innovative region that can account for the development of the AREs in Zhongguancun, Beijing.

Other existing studies (mainly done by Chinese scholars) often portray the AREs as something "Chinese characteristic," implying that there is no counterpart to be discussed together or compared with in other countries. In sum, we argue that the existing studies have problems of "false/inadequate generalization" or "excessive particularism".

This study is different from the existing studies in that we regard the ARE as a specific governance (or organizational) form of "knowledge industrialization." In other words, we believe that the AREs can be understood as an alternative organizational form that is selected by the Chinese academic institutions in a certain circumstance.

2. Theoretical Framework

Our discussion departs from the notion that the ARE is a specific governance form of knowledge industrialization adopted in a certain circumstance. This is to say, S&T knowledge from academy to industry can be mediated through alternative governance forms including technology exchange market, patent licensing, cooperative R&D between academy and industry, cooperative research center on or off campus, university Science Park etc. What attracts an attention here is the fact that some of the governance forms listed above are based on market mechanism while others are based on more hierarchical or hybrid institutional setups. Therefore, we believe the wisdom cumulated in the field of organization theory (or theory of the firm) can be very helpful to our exploration of the *raison d'etre* and the evolution of the AREs in China.

However, we have to deal with at least two problems when we apply theory of the firm to

the issue of knowledge industrialization or AREs. First, we should be cautious to apply to the wisdom of the traditional organizational economics to the analysis of the AREs, because the focus of our interest is not the link (or integration) *between two firms*, but the link *between a firm*[4] *and an academic institution*. As Kano insisted, mechanism (or organization) which links academy and industry is another "black box" which is different from the one that traditional theories of the firm have addressed[5].

The notion of another black box, however, does not totally disapprove the applicability of the organization theory to our issue, because the organization theory, in principle, is not limited to the economic institutions. For instance, Douglass C. North (1990) regards transaction costs as not only the sources of economic institutions but also those of *social* and political institutions (p.27). Thus, what is needed here is not to abandon the organizational theory, but to adapt it to the issue of academic institutions.

Among the differences between the academic institution and the firm, the most salient one is that the former is not a natural-born profit-maximizing economic entity while the latter is. In organization theories, firms are assumed to select the governance form (or to set their boundaries) to maximize economic gains although the bases of the decision (governance form selection or boundary setting) are different according to the sub-streams of the organization theory (e.g. transaction cost economics, resource-based view). However, the economic efficiency cannot solely determine the governance form of knowledge industrialization conducted by academic institutions (Branscomb et al., 1999; OECD, 2002). Rather, some constraints could be put on the governance form by the academic institutions themselves or the historically formed social contract.

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[4] Although work in the economics area is not only concerned with alliances between business firms, but also inter-organizational linkages of all kinds, the focus nevertheless tends to be primarily on *firms*. And, while informal networks between individuals are recognized as important, in which the exchange of tacit knowledge is a significant component, the focus in many economic studies is on formal agreements, such as those involving legal contracts between organizations. (Coombs et al., p.2)

[5] Coase (1937) focused on the uniqueness of resource allocation mechanisms within businesses, as opposed to conventional approaches that analyzed resource coordination by price mechanism. Similarly, inter-organization coordination between universities and companies requires the clarification of the contents of the UIR black box, based on the assumption that there is an inherent resource allocation mechanism other than the price mechanism (Kano, p.368).

Thus, in discussing the governance form of knowledge industrialization adopted by academic institutions, we should take into account an additional factor, the "degree of academic entrepreneurship", which indicates the academic institutions' willingness to directly engage in economic activities. By this, we can locate each governance form of knowledge industrialization on the two-dimensional space of which one vector is market-hierarchy and the other is the degree of academic entrepreneurship as illustrated in Figure 1, which is our macro-level conceptual framework. Furthermore, we could match the bottom, middle, and top layers of the Figure 1 with the regimes of "teaching university", "research university" and "innovative university" (Etzkowitz, 1997, 1999) respectively.

<Figure 1>

Figure 1 indicates that the ARE is just a hierarchical form of knowledge industrialization adopted by highly entrepreneurial academic institutions. On the other hand, technology sales or patent licensing is quite a market-like form of knowledge industrialization also adopted by highly entrepreneurial academic institutions. Even education itself can also be interpreted as an alternative governance form of knowledge industrialization, of which salient characteristic is low degree of entrepreneurship. Relative locations of the other forms of knowledge industrialization can be found as roughly illustrated in Figure 1.

The second problem to be addressed in applying theory of firm to our topic is the fact that different schools of organization theory voice differently. Most prominently, transaction cost economics (TCE) and resource-based view (RBV) indicate different underlying forces in firms' determining their boundaries. And the forecasts of the TCE and RBV are not always congruous as shown in Figure 2. In situation (ii) and (iii), the forecasts of the two approaches are congruous: in situation (ii), the academic institutions are expected to expand their boundary to engage in running their own enterprises (AREs); in situation (iii), the academic institutions are not expected to run AREs. However, in situation (i) and (iv), those two approaches voice differently: in situation (i),

RBV recommends the academic institutions to engage in running AREs while TCE recommends not to; in situation (iv) vice versa.

<Figure 2>

Conner & Prahalad (1996) comment on this contradiction as follows: The opposing predictions in situations…indicate the need for future theory development that incorporates both resource- and opportunism-based considerations into an explanation of the firm's existence. The now-conflicting predictions…need to be replaced, through creation of new theory, with single, unified ones (p.491). And many authors emphasize complementarities between the two approaches (Dosi et al., 1992; Poppo & Zenger, 1998; Teece et al., 1997, 2000; Teece, 1998; White, 2000). Foss (1996) goes further to insist that some phenomena such as the organization of innovation activities can be fully addressed only by such a combined theory. Williamson (1991), one of the founding fathers of TCE, also acknowledged the insufficiency of TCE in addressing innovation issues.

