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A New Pattern of Technology Transfer in Rural China: Triple Helix of Academy-agriculture-government Relations in Baoji City[1)]

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Summary

During the transformation of the agro-technology extension system in rural China, many new policy experiments are emerging to rebuild the lost linkages and to improve technology transfer with the system and among systems. Applying the Triple Helix Model of academy-agriculture-government relations, this paper explores a new pattern of technology transfer with the case of BaojiCity. The authors interpret the mechanism of "Courtyards for Agro-experts", as well as the comparison between different types of courtyards. This article concludes that the Triple Helix in the agro-sector improves technology transfer and accelerates knowledge-based regional development. In the interest of farmers there should also be concern over reducing inequity during the reform.

Key words: technology transfer, agro-technology extension system, triple helix model, academy-agriculture-government relations, courtyards for agro-experts

1. Introduction

During the transitional process from the Planned Economy to the Market Economy in China, the agro-technology extension system is undergoing a painful re-structuring. At the end of the last century, under the impact of market reform, the former countrywide extension system was

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disassembled in many regions. Therefore, the accompanying loss of linkages in the agro-technology extension system made it extremely difficult for farmers to receive technical training, new breeds of plants, and additional useful information.

The lack of technology transfer leads to at least two serious problems. Firstly, nowadays, modern planting techniques are much more technology intensive compared to what were traditional ways. With inadequate support, farmers are unable to properly utilize new biological breeds, seriously constraining productivity, even though new varieties are introduced from abroad. A parallel problem also puzzles researchers in universities and research institutions. Their research outputs can barely be transferred from laboratories to markets.

Secondly, farmers now receive less training in basic planting technology than they did before because of the disassembling of the public technology extension system. The first problem restrains the farmers' capability of adopting new technology; whereas, the second problem might be quite serious, affecting fundamental survivability. One typical tragedy took place in a small village of ShandongProvince. A farmer's wife dipped seeds in boiling water, spoiling all of them. Because of this small but awful mistake, the family broke apart, and the farmer's wife even tried to commit suicide. The sufferings of the peasants strongly shocked officials and technicians alike, which finally led to a consensus that the restructuring of the agro-technology extension system is an urgent matter.

Although almost all of the cities and counties are trying to find efficient measures to improve regional innovation, only a few have achieved a certain level of success until now (Tu, 2004; Gu, 2004). In some "leader" counties, a farmer's income is enhanced as well as is the agricultural GDP. While their pathways are quite different, they are all applying, deliberately or unconsciously, the same principle - to improve technology transfer in the local agro-sector.

Since the government solely is no longer able to maintain or develop the agro-technology extension system, a crucial question is: "Who will take the place of the public extension stations?" Universities are expected to take up an advanced role in the new network of the regional agricultural innovation system. Some western scholars believe that the "second academic revolution" (see Table 1), combining the mission of economic and social development with traditional missions, requires the universities to take up this new task, or become entrepreneurial (Etzkowitz, 2003).

The relations among government, university and agriculture are quite nationally specific. The agricultural innovation and production system of China is in fast transformation, which provides interesting observation of ongoing institutional changes. BaojiCity, a typical "below-average" city in China, has recently drawn great attention in both the academic circle and among policy makers. The experiment of "Courtyards for Agro-experts" in Baoji is now regarded as being

Table 1 : Expansion of University Missions

Teaching	Research	Entrepreneurial
Preservation and dissemination of knowledge	First academic revolution	Second academic revolution
New missions generate conflict of interest controversies	Two missions: teaching and research	Third mission: economic and social development; old missions continued

Source: Etzkowitz (2003).

very successful.

In the following section, the authors will briefly review the theory applied to this analysis: The Three Helix Model of Academy-agriculture-government relations. This paper then reviews historical changes in the agro-technology extension system in China during the process of opening and reform. As an interesting case, the mechanism of technology transfer in the rural region of BaojiCity is analyzed in Section 4. Both the rational fundamental and the weakness of this new pattern are explored and compared. This study concludes with the possible future development of the Triple Helix of Academy-agriculture-government relations as well as its implications to ongoing reforms in rural China.

2. Framework for Analysis: Triple Helix Model and Technology Transfer in the Agro-sector

The triple helix approach emphasizes relations between the university, industry and government in innovation and technology extension, which is slightly different from the national innovation systems approach, which places the central role for innovation on firms (Edquist, 1997). The "triple helix" is a spiral model of innovation that captures multiple reciprocal relationships in the process of knowledge capitalization. There are three dimensions of technology (or knowledge) transfer in the triple helix model. The first dimension is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances, or an assumption of an economic development mission by universities; the second is the influence of one helix upon another; and the third dimension is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices, formed for the purpose of coming up with new ideas and formats for high-tech development (Etzkowitz, 2002).

Discussion of the Triple Helix is mainly organized in three parts: (1) institutional transformation,

(2) evolutionary mechanisms, and (3) the second academic revolution (Etzkowitz, 2000).

First, the impact of new technologies and global value chain restructuring unavoidably leads to relevant institutional transformation. The increasingly complex innovation process calls for complex institutional infrastructure as well as adequate human capital (Nowak, 2000). The dynamic of society development, therefore, derives from the overlapping of actors.

Secondly, the mechanism of transformation is characterized by evolutionary factors. Loet Leydesdorff extended Arthur's "lock-in" model, demonstrating that triple interactive dynamics may generate highly unpredictable effects (Leydesdorff, 2000). The overlapping of three institutional spheres involves knowledge space, consensus space and innovation space. A fully developed triple helix shall be comprised of all of these spaces (Etzkowitz, 2002) (see Table 2).