As mentioned above, it is quite clear that a new theory synthesizing TCE and RBV is in need especially in case of analyzing innovation-related phenomenon such as our topic. Although some authors (Teece et al., 1997, 2000; Teece, 1998) have explored the innovation-related organizational choice issue using the wisdom of RBV and TCE[6], however, the contradiction between RBV and TCE (as illustrated in Figure 2) has not been explicitly addressed or reconciled theoretically. As a result, TCE and RBV seem still remain competing (not complementing) hypotheses for empirical tests.

However, we believe it is possible to synthesize RBV and TCE. And we will start from making clear the differences between TCE and RBV. TCE mainly focuses on the *external market*

[6] Teece (1998) argues that one should take into account the characteristics of technology to design innovation-friendly organization. Among the seven characteristics of technology he mentions (i.e. uncertainty, path dependency, cumulative nature, irreversibilities, technological interrelatedness, tacitness), some have root in evolutionary theory and RBV's tradition (e.g. path dependency, cumulative nature, irreversibilities, technological interrelatedness, tacitness) and others have roots in TCE's tradition (e.g. uncertainty, inappropriability).

situation (which determines the market transaction cost) while RBV mainly focuses on the *individual organization's internal situation* (or resource, which determines the competitive advantage of the organization) concerning the determining factor of organizational boundary. More importantly, TCE implicitly assumes that every decision maker perceive the external market situation *correctly*, because TCE regards the *objective* level of market transaction cost as the major determinant in make or buy decision. But, RBV does not need this "cognitive assumption" (White, 2000), because RBV regards the decision maker's *subjective perception* on internal resource as the major determinant in make or buy decision. In other word, RBV allows individual organizations to view an objective situation differently and to act differently, while TCE basically doesn't.

Based on the characteristics of the two approaches, we argue that the forecasts of RBV are dominant over those of TCE in individual academic institutions' actual decision-makings on their boundaries or governance forms knowledge industrialization. On the other hand, the forecasts of TCE are more relevant to *ex ante* performance of the selected governance form.

Furthermore, as in the macro-level framework (Figure 1), in individual academic institutions' choice of governance form of knowledge industrialization (a micro situation), we should take into account the academic institutions' "willingness to directly engage in economic activities." As mentioned above, academic institutions are not natural-born economic gain chasers. Thus, if they don't want to pursue economic gains, they can simply remain in an ivory tower (i.e. they will not set up AREs no matter how strong their internal resources are).

Thus, our micro-level conceptual framework is as shown in Figure 3. In Figure 3, we add another vertical axis, the degree of "willingness", to the original RBV-TCE forecast box. This indicates that only when an academic institution tries to pursue economic gains (i.e. cross the threshold in Figure 3), the problem of governance choice (e.g. whether set up AREs or not) becomes relevant to the strength of internal resource.

<Figure 3>

3. Methodology

Since our goal is to conduct a microanalysis of the academy-run enterprises in China, we have resorted to a questionnaire survey result, publicized statistics, and in-depth interviews with many persons involved. We have interviewed the following persons: CEOs and staff members in the Chinese academy-run enterprises on different stages of development, university professors who have been engaged in establishing an academy-run enterprise, executive officers in a university's industry interface organizations, a local government officer in the Administrative Committee of Zhongguancun Science Park (up to here, the interviewees are Chinese), and staff members in Beijing branches of several Korean companies (Samsung, LG, etc.), and executive officers of Beijing branches of several Korean government-sponsored technology collaboration or incubating centers (up to here, the interviewees are Korean).

For the questionnaire survey, we tried to identify all the high-tech AREs affiliated to "major[7] academic institutions" (for details see the appendix). As a result, we have identified more than 600 AREs. Among them, however, only 477 AREs affiliated to 67 academic institutions publicize their postal addresses on the Internet. Thus, to the CEOs (president or vice-president) of the 477 enterprises, we sent questionnaires by mail during August-September 2003. Among them, by the 31st October 2003, 96 CEOs replied. In addition, we have visited a dozen of academy-run enterprises during July-October 2003 and could get 6 more questionnaires answered. Thus, the analysis below will be based on the 102 firms affiliated to 36 universities and 2 research institutes (Chinese Academy of Science and China Academy of Engineering Physics).

Viewed from the point of geographical distribution, 25 sample firms (24.5%) are from Shanghai, 22 firms (21.6%) from Beijing, 10 firms (9.8%) from Jiangsu (Nanjing) and another 10 firms (9.8%) from Hubei (Wuhan). These four regions account for more than 65% of the sample

[7] We define the major academic institution as all the 30 universities under the jurisdiction of the Ministry of Education, and universities of which S&T expenditure exceeded 50 million RMB in 1997, and all the research institutes under the Chinese Academy of Sciences.

firms.

The sample firms' average number of employees is 212.2 and the average sales revenue is 85 million RMB. Compared with the population, of which the average number of employees was 62 and the average sales revenue was 22.5 million RMB by the end of 2001 (*Year 2001 Statistical Report of University-run Industry in China*, p. 10, p.16), the sample firms seem to be much bigger than the average S&T AREs. However, we should take into account the time lag between the population statistics (the end of 2001) cited above and our survey data (the mid of 2003). In addition, even in our sample, as many as 65.7% of the firms have less than 100 employees. And the majority (78.9%) of the sample firms has sales revenue below 100 million RMB.

4. Explanation on the Emergence, Growth, and Development of the AREs in China

Let us first address the issue of why so many AREs have emerged in post-reform China. Our story is that the academic institutions have resources (technologies, brand, human capital, network, etc.) and they have to choose whether to internalize the resources (starting AREs) or externalize (transferring the resources to the manufacturing firms). The choice between internalization and externalization is like the make or buy decision in the firm theory setting. Given this situation, the Chinese academic institutions have decided to make their own firms because they were highly motivated to make money (i.e. crossed the threshold in Figure 3) by the reform of S&T system in 1985, which drastically cut down the government fiscal support for academic institutions, and because they felt they were more competent in industrializing knowledge than the outside manufacturing firms. According to our interviews with directors of academic institutions, the main obstacles for transferring technology to outside manufacturing firms were (1) weak absorptive capacity of manufacturing firms (2) underdevelopment of the related institution (including information service agency, patent licensing office, intellectual property right protection, etc.). In other words, the academic institutions' confidence in their own internal resources come from the high

market transaction cost, which is mainly due to the weak absorptive capacity and underdeveloped institution, in addition to their own unique assets which outside firms did not have (e.g. well-established brand, network, etc.).

For the explanation of the AREs' fast growth in China, we need to solve a puzzle: The Chinese academic institutions have actively exploited their technologies for industrial application even before the promulgation of the Chinese equivalent of Bayh-Dole Act. The Chinese version of Bayh-Dole Act, <Regulation on the management of intellectual property right generated by the state science research project>, was promulgated in MAR. 2002.

For the solution of the puzzle, we suggest to borrow a useful concept, *Danwei*, from the literature of Chinese studies. *Danwei* is Chinese specific work unit. The *danwei* is a self-sufficient and multifunctional social community that excludes those who are not members, while at the same time it provides a basis for integrating those within it into an effective social, economic, and political unit (Lu & Perry, p.9; Bjorklund, p.21). The exclusive nature of the *danwei* has also helped the Chinese academic institutions as *danweis*, to exclusively exploit their S&T knowledge and collateral assets for knowledge industrialization (e.g. brand, skilled manpower etc.), even though most of them are national/public universities. It is to say that the national/public academic institutions in China have long had an "actual right" to exclusively (at least preferentially) exploit the intellectual properties (S&T knowledge, brand, etc.) generated by them. This seems similar, in some sense, to the situation of the United State after the promulgation of Bayh-Dole Act in 1980. At the same vein, we might say that there has existed the "virtual intellectual property right" for Chinese academic institutes even before China legislated the patent law in 1985. From the stand point of AREs, the virtual IPR has been a blessing for them and a basis of their competitive advantage.

However, the AREs are not on the rise for now. Rather, with the market development and growth of other types of the firms, the Chinese AREs seem to be losing their original competitive advantages and even become a target of reform. In Nov. 2001, the State Council issued the <Circular on Peking and Tsinghua universities' experimental scheme for the standardized management of

university-run enterprises[8]>, which requested the separating reform of universities and business firms. The reform is now on the initial (or experimental) stage. The detailed measures to reform the AREs are still at large. However, it is quite clear that the government's general inclination is to separate the intertwined relationship between the firms and mother academic institutions to a certain degree. On the other hand, alternative channels of knowledge industrialization have emerged, and the Chinese universities seem to try to back up from the downstream activities and to focus on the upstream activities.

We believe that the discussion above can be reiterated with the micro-level framework developed in section 2 (see Figure 4).

<Figure 4>

5. Some Questionnaire Survey Results

Concerning the technology sources, we found that the AREs usually depend on the internal technology sources rather than external sources. When asked the major source of technology for the firm, 37 firms (47.4%) out of 78 firms, which answered with single choice, indicated "mother institution," and 35 firms (44.9%) indicated "in-house R&D center." By examining all the sample firms with weighted score[9], we can confirm that the two most dominant technology sources for the AREs are the mother institution (WS = 44.83) and in-house R&D center (WS = 45.33). The contributions of the other three possible technology sources are minimal (see Table 1).

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[8] *Guanyu Beijingdaxue Tsinghuadaxue Guifan Xiaobanqiye Guanlitizhi Shidianwentide Tongzhi*

[9] For some questions, like the question about the major customer, some sample firms chose several answers simultaneously while others chose just one most relevant answer.

To attenuate the problems brought by these different ways of answering, we developed a scale, which we call it "weighted score." The weighted score is calculated as '1 / the number of answers simultaneously chosen'. Therefore, if a respondent chose only one answer for a question, the answer chosen has 1/1(=1) point. And if he or she selected three answers simultaneously, each of the three answers has 1/3 point. We assume that the simultaneously chosen answers have "same" and "biggest" significance for the sample firm. As a result, the "sum of weighted score" always equals to the "number of firms that answered the question". The weighted score of a specific answer for a question means the (weighted) number of firms that selected the answer.

<Table 1>

When asked of the field that the mother institution contributed, the sample firms most frequently indicate the "Brand Popularity." "Technology" was ranked the second, and then "S&T Human capital" followed. Very few firms indicated "Management Human Capital" and "Marketing Network" as the mother institutions' major contribution (see Table 2).

<Table 2>

For start-up companies, the right to use (even for free) the title of well-known academic institutions in their firm titles (or product names) must be a blessing. Even for grown-up companies, which already acquired the capacity to stand alone, mother institutions' popularity still seems to be a positive business asset. It sounds quite natural that the technology is highly ranked in terms of the mother institutions' contribution for the AREs, especially for the high-tech AREs, which are the object of our survey.