Table 2 : Conceptual Framework for Knowledge-based Regional Development

Stage of development	Characteristics
Creation of a knowledge space	Focus on "regional innovation environments" where different actors work to improve local conditions for innovation by concentrating related R&D activities and other relevant operations
Creation of a consensus space	Ideas and strategies are generated in a "triple helix" of multiple reciprocal relationships among institutional sectors (academic, public, private)
Creation of an innovation space	Attempts at realizing the goals articulated in the previous phase; establishing and/or attracting public and private venture capital (combination of capital, technical knowledge and business knowledge) is central

Source: Etzkowitz (2002).

Thirdly, the second academic revolution emphasizes the multiple role of the modern university in the regional economy. Universities are devoting much more resources to entrepreneurial and commercialization than before (Jerry, 2002). Thus, academia is increasingly contributing to knowledge-based regional development. In the U.S., for instance, university research has played a major role in the development of agricultural technology, helping companies identify and design fertilizers and insecticides (Nelson, 2004).

Agricultural R&D and economic development in China are all relatively inferior in basic research compared to developed countries. The innovation process of China's agro-sector is steadily moving toward technology acquisition, assimilation, absorption and production. In other words, the innovation system of the agro-sector mainly consists of technology extension systems.

During the transformation of technology extension systems, each part of the trilateral network is acting enthusiastically in response to serious challenges; therefore, triggering new rounds of institutional innovation.

In Asia, research on agricultural institutional innovation is being conducted in many countries, including Thailand, India, China, and Vietnam. Based on his study on post-harvest innovation system in India, Dr. Hall argued that the norms, routines and rules, together with the organizations involved, comprise the institutional environment (Hall, 2001; 2003a; 2003b). Chairatana analyzed the key actors in AIS and cataloged them into three groups, or producers, supporters and influenced institutions (Chairatana, 2000). In Brazil, Vargas analyzed the wine and tobacco agro-industrial cluster, discussing the origins and dynamics of the local innovation system (Vargas, 2000).

Based on the Triple Helix Model, some scholars apply a relevant research method in their studies on the agro-sector. On the Second Triple Helix Conference, a special panel was allocated to discuss "Is a Triple Helix Emerging in Agriculture?" (http://users.fmg.uva.nl/lleydesdorff/th2/program.htm) At the Second Conference on Biotechnology for Asian Development, Dr. Rajeswari's slide examined the partnerships inside a biotechnology triple helix as well as implications for Agro-biotechnology capacity building (http://www.ris.org.in/rajeswari raina.pdf).

3. Technology Transfer in Rural China: From Linear to Complex

3.1. Thriving and Fading of the Traditional Linear System

Being the most populous country in the world, China accordingly possessed the biggest system of agro-technology extension. Since the establishment of the PRC, the extension system was fast developed despite the impact of political turbulences. From the 1950s to the 1970s, it was incorporated into the four-level administrative bodies of "county", "commune", "brigade", and "production team".[2] Up to the end of 1975, 1, 140 counties had their R&D institutions for agriculture science and technology; 26, 872 communes had set up their agro-technology extension stations (Pan, 1995). Since 1976, the government had been regularly allocating special funds for the four-level agricultural technology system.

Giving thanks for the public fund of the Planned Economy, from the 1960s to the mid-1980s, China kept investment in agricultural R&D at about 0.4% of GDP, which is higher than the

2) County, commune, brigade, and production team were four levels of administration existent in the Planned Economy in China.

average of ninety-two less-developed countries on which ISNAR has statistics (Fan, 1993). Universities account for a growing but still relatively minor share of the agricultural research sources (see Table 3). While the ratios of researchers and research expenditures in universities rose from 6% and 2% (in the 1960s) to 15% and 6% (in the 1980s), they had not played important roles in the AIS.

Table 3 : Agricultural Research Investment in China, 1953-1988

	1953-57	1958-69	1961-65	1966-76	1977-85	1986-87	1988
Research Personnel (in full-time equivalents)							
Scientists and engineers (graduates or equivalent) Research institutes	-	-	6,966	11,118	27,207	41,808	46,649
Universities	193	363	504	503	3,051	6,728	8,597
Total	193	363	7,669	11,621	30,257	48,536	55,246
Technical support staff Research institutes	-	-	4,644	7,411	17,921	30,043	28,895
Universities	-	-	66	82	400	943	927
Total	-	-	4,710	7,494	18,320	30,986	29,822
Research expenditures (in millions of 1980 PPP dollars per year) *							
Research institutes	78.1	560.0	476.2	724.8	1,485.2	1,843.1	1,974.7
Universities	4.7	7.3	10.5	11.4	58.7	112.2	124.8
Total	82.8	567.3	436.2	736.2	1,543.9	1,955.3	2,099.5
Agricultural research intensity	0.007%	0.58%	0.41%	0.36%	0.41%	0.39%	0.40%

Notes: * Current Yuan data were first deflated to constant 1980 Yuan using the national retail price index taken from China's Statistical Yearbook 1991, then converted to purchasing power parity (PPP) dollars using Summers and Heston's 1980 PPP over GDP conversion factor (see Summers, R. and A. Heston, 1991."The Penn World Table [Mark 5]: An Expanded Set of International Comparisons." *Quarterly Journal of Economics* Vol. CVI: 327-368).

Source: Fan, S. G. (1993).