On the other hand, we found big difference in terms of the mother institution's contribution acknowledged by the AREs between the fields of S&T human capital (WS = 23.45) and Management human capital (WS = 5.12). This results shows that the AREs could successfully mobilize the engineers in the mother institutions, but not successfully in case of managerial personnel. It doesn't mean that the mother institutions have never engaged the management of the AREs. Rather, in many cases, the top management of the new AREs have been formed with the professors or researchers in the mother institutions. However, as shown in the survey result, the AREs don't regard the management personnel dispatched from the mother institutions as a blessing. Actually, an often-heard rationale for the reform of the university-run enterprises is the managerial interference (rather than "help") from the mother institutions.

Concerning building up the marketing network, the role of the mother institution proved not

to be significant (WS =0.2). If we take into account our findings on the major customer (mainly the SOEs) of the AREs, and the nature of their product (mainly the intermediate product), we could infer that the AREs don't have big demand for marketing activities and, as a result, the role of the mother institutions in this field is not highly acknowledged.

We can also examine the survey results from the standpoint of the technological innovation process (or the S&T knowledge industrialization process). We assume there exist three different stages in the process of technological innovation (i.e. Information acquisition, Technology assimilation, Commercialization). When asked of the stage where the mother institution's help is most effective, about a half of the sample firms indicated the first stage. The second most frequently indicated stage was the second stage – Technology assimilation. And the final stage of the technology innovation – commercialization – proved not to be the main field where the mother institutions play significant roles for the AREs (see Table 3).

<Table 3>

In addition, the role of the mother institutions in the final stage of the technology innovation is less important for the more recently established AREs (see Table 4). This implies that the academic institutions have gradually pulled back from the downstream activities, and the importance of the upstream role concerned with the technological innovation has gained importance.

<Table 4>

We also asked the CEOs of our sample firms to assess the short-term and long-term effects of the separating reform from the standpoint of their firms. The preliminary analyses of the survey results are as follows:

In the short run, more AREs viewed the reform as negative rather than positive event. But, in the long run, the majority of the sample firms viewed the reform as positive event (see Table 5). This

result seems to show that for the average AREs the gains from "enhanced managerial autonomy" would be smaller in the short run than the losses from "restriction on the utilization of the mother institution's assets". In the long run, however, the gains could exceed the losses occurred by the separating reform.

<Table 5>

Our survey also found that the extent of the contribution by the mother institutions in the formation of the AREs' competitive advantage has declined over the initial to present stages. The t-test result shows that there is significant difference between the two Likert scores (see Table 6).

<Table 6>

In addition, as a technology source, the mother institution appears to lose importance at least compared to that of other alternative sources. 37.2% of the sample firms state that the importance of the mother institution as a technology source is now diminishing, while only 17.8% and 9.9% of the sample firms stated likewise for the other domestic academic institutions/firms and foreign ones respectively. Moreover, the propensity for the sample firms to perceive growing importance of the mother institution as a technology source was lower than those in other two technology sources (see Table 7).

<Table 7>

Much more analyses need and planned to be done.

6. Extended Conceptual Framework and International Comparison

Up to now, what we have addressed is about "forward engineering" (Lu, 2000), which indicates downward flow of S&T knowledge from the original knowledge creator. However,

forward engineering or knowledge industrialization is just one of various means of technological development. Firms or countries can achieve technological development through learning from other knowledge sources (rather than domestic academic institutions) including foreign companies and even final products through "reverse engineering" (Kim, 1997). Although these kinds of technological development look quite a different issue, we believe that they could be discussed in our framework.

The magic link that makes it possible to incorporate forward engineering and other ways of technological development is *absorptive capacity*. As we have discussed in the previous sections, absorptive capacity of industrial firms accounts for major part of transaction cost of S&T knowledge that is to be transferred from academia to industry. At the same time, the absorptive capacity is quite relevant also in cases of learning from foreign companies (We will call it "parallel learning" afterwards) and reverse engineering (Kim, 1997). Concerning parallel learning from foreign companies (or FDI), authors have emphasized that the assimilation of outside technology is heavily dependent upon the development of domestic technological (absorptive) capabilities (Gabriele, 2001; Tolentino, 1993; Young & Lan, 1997). Moreover, Tolentino (1993) insists that there is a threshold in the level of domestic technological competence (i.e. absorptive capacity), below which FDI might even stifle domestic competition and thus provoke underdevelopment, dependent development, and technological decline in low-income countries which lack domestic R&D and technological capacities. Also in the literature of reverse engineering, the absorptive capacity of developing country is regarded as a critical success factor (Kim, 1997). Even though the concept of threshold is not seen in the literature of reverse engineering, we believe it is natural to assume there is similar threshold of absorptive capacity in reverse engineering as in parallel learning. Therefore, we may argue that the rate of parallel learning or reverse engineering will increase as the domestic firms' absorptive capacity grows beyond the threshold (see the graph in Figure 5).

<Figure 5>

As shown in Figure 5, reverse engineering and parallel learning are more probable when the absorptive capacity is high. Thus, the left column of the TCE-RBV forecast box in Figure 5 indicates the situation where reverse engineering and parallel learning are more frequently witnessed in comparison to the situation that the right column stands for. On the other hand, as we discussed before, the top row of the box indicates the situation where academic institutions prefer to establish their own enterprises (i.e. choose hierarchical form of knowledge industrialization) in comparison to the situations where the middle and bottom rows stand for. In sum, the "feasible zones"[10] for forward engineering through the AREs, reverse engineering and parallel learning can be located in the forecast box as shown in Figure 6. The dark areas in Figure 6 show the feasible zones for each mode of technological development.