In the Planned Economy, the agro-technology extension system was under the control of local government. As shown in Figure 1, from 1949 to the 1980s, it was a linear system. Contributions from agricultural firms, universities and the demand of end consumers were weak while the government directly controlled the extension system.

The famous opening and reform were launched in 1979-1980, which greatly enhanced productivity of the agro-sector. One of the institutional innovations is the change of agricultural production organizations (from the previous commune system to individual farmer households). This reform

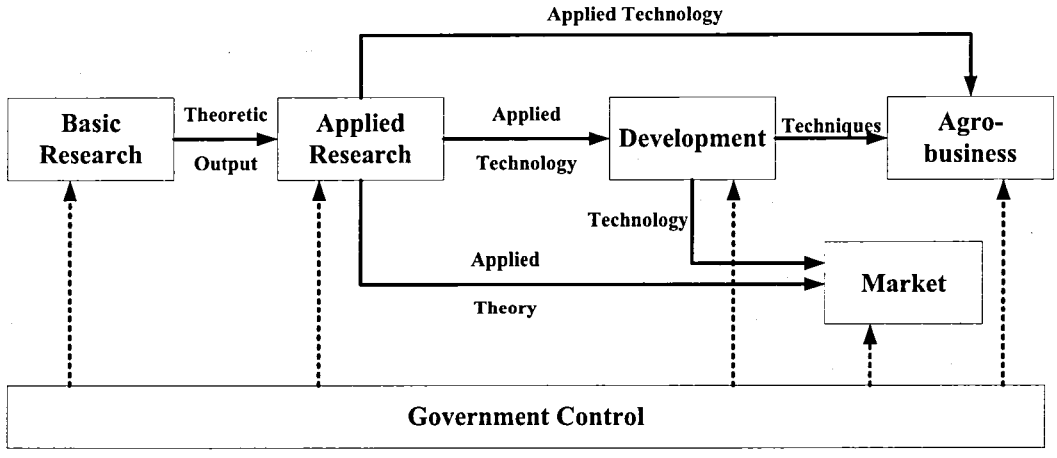


Figure 1 : The Traditional Agro-technology Extension System - A Linear Model

broke the basis of collective production, and affected the established agro-technology extension system. Technicians began to leave the extension stations because of declining research funds and their declining incomes. Farmers are now working individually based on contracted land use, and are not able to get basic training in agricultural techniques. According to a survey in ShandongProvince, 62.4% of all the correspondents could not figure out the names of local responsible technicians; as for the quality of technicians for agricultural equipment, 80.3% of the correspondents thought that their service is about or less than acceptable (Jiang, 2001).

3.2. The Emerging Dynamic System

After ten years of chaos, new mechanisms of agro-technology transfer began to emerge. One of the crucial symbols is that actors other than the state have become active.

Private agricultural enterprises and foreign companies are playing significant roles in technology transfer. (Their involvement is for sure profit oriented.) Private companies are expected, as believed, to engage in agricultural R&D and technology transfer. They are also expected to manage collaborations with external knowledge resources, including that embodied in university researchers (Etzkowitz, 2002). One of the results from the changing agro-sector is that the traditional agricultural products are in decrease while new and high-yield varieties of food crops and other agricultural products are being introduced at an accelerating pace. Meanwhile, the situation of rural labor's access to training is very low with regard to improvement. (see Table 4) Even where local governments do contribute to training there is a declining trend. (see Table 5). Private firms and universities are gradually becoming major actors in many R&D and training projects.

Table 4 : Ratio of Technical Personnel in Rural Population (%)

Year	1986	1987	1988	1989	1990	1991
Rural labor with good techniques	5.64	5.66	5.63	5.72	5.96	6.25
Rural labor received professional education or training	1.67	1.68	1.67	1.91	2.13	2.16
Rural labor with professional title	--	--	--	--	--	--
Year	1993	1995	1996	1997	1998	1999
Rural labor with good techniques	6.22	--	--	--	--	--
Rural labor received professional education or training	2.22	2.75	3.00	3.04	3.07	3.09
Rural labor with professional title	0.89	2.06	1.85	1.87	1.65	1.66

Note: The symbol '—' means no data.
Source: Ministry of Agriculture of China (2001). Compiled by the authors.

Table 5 : Training Activities Held by County Governments

Year	Training courses		Establishment of rural technology association
	Number of courses	Participants	
1997	8,609	1,755,679	2,584
1998	12,861	1,941,153	3,328
1999	13,571	1,238,641	3,463
2000	9,973	851,961	2,447
2001	12,916	990,546	3,714
2002	13,395	942,466	2,137
2003	10,433	918,249	2,262

Source: National Bureau of Statistics of China (2002).

Fan (1999) listed obstacles to technology transfer in a survey of local technicians. This survey shows that the withdrawing of funds from the government was thought to be the No.1 obstacle. In light of this reality, collaboration between academia and agriculture might have been a promising way to improve technology transfer for agricultural development. Mainly for this reason, many regions in China launched reform programs aiming to incorporate agricultural firms into agro-technology extension systems. Laizhou City, for example, did this with considerable attention by supporting private enterprises run by farmer entrepreneurs for the construction of a local technology network (Wu, 2002). ShouguangCity selected a different approach based on it's own advantages by developing the support system and market linkages for a similar purpose (Tu, 2004).

More experimentation is going-on. While the policies taken in different regions are rather regional specific, they share a similar principle - to promote knowledge creation and technology transfer through interactions. Innovation infrastructures and "innovation climate" such as local trust are also frequently found in these interesting cases.

Different from the situation in developed countries, Chinese universities are relatively weak when it comes to an innovation system. Hence, academia in China is much less active in the "second academic revolution." In history, some universities in China made efforts for agricultural development based on "bilateral" practice. JinLingUniversity, for example, established its agricultural college in the 1920s (Zhang, 1998). This university endeavored in transferring technology to peasants by providing training courses and distributing handbooks; their research work also benefited from feedback coming from experimental fields. This tradition was not continued during the centrally planned period. In this sense, the current emergence of collaboration between university and agriculture with the support of the government is of both practical and theoretical importance. We now turn to analyzing the Baoji case to see if it implies a new pattern of agricultural Triple Helix.

4. The Case of Baoji City: A New Pattern of Triple Helix

4.1. How Did the "Triple Helix" Come into Being?

(1) The Disassembling of the Old System and the Following Breakthrough

Unlike Shouguang or Laizhou City in Shandong Province, Baoji City is located in Shannxi Province in the western part of China. "Baoji" means "Golden Cock", and it is the birthplace of the Chinese Culture. However, it is not a rich city nowadays. It consists of nine counties and three districts. In 2003, the GDP of this city was 26.11 billion Yuan (about US$ 8 billion). The income per capita of farmers was 1,846 Yuan (about US$ 200), which is only 70% of the national average for that year (2,622 Yuan).

Besides the historical reasons that indirectly led to the poverty of Western China (this could really be a long story of war, politics and geography), the broad conditions of Baoji make it difficult to achieve the fast growth that the eastern cities have. Because of its geographic location and economy status, Baoji City is not able to attract enough FDI, as that is what most of the eastern coast cities rely on. Thus, they have not been able to receive enough money or to induce technology from external factors (let's say MNCs). From the perspective of local

culture, Shannxi people are more conservative and prudent, and therefore lack a brave entrepreneurial spirit. It is commonly agreed that eastern people, especially those who live close to the coast, are more innovative and enthusiastic for entrepreneurial activities than those who live in the western hinterland. Shannxi people, obviously, are not in the same category with eastern residents, which implies that a breakthrough could hardly take place endogenously in the form of new startups and venture capital. There are no higher education and research institutions of agriculture in Baoji, which makes the future for the people of that area even gloomier.

The trigger of innovation befell in 1997, when the then vice mayor Wang visited the Baoji Breeding Farm of Agriculture and Herd. This institution got into a hobble like many other farms. The angry employees interrupted Wang's visit, and asked for a resolution. Shocked by the serious situation, Wang and his colleagues decided to seek out an efficient way to help with local development.

The reorganizing of local technology transfer was the first step they were concerned about: the farmers were eager for market information and technology training; the firms needed more technology support; the technology extension stations lacked both money and professional training; and the whole system was broken, with the actors isolated from one another (see Figure 2).

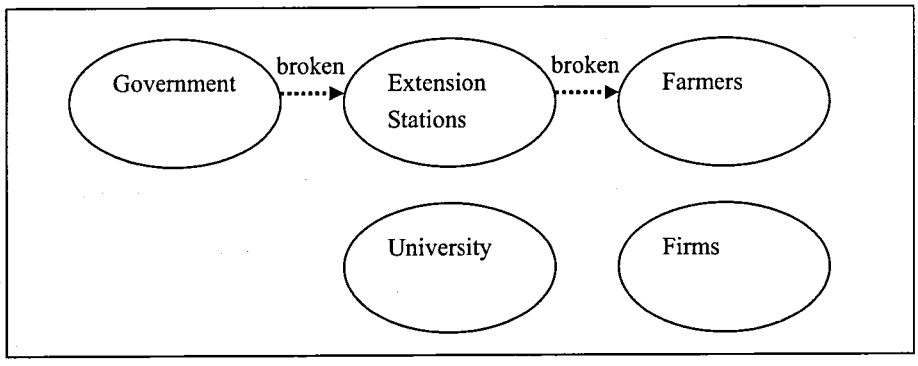


Figure 2 : Old Agro-technology Extension System in Rural Baoji

(2) "Courtyard for Agro-experts" Project and Its Emerging Magic Power

After two years of careful review and demonstrability, in 1999, the local government of Baoji City launched the "Courtyard for Agro-experts" project. The government started inviting "outside" experts every year to make a short stay in the rural region of Baoji, normally inside or nearby a village. Since there is no strong academia institution in Baoji, most of those invited were

from the Northwest Sci-Tech University of Agriculture and Forestry, which is located in their neighbor city - Yangling.[3] Northwest Sci-Tech University of Agriculture and Forestry derived from the combination of several colleges in 1997. It is among the top agro-universities in China. However, the linkage between basic research on campus and the technology extension on farms has been historically very weak. Researchers and professors were worried about how to improve applied research based on the output of laboratories. Before the project, some experts had already kept certain relations with the local experimental fields. However, they were not able to stay for long due to the poor living conditions and lack of research facilities. While some of them stayed among the farmers a few days every year, the effect was extremely limited.