<Figure 6>

We believe we can use the extended conceptual framework in comparing different countries' (especially, developing countries') evolutionary paths.

[10] To be precise, we should call them "*more* feasible zones", because the probabilities of forward and reverse engineering will continuously increase as the real situation moves to the left along the horizontal axis (absorptive capacity) and upward along the vertical axis (willingness and perceived resources) respectively. The darker shadows on the top and the left end in the matrixes of Figure 2 represent the greater feasibilities (or higher probability) of forward engineering and reverse engineering respectively. However, for the convenience of discussion, we will mainly treat the difference in feasibility in binary way (i.e. feasible vs. non-feasible) as far as this simplification does not hurt the main logic.

<Figures and Tables>

Figure 1 Two-dimensional Map: Macro-level Conceptual Framework

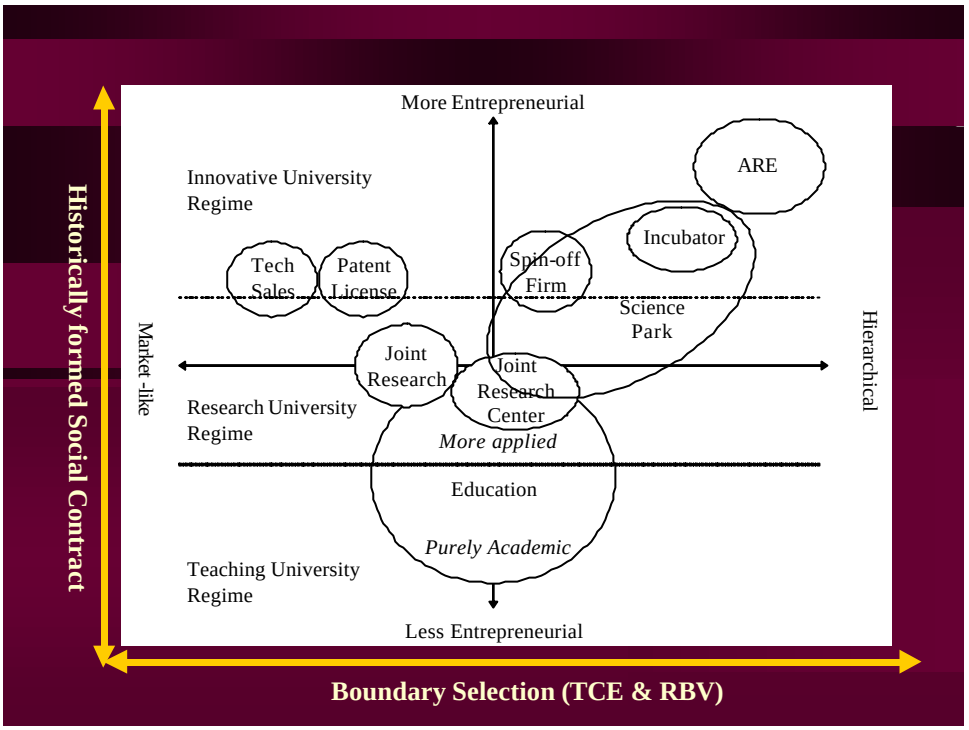


Figure 2 RBV-TCE Forecast Box: Whether an academic institution should run ARE or not

TCE / RBV	Market Transaction Cost: Low	Market Transaction Cost: High
Resource: Strong	(i) (O, X)	(ii) (O, O)
Resource: Weak	(iii) (X, X)	(iv) (X, O)

Note: (Forecast of RBV, Forecast of TCE)