As the key point of breakthrough, the Baoji government established a group of necessary facilities. They invested to build up courtyards, which are typically two floored buildings that include a sitting room, bedroom, laboratory, computer room and other necessary equipment. Normally, there is a certain amount of experimental field space that is also allocated to the courtyard. Able to settle down in the courtyards with both research and living facilities, experts are willing to stay among the farmers for a certain duration of time every year. Not only can

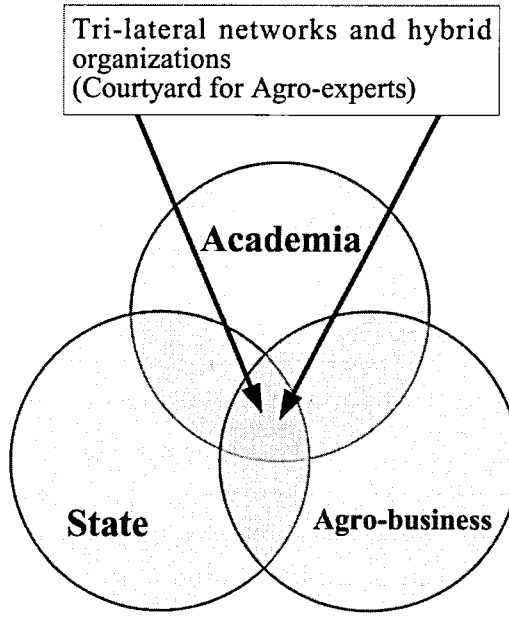


Figure 3 : Triple Helix Model of Academy-agriculture-government Relations

3) While NSTU is the most important source of intellect, some other universities also contribute to courtyards. The Shannxi Teachers College, for example, helped set up the Taibai Pharmaceutical Valley.

they help to train the farmers and introduce them to new breeds, but they are also able to make use of the experimental field around the courtyard to do their own research. This measure was immediately welcomed by all parties: farmers can receive expeditious directions and advice inside or beside the village; experts can stay on the farm, doing research in experimental fields and record the responses from farmers; and firms combined with the courtyards are able to get intellectual support to upgrade their technology and production line.

Thus, the project led to an overlay of a trilateral network. In the center of this system is the hybrid organization—Courtyard for Agro-experts (see Figure 3).

The "Courtyard for Agro-experts" makes up for the divide between technology producers (university) and technology users (technical diffusion service, farmers, firms, etc.). Thus, the integral system was activated, and technology transferred through the crucial linkages, which amounted to a brand new agro-technology extension system in Baoji (see Figure 4).

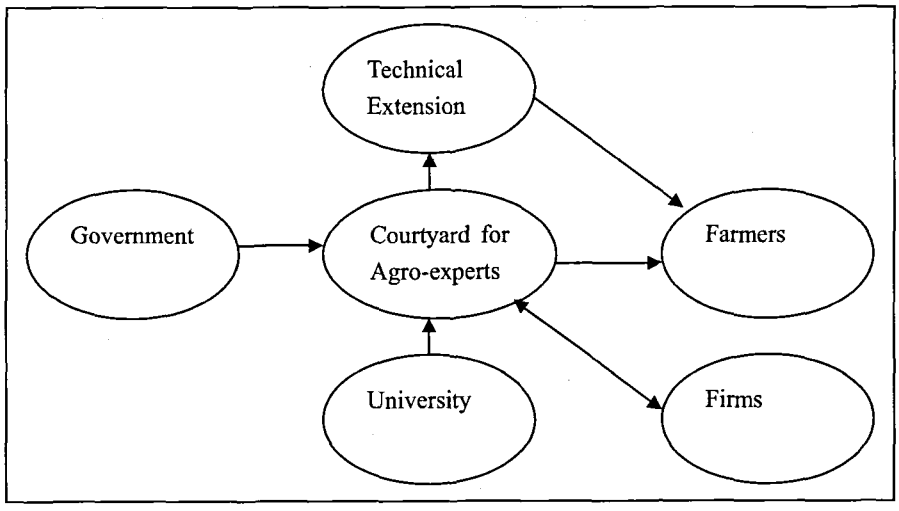


Figure 4: Agro-technology Extension System with "Courtyard for Agro-experts" in Rural Baoji

In this system, the government sets up infrastructures for innovation, helping establish an innovative environment, and even provides loan assurance for R&D in hybrid organizations. Academia and agriculture are encouraged by the state to engage in new cooperation on the basis of courtyards. Experts are rewarded with stock shares or salary from the research outputs. Since they live close to villages, experts are able to provide training courses directly to farmers. Meanwhile, they also train local technicians who will spread the technology to other villages. Most training courses, including those given by private firms, are for free. This is because

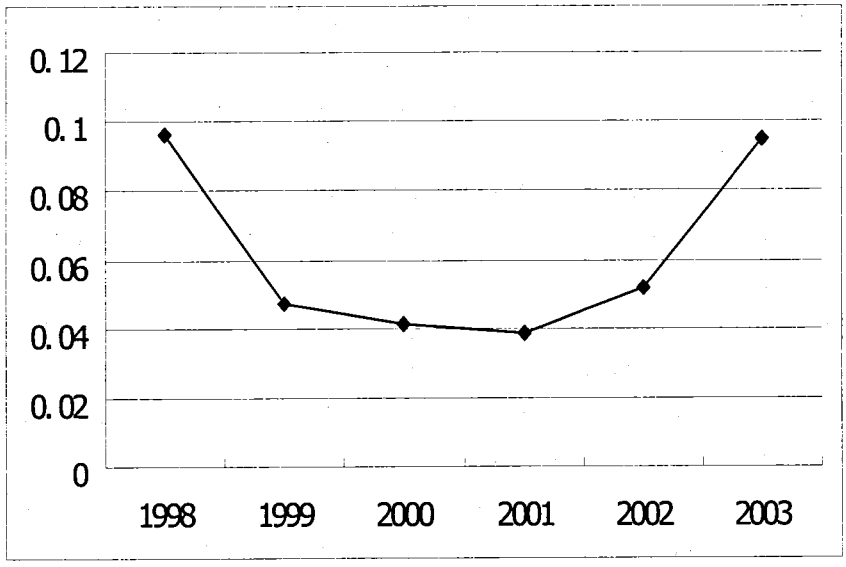
the firms are willing to help enhance the technological capabilities of farmers and in turn, improve both upstream supply and downstream purchase.

This cooperation at first was between individual experts and local government. Universities were quite prudent to cooperate with the firms or farmers. Now, they too realize the importance of response and reward from the collaboration. After careful demonstrability, they have begun to promote academy-agriculture-government cooperation, and some have established their teaching bases in relevant courtyards.

As of now, thirty-four Courtyards for Agro-experts have been set up in this region, covering all districts and counties of this city and many agricultural chains. (see Appendix) They have brought a total of around 400 million Yuan (or US$ 50 million) of growth to the annual agricultural GDP of Baoji City, and about 100 Yuan (or US$ 12.5) of growth to the average annual income per farmer, which is quite impressive for this region. (The agricultural GDP of Baoji in 2003 was 5.323 billion Yuan(or about US$ 665 million)). Since the starting of this project, the decline of growth rate of income per capita in the rural region has been stopped effectively, and has climbed back up quickly in recent years (see Figure 5).

Obviously, the "Courtyards for Agro-experts" projectworks efficientlyin increasing income per capita. Linyou County, for example, is one of the national poverty-struck counties. In 1998, a huge Embryo Transplant Centerwas set up in Linyou. From then to the end of 2003, over 31.27 million Yuan has been invested in goat feeding and the breeding business all over the county. Therefore, a well-established network has comeinto being based on the technological support of the research center. The network includes three demonstration towns for 10 thousand Boer goats breeding, forty demonstration villages for one thousand Boer goats breeding and fifty-two Boer goat breeding farms. Until the year 2004, 7,295 rural families had comprisedthe Boer goat breeding business, which account for 42.9% of all the families in Linyou County. Income per capita from stockbreeding reached 236.4 Yuan, accounting for 31.3% of income per capita of local farmers. By developing the stockbreeding business, about 8,000 people of the rural poverty stricken population of Linyou County emerged out of poverty, and set out on the road to prosperity.

The overlapping of the triple helix also involved the creation of knowledge, consensus, and innovation space in Baoji, which is mainly pushed by government policy (see Table 6). To create knowledge space, the government "steals" experts from the neighboring city, and provides satisfying infrastructure to improve local innovation. As a consensus space, the Courtyards for Agro-experts project was highly promoted. The people and the firms also believe this new pattern will change the how-d'ye-dothey were facing. More detailed policies and management measures



Source: Baoji Statistics Yearbook 1998-2003.

Figure 5 : Growth Rate of Income per Capita of Farmers in Baoji (1998-2003)

were carried out in Baoji to create innovation space, which, based on the former two spaces, successfully gives birth to a new phase of regional development.

4.2. Structural Patterns of Courtyards in Baoji

Courtyards in this study are primarily cataloged into three types:

(1) R&D Departments of Firms

In these cases, courtyards are set up inside existing firms or startups. Scientists are awarded with a certain proportion of company stock. The courtyards work as R&D departments inside the firms. Experts can work both as a researcher and a project manager. Some of them even attend all the important activities in the company: design of strategy, resolution of problems in planting, and R&D in the laboratory.

(2) Quasi Firm

A little different from the quasi firm identified by Etzkowitz (2003), these courtyards are neither university (though the group consists of professors and students) nor registered firms

Table 6 : Application of Knowledge-based Regional Development Framework in Baoji

Stage of development	Activities in the Baoji Case
Creation of a *knowledge space*	Providing infrastructures to the experts, which include the courtyard building, information station, and necessary funds. Improving local innovation circumstances, such as encouraging farmers to adopt new breeds and set up local trust both formally and informally.
Creation of a *consensus space*	Courtyard of agro-experts were emphasized and regarded as the top issue in local policy. Experts and agricultural firms, therefore, are willing to set up new relations in this framework. Farmers also welcome courtyards to locate beside their own village.
Creation of an *innovation space*	Establishing a whole management system set for the courtyards. The output of courtyards were soon promoted and commercialized to help local economic and social development.

(though they do sell products and some even have small inventory and a processing line). They are more neutral and share almost the same focus on research (education) and profit.

(3) Cooperating with Local Government

Some courtyards are established by the town/village governments. While local officials are quite enthusiastic about receiving intellects from universities, their management capabilities seriously limit their achievement.

When the project began, some courtyards were new startups, while some there already had been ongoing previous cooperation for many years. With the identification of Courtyard for Agro-experts, the government provides both funding and institutional support to all types of institutions.

These courtyards are all playing multiple roles involving research-training-testing-marketing. However, there are opposite fates between different types of courtyards. Only two-thirds of the present courtyards are running well. Some have difficulties, and a small number of them even have become a burden on the local government. Based on an interview, most upsetting cases happened in those courtyards that cooperate with village/town governments or with another research institution. The Strawberry Courtyard, for example, was first located in the town government. However, it did not work as well as the quasi firms. The city government had to re-locate it to the Golden Fruit Company, which revived the courtyard. Saanen Milch Goat

Courtyard is additional strong evidence. It cooperated first with the Local Breeding Research Center, and then with some villages. In neither situation was the courtyard motivated to be innovative.