O: Academic Institutions should set up AREs

X: Academic Institutions should not set up AREs

Figure 3 Adjusted RBV-TCE Forecast Box: Mirco-level Conceptual Framework

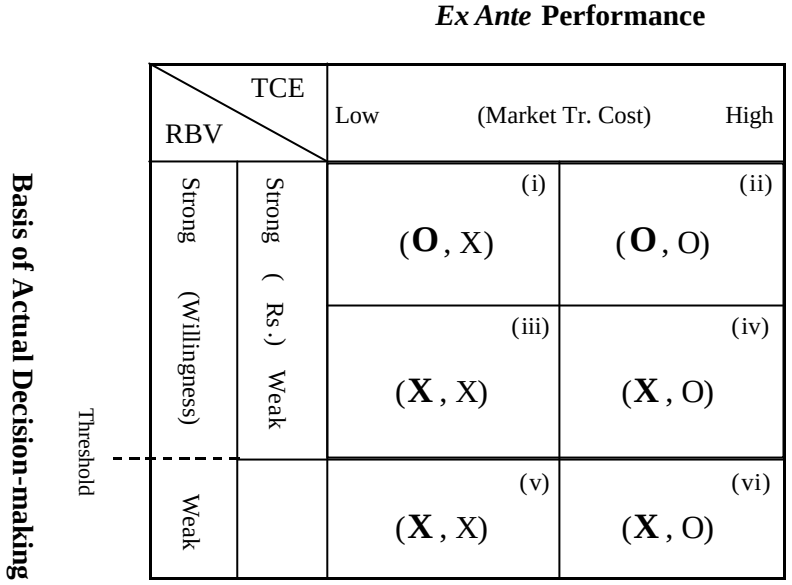


Figure 4. Origin, Current State, and Reform Trend of the AREs

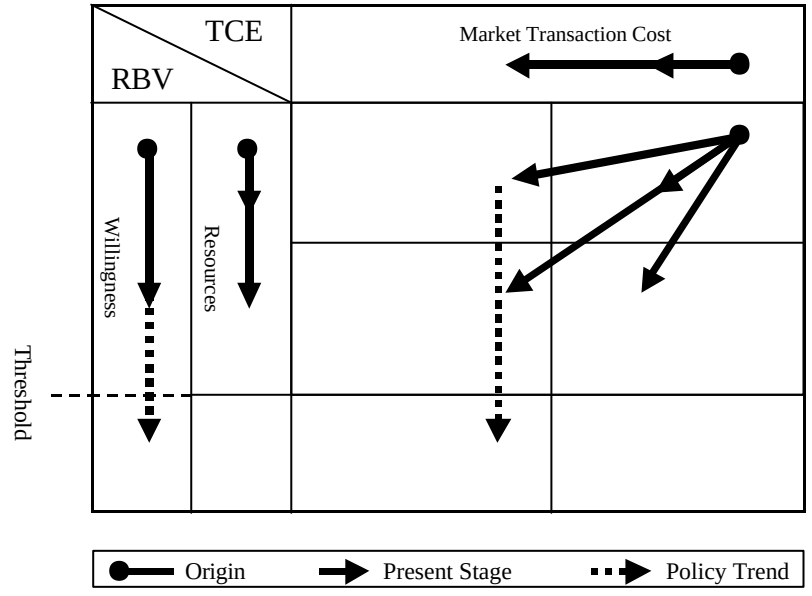


Table 1 Major Technology Sources of the AREs in China

(a)

	Frequency of Choices (single choice)	Frequency of Choices (double choice)	Frequency of Choices (triple choice)
Mother University or Research Institute	37	15	1
In-house R&D Center	35	20	1
Other Domestic University or Research Institute	3	3	0
Foreign University or Research Institute	0	0	0
Foreign Company	3	2	1
Subtotal Number of Answered Firms	78	20	1

(b)

Major Technology Source	Weighted Score (WS)
Mother University or Research Institute	44.83
In-house R&D Center	45.33
Other Domestic University or Research Institute	4.50
Foreign University or Research Institute	0.00
Foreign Company	4.33
Sum of Weighted Points = Total Number of Firms	99

The weighted points in the table (b) are calculated from the table (a).

Table 2: Major Contribution of the Mother Institutions

Business Asset	Weighted Score
1) Technology	31.78
2) Brand Popularity	40.45
3) S&T Human Capital	23.45
4) Management Human Capital	5.12
5) Marketing Network	0.20
Sum of Weighted Points = Number of Firms	101

Table 3 Mother Institution's Contribution in the Process of Technology Innovation

Innovation Stage	Weighted Score
1) New Technology Information acquisition	45
2) Assimilation of the Technology	27.5
3) Commercialization of the Technology	22.5
Sum of Weighted Points = Number of Firms	95

Table 4 Mother Institution's Role in the Process of Technology Innovation of AREs

Year of Foundation	Acquisition	Assimilation	Commercialization	Total
1983~1987	25.00%	0.00%	**75.00%**	100%
1988~1992	53.17%	17.46%	**29.37%**	100%
1993~1997	40.67%	36.67%	**22.67%**	100%
1998~2002	50.83%	30.83%	**18.33%**	100%

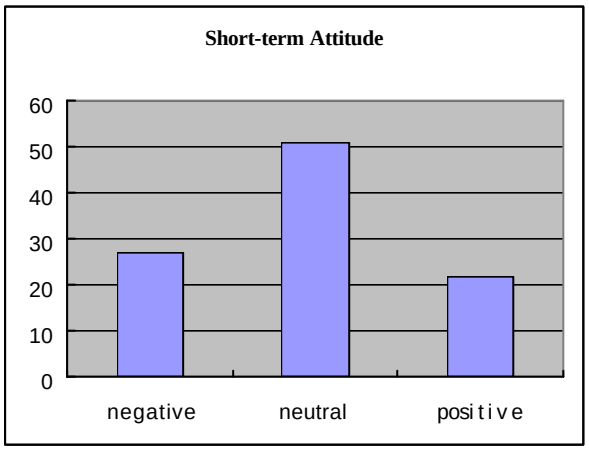
Table 5 Attitudes for the Reform of AREs

(a) Short-term Attitude

Attitude	Frequency	Percent
Very Positive	4	4%
Positive	18	18%
No Effect	51	51%
Negative	26	26%
Very Negative	1	1%
Total	**100**	**100%**

(b) Long-term Attitude

Attitude	Frequency	Percent
Very Positive	12	12.1%
Positive	42	42.4%
No Effect	27	27.3%
Negative	18	18.2%
Very Negative	0	0.0%
Total	**99**	**100%**



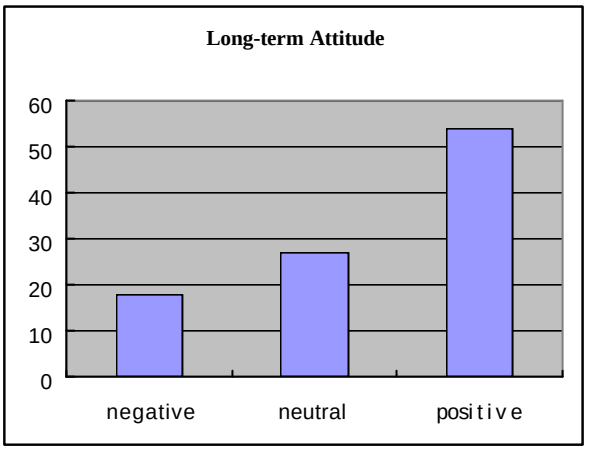


Table 6 Mother Institution's Contribution to the Firm's Competitive Advantage

(a)