4.3 Why Some Suffer while Some Succeed?

Why does the quasi-firm mechanism of the triple helix work better than mere academy-government cooperation? Since the latter way is ultimately the same as the former way, there is no institutional innovation with this type. In the quasi-firm organizations (and the R&D department courtyards), the proper incentive mechanism is identified. Therefore, scientists are reasonably rewarded from their contribution. Since most of their research is in the "Pasteur's Quadrant", the firms and local economy also benefit from the technology development as well. Farmers enjoyed a rapid increase of income and improvement of living conditions. At lease five main characters of the triple helix are important with this case. (see Table 7)

(1) The hybrid organizations have rational and flexible institutions. On one hand, scientists have considerable freedom to choose projects based on their own interests, or do the work they think most important. On the other hand, their interest is in coherence with the firm's. Thus, their research will fully respect the profit of the quasi-firms (or firms). On the contrary, in the Old Planned Economy, research and innovation were not properly rewarded, and the experts had no choice but to stay on the campus, far away from where their research output would be implemented.

(2) While this approach successfully amended the shortcomings of the old system, some economists expressed worries about the benefit distribution between firms and farmers (Gu, 2004). A reminder that the courtyards should avoid being over-commercialized is necessary here. One of the key factors of quasi-firms is their recognition of social responsibility in addition to their own interest.

In the case of the Qinchuan Cattle Center, entrepreneurs there have begun to think a great deal about their contribution to the society and the people. While they have sufficient monopoly power in marketing and technology to control the whole production line, they deliberately adjust the benefits of distribution to favor the farmers. Therefore, with the quasi-firm institutions (perhaps should be more advanced in the future), plus public responsibility recognition, a monopoly power of technology will not lead to monopoly price (see Figure 6).

Another advantage of the courtyards is the establishment of local "trust." As in many other developing countries, China's agro-sector is characterized by the small-scale farm. The huge

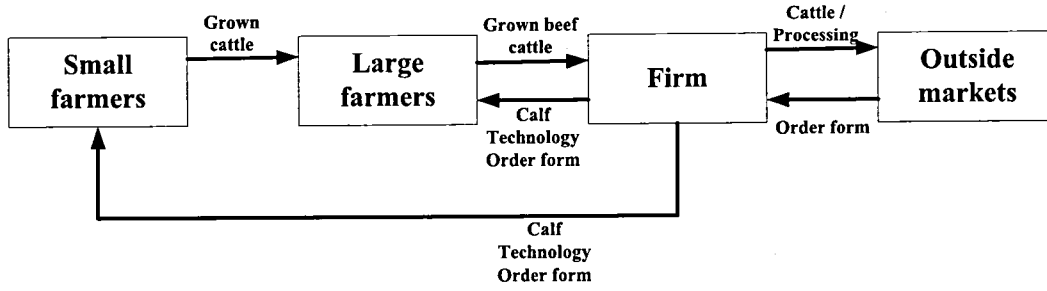


Figure 6 : Production Line of Qinchuan Cattle

rural population, plus cultural and historical factors, lead to the "lock-in" of the small-scale farm and its relative limitations. Farmers are not able to communicate outside their region. Nor do they have a long-range vision to support a regional trust system. The courtyards, in practice, help to extend the farmers' vision. In the Qinchuan Cattle case, besides contracting with farmers in cooperation, farmers even provide assurance for rural families to make loans for funds necessary for livestock reproduction. The company maintains an expert hotline for farmers, and has set up an insurance fund for cattle's disease and death. Influenced by the company, the farmers rejected many purchase requests from outside companies, even though the latter gives a temporary higher price.

(3) With the support of top experts, the courtyards are furnished with new applied technologies. National or provincial S&T projects as well as international gene pools began to locate in these emerging organizations. Advantages of technology upgraded the old agro-production system, which, with traditional technologies and products, was ever at the bottom of the international value chain.

(4) Technology transfer ultimately is part of a citizen's courtyard obligations. Since the original technology extension system encountered difficulties, the triple helix effectively replaced the old system. The courtyard of Fruits Center, for instance, held seventy-three classes in 2003, which is much more than the local extension station provided, though the latter has more than triple the number of technicians than the courtyard. The "Golden Fruit" Strawberry Center also holds thirty classes each year.

(5) The experts, firms and government, even including farmers, each hold their up-to-date information in respective fields. The combination of information serves the courtyards with the fastest reaction to changes in technology, market, and policy. In fact, this is also one of the key reasons for the existence of the triple helix model.

Table 7 : Main Characters of Quasi-firms - Courtyards for Agro-experts

Characters	Reasons
Rational and flexible management	Operation of the hybrid organizations is controlled, and the experts' interest accords with the firm's.
Citizen obligations of institutions	Realizing their social responsibility, the quasi-firm is more likely to set up a local "trust" environment. The farmers' interest is fully considered. The organizations shall not abuse their monopoly power.
Advantages of technology	With the support of top experts, quasi-firms incorporate strong S&T power with corporate governance.
Technology transfer	Hybrid organizations take the place of former technology extension stations, training farmers and providing technical instruction.
Fast reaction to changes	Experts, firms, and government, even including farmers, all hold their up-to-date information exchanges in respective fields. The combination of information serves the courtyards with fastest reaction to the changes in technology, market and policy.

Government, in this triple helix, is creating a platform. On one hand, it encourages farmers to be brave in adapting new technologies as well as new institutions. On the other hand, government policy secures the environment of academy-agriculture-government relations.