Contribution to the Firm's Initial CA	Number of Firms
Very significant (Likert Score = 1)	23
Significant (Likert Score = 2)	52
Normal (Likert Score = 3)	24
Insignificant (Likert Score = 4)	2
None (Likert Score = 5)	1
Total	102

(b)

Contribution to the Firm's Current CA	Number of Firms
Very significant (Likert Score = 1)	19
Significant (Likert Score = 2)	44
Normal (Likert Score = 3)	29
Insignificant (Likert Score = 4)	9
None (Likert Score = 5)	1
Total	102

t-test of the significance of the mean difference

Initial CA Likert Score	Present CA Likert Score	t-statistics	significance
2.0784	2.3039	-1.888	0.06

Table 7 Significances of the Three Different Sources of Technology

	Growing	No Change	Diminishing	
Mother Institution	39.36%	23.40%	37.23%	100% (94 firms)
Other Domestic	42.22%	40.00%	17.78%	100% (90 firms)
Foreign	41.98%	48.15%	9.88%	100% (81 firms)

Figure 5. Extended Conceptual Framework

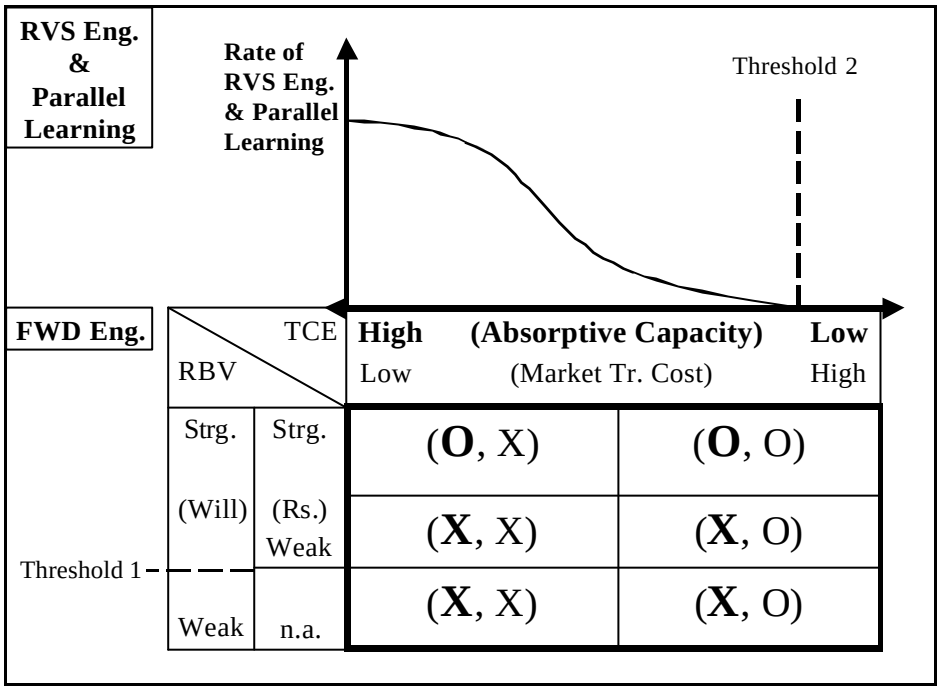
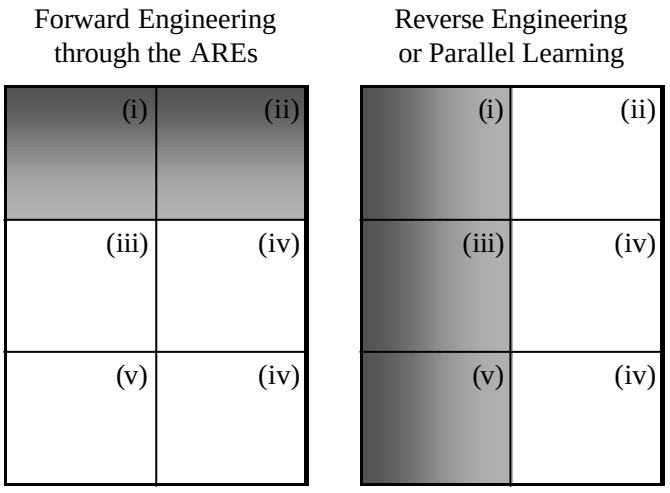


Figure 6 Feasible Zones for Each Mean of Technological Development



<Appendix: Questionnaire Survey>

1) Survey Design

The object of our study is the academy-run enterprises (AREs), which comprise the firms that are affiliated to universities or academic research institutes. The concept, academy-run enterprise is bigger in scope than the more frequently used term 'university-run enterprise' (*Xiaoban Qiye*), in that it also includes the 'public research institute-run enterprise'. We define, for operational convenience, academic research institute as the research institutes under the jurisdiction of Chinese Academy of Sciences, the ministerial level institution that has mainly taken charge of basic researches in China. Other public research institutes established by the individual ministries are excluded from the study.

To locate the Chinese academy-run enterprises, we searched the Chinese major academic institutes' internet homepages during March-June 2003. The major academic institutes we searched include all the 30 universities under the direct control of the Ministry of Education, and 35 universities[11] of which S&T expenditure exceeded 50 million RMB in 1997, and dozens of research institutes under the Chinese Academy of Science. Additionally, we surfed internet using China's one of the most frequently used internet search engines (www.sina.com.cn) with the search words '*Xiaoban Chanye* (university-run industry)' and '*Xiaoban Qiye* (university-run enterprise)' to augment the list of Chinese AREs. Also, we added 40 listed University-run enterprises[12] if they had been omitted in the above-mentioned process.