In failure cases, lack of the aforementioned factors is the chief cause. In a vegetable center, for instance, experts signed loose contracts with farmers without regard for the trust system. Finally, farmers easily broke faith, and brought numerous losses to the courtyards. More cases can be attributed to the improper intervention of town/village government. The lack of rational management replayed the tragedy of the old system.

5. Conclusions and Implications

Because of the characteristics of agro-production, the agro-sector is regarded as being an industry with high risk, long-term investment, high uncertainty, and oceans of tacit knowledge, which is difficult to diffuse. The Triple Helix Model might be a good solution to this puzzle because:

(1) The rational management of firms leads to proper incentives for researchers, and secure

efficiency of production. The entrepreneurial spirit stimulates tolerance to risks and failures.

(2) The new tasks of universities are to make up for the lack of science and human capital in rural regions of China. What's more, the upgrade of the technology extension system in the less-developed countries could be achieved through one or two significant technological breakthroughs. The scientific fundamental should be incorporated into the evolutionary process of production and innovation. Thus, motivated by the learning and interaction among all the actors, the co-evolution of the tech-socio-economy is able to continue. This process is the right dynamic of the capitalist engine.

(3) Government policy shall promote cooperation. In most regions of China, local government cannot afford to directly provide subsidies to the rural population. Now they can concentrate limited funds on the building of Courtyards for Agro-experts, and the latter will function to improve regional development.

In this system, the tacit knowledge lying in farmers should not be forgotten. The reservoir of local traditional experiences is part of key innovative infrastructures. In the Fruits Center and the "Golden Fruits" Strawberry Center, indigenous "farmer experts" are taking the most important role. Technicians in the old system, for example, should also be regarded as crucial technology sources. The courtyards are not totally discarding the old system, but incorporating it into the new system. Their capabilities and experiences in technology extension are prerequisites to the experts.

According to the comparison between different types of courtyards, absence of any part in the tri-lateral network might lead to instability of the system. The failures of mere academy-government cooperation are persuasive enough to prove this point. People, in this manner, should keep flexible institutions in practice so that the advantages of Triple Helix can work.

"To run the Courtyards for Agro-experts as a firm" is one of the policies issued by the Baoji government, which might possibly mislead the reform. Pure commercialization will not make the courtyard a hybrid organization but a pure firm with an R&D center. From the perspective of regional social development, the government shall remind these institutions of their "Citizen Obligations" as well as their social responsibility. The co-evolution of the regional socio-economy is the eventual objective of local development.

In any sense, the Courtyards for Agro-experts as well as the framework of the academy-agriculture-government relations are emerging concepts. The future of this pattern is relatively unstable in the bureaucratic environment of China. Discontinuity of policy happens from time to time when the local leaders change. To keep continuity, the consensus space for the triple helix model, as well as the importance of knowledge flow in regional development,

need to be created and fixed as recognized institutions.

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Appendix: Distribution and Characters of the Courtyard for Agro-experts in Baoji City

	Courtyards	Location	Cooperation with	Experts	Theme
1	Information Center	Baoji City	Agro-information center of Baoji City	Prof. He	Creation and management of information platform; automatical collection and analysis of production data
2	Milk Processing Center	Baoji City	Delikang Milk Co.	Prof. Jiang	Processing of milk, production of yoghurt and fresh milk
3	Disease Prevention and Cure Station of the Cow Center	Baoji County	Delikang Milk Co.	Senior Veterinarian Li	Resistance and cure for milk cows
4	Feeding Management Station of the Cow Center	Baoji County	Delikang Milk Co.	Dr. Yao	Breeding, feeding and milking
5	Yangjiagou Vegetable Center	Chencang District	Local village of Yangjiagou	Prof. Chen	Vegetable planting and marketing
6	Edible Fungus Center	Feng County	Mushroom firm	Prof. Lai	Industrial planting and inventory of mushrooms
7	Chinese Red Pepper Center	Feng County	Forestry Bureau of the County	Prof. A. Wei	R&D and demonstration of Chinese red pepper planting
8	Fruits Center	Fengxiang County	Private Firm	Scientist B. Li	R&D, production, training and demonstration of new breeds
9	Tang Vegetable Center	Fengxiang County	Village government	Prof. Liu	Introduction of new varieties, diffusion and demonstration of new technology
10	Hengshui Vegetable Center	Fengxiang County	Town/village government	Prof. Gong	R&D, training, demonstration and testing of modern sightseeing agriculture model
11	Qinchuan Cattle Center	Fufeng County	Private Firm	Prof. Jiu; Prof. Dou	Qinchuan Cattle breeding, slaughter, processing, expert
12	Fufeng Wheat Breeding Center	Fufeng County	Fufeng Demonstration Farm	Prof. H. Wang	Breeding and diffusion of new varieties
13	Rougu Vegetable Center	Fufeng County	Town/village government	Prof. J. Liu	Planting and diffusion of new varieties
14	Jiuchenggong Embryo Transplanting Center	Linyou County	Boer goat breeding company	Prof. Dou, etc.	Breeding, embryo transplanting and feeding of Boer Goat
15	Boer Goat Center	Linyou County	Stock Company	Prof. Cao, etc.	Breeding, embryo transplanting, frozen sperm production
16	Jiuchenggong Dry Fruits Center	Linyou County	Quasi firm	Scientist Liu	Breeding of dry fruits and trees

Source: Provided by the office of Baoji S&T Bureau.