In this way, we could identify more than 600 academy-run enterprises affiliated to 67

[11] These universities are heavily overlapped with the 30 universities under the direct control of the Ministry of Education. Commonly, these universities are regarded as 'national best universities' in China.

[12] Partly because of the ambiguity of the concept '*Xiaoban qiye* (University-run enterprise)' and partly because of the complexity of the distribution of control right in the listed companies, it is difficult to precisely define which firms are *Xiaoban qiye*. These 40 firms, however, are generally passed as *Xiaoban qiye* at the stock market and mass media, mainly because universities founded the companies at the beginning and/or still hold dominant portion of the companies' equity.

universities and Chinese Academy of Science. However, some of them do not notify their postal addresses on their internet homepages. Those enterprises are excluded from our questionnaire survey. In addition, dozens of firms, which are obviously not related to science and technology, like building maintenance companies, are also excluded from the survey. As a result, 477 academy-run enterprises affiliated to 67 universities and Chinese Academy became the object of our survey.

To the CEOs (president or vice-president) of the 477 enterprises, we sent questionnaires by mail during August-September 2003. Among them, by the 31st October 2003, 96 CEOs replied (rate of answer = 20.1%). But 61 questionnaires were sent back to us, by the 31st October 2003, due to the incorrectness of the postal addresses[13]. If this is taken into account, questionnaires were effectively sent out to 416 AREs, and the rate of answer was 23.1%.

In addition, we have visited a dozen of academy-run enterprises during July-October 2003 and could get 6 more questionnaires answered[14]. Thus, the analysis below will be conducted on the 102 firms affiliated to 36 universities and 2 research institutes (Chinese Academy of Science and China Academy of Engineering Physics).

2) The Sample Firms

The 102 sample firms of this study have 38 different "mother institutions" including 36 universities and 2 research institutes[15]. Among the 38 mother institutions, the Chinese Academy of Science (CAS) was the most frequently designated mother institution among the sample firms. This is quite natural because the CAS is not an individual research institute; rather it is a ministry-level

[13] Many Chinese firms seem not to duly update their own internet pages. Moreover, allegedly, many academy-run enterprises recently moved out to new places (often located in their own newly developed science parks) from the original places (often located on campus). It is also possible that some of the missing 61 firms were liquidated. However, even though we can not assure, there seem more moving out cases rather than liquidated cases.

[14] Four of the six are from the firms affiliated to the China Academy of Engineering Physics, which had not been included in the questionnaire survey by mail

[15] Put it more precisely, about a dozen of research institutes under the jurisdiction of CAS and CAEP.

institution in charge of over a hundred of research institutes distributed across wide spectrum of research areas. After the CAS, followed Fudan University, Huadong S&T University, China S&T University, Tsinghua University, Beijing University, Zhejiang University, and Nanjing University, most of which are the top universities in China.

Viewed from the point of geographical distribution, 25 sample firms (24.5%) are from Shanghai, 22 firms (21.6%) from Beijing, 10 firms (9.8%) from Jiangsu (Nanjing) and another 10 firms (9.8%) from Hubei (Wuhan). These four regions account for more than 65% of the sample firms. According to the national statistics on the regional distribution of the S&T AREs (*Year 2001 Statistical Report of University-run Industry in China*, p.17), the Big-3 regions (in terms of the number of the S&T AREs) are still Shanghai, Beijing and Jiangsu, but the fourth is Liaoning rather than Hubei province (Hubei is ranked 7th in the population). Moreover, the Big-3 and Hubei account only for 50.0%[16] of the national total. Thus, we should say that the portions of the Big-2 (Shanghai and Beijing) and Hubei were somewhat exaggerated in the sample compared to the population distribution.

Concerning the scale of the firm, we will look into the number of employees and sales revenue. The sample firms' average number of employees is 212.2 and the average sales revenue is 85 million RMB. Compared with the population, of which the average number of employees was 62 and the average sales revenue was 22.5 million RMB by the end of 2001 (ibid., p. 10, p.16), the sample firms seem to be much bigger than the average S&T AREs. However, we should take into account the time lag between the population statistics (the end of 2001) cited above and our survey data (the mid of 2003). In addition, even in our sample, as many as 65.7% of the firms have less than 100 employees. And the majority (78.9%) of the sample firms has sales revenue below 100 million RMB. Thus, we tentatively assume that the sample is not significantly biased.

The sample firms are broadly distributed in terms of the year of foundation. The earliest one

[16] In the population statistics by the end of 2001, Shanghai accounts for 14.8% of the national total with 295 firms, Beijing and Jiangsu account for 10.8% with 215 firms respectively. The S&T AREs in Hubei province only account for 4.6% of the national total.

is founded in 1952 and the latest in 2002. Although the population statistics show very clear declining trend of the number of AREs (both the non-S&T and S&T AREs) at least since the late 1990s, in our sample the trend is not detected. To the contrary, more firms founded during 1998~2002 than the firms founded during the previous 5 years responded our questionnaire survey. This discrepancy could be interpreted in two ways. First, even though the population statistics indicate that the total number of AREs was bigger in the past, many of the early-founded firms could be liquidated in the later years[17], resulting in higher share of the younger firms among the living firms at present time. Thus, the discrepancy might come from the simple fact that only the living firms were (in fact, inevitably) the objects of the questionnaire survey. Second, it is also possible that younger firm were more responsive to our survey. However, considering the relatively bigger scale of our sample firms than the average as mentioned above, we believe the first interpretation is more realistic.

As discussed above, our sample doesn't seem to have any significant bias in representing the population, except for the mild over-concentration in Shanghai, Beijing and Hubei.

<References>

Sorry, references are not listed up yet.

[17] Detailed statistics about the entry and exit of the AREs were not available.