

## **China: An Unfinished Reform Agenda**

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### **Introduction**

Agricultural production in China has grown rapidly—relative to other countries—over the past four decades. Much of this growth can be attributed to investments in agricultural research by national and regional governments combined with policy reform and increased use of inputs.<sup>1</sup> After 50 years of development, the Chinese agricultural research system is now arguably the largest in the world, employing over 50,000 senior scientists and spending more than US\$3.8 billion in 2002 (measured in 1995 international dollars).<sup>2</sup> However, the system is currently facing a dilemma. Chinese agricultural production is becoming increasingly dependent on new technologies generated by research, especially as agricultural land and other natural resources become more limiting factors. The quantity of agricultural land—and high-quality land in particular—will only decline further in the future with rapid industrialization and urbanization. At the same time, a national policy introduced in the mid-1980s has encouraged research institutes to become financially self-supporting. As a result, on the positive side, research has become more integrated with economic development because research institutes have sought financial support by selling their services. On the negative side, however, areas of research not easily commercialized, including significant aspects of agricultural research, face financial problems as governments at various levels reduce funding for R&D.

The objectives of this chapter are to review the evolution of the organizational structure, institutional management, and financing of the Chinese agricultural research system and to explore reform options to promote future agricultural growth and food security and reduce poverty. We first review the trend in agricultural

production and productivity growth in Chinese agriculture, using newly available data and new aggregation methods. We then discuss the institutional and policy environment of the Chinese agricultural R&D system. Next, we analyze major issues in the provision and financing of agricultural R&D in China. This analysis is followed by two case studies: one of a national research institute, and the other of a provincial institute. Finally, we offer some policy choices regarding reform of the existing system in light of emerging challenges in the 21st century.

### Production and Productivity in Chinese Agriculture

Over the past several decades, and particularly since 1978, the Chinese economy has performed spectacularly well. Per capita gross domestic product (GDP) grew at 6.2 percent per year from 1952 to 2002. Prior to 1978, the growth rate was only 3.4 percent, but between 1978 and 2002 it jumped to 8.2 percent per year (*China Statistical Yearbook*, various years). The economy has also undergone dramatic and continuing structural change.

In 1952, agriculture accounted for more than half the national GDP, while urban industry and services accounted for 21 and 29 percent, respectively (Table 3.1). The Chinese economy was largely agrarian. By 2002, however, agriculture had declined to around 15 percent of GDP—a rapid decline of about two-thirds of

**Table 3.1 China: Structural change in the economy, 1952–2002**

Indicators	1952	1960 <sup>a</sup>	1970	1980	1990	2000	2002
Share of GDP (percent)							
Agriculture	50.5	23.4	38.0	30.1	27.1	15.9	15.4
Industry	20.9	44.5	35.6	48.5	41.6	50.9	51.1
Service	28.6	32.1	26.5	21.4	31.3	33.2	33.5
Share of employment (percent)							
Agriculture	83.5	82.1	80.8	68.7	60.1	50.0	50.0
Industry	7.4	7.9	10.2	18.2	21.4	22.5	21.4
Service	9.1	9.9	9.0	13.1	18.5	27.5	28.6
Per capita GDP (1995 U.S. dollars)							
Official 1995 exchange rate	46.31	58.3	94.6	144.0	341.7	804.5	924.2
Purchasing power parity <sup>b</sup>	203.6	256.4	415.6	632.9	1,501.9	3,536.1	4,062.1
Exports as percentage of GDP	4.0	4.1	2.5	4.7	16.1	23.1	25.7
Imports as percentage of GDP	5.5	2.9	2.5	5.4	13.9	20.8	23.3

Sources: National Statistical Bureau, various years, for all data, except per capita GDP converted with purchasing power parities (PPPs), which was obtained from World Bank 2004.

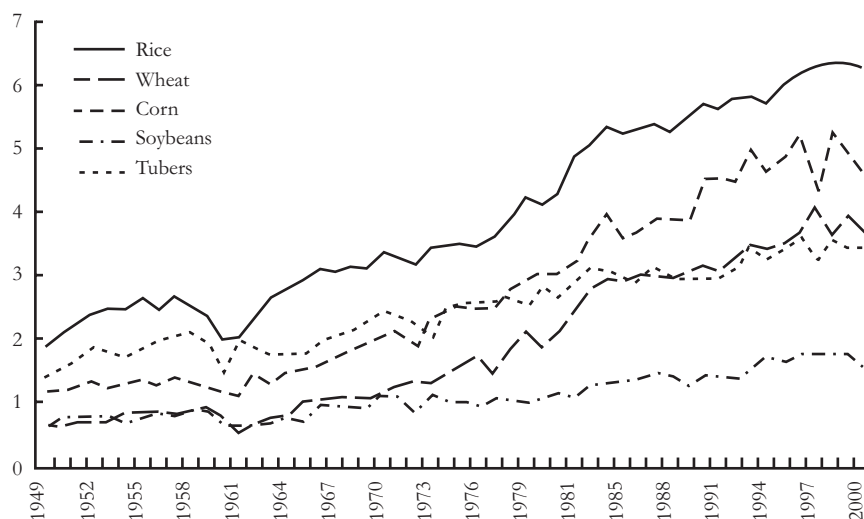
Note: Percentages do not always sum to 100 given rounding errors.

<sup>a</sup>Italicized data for 1960 are 1962 values.

<sup>b</sup>Purchasing power parity, or PPP, is an index used to reflect the purchasing power of currencies by comparing prices across a broader range of goods and services than conventional exchange rates.

**Figure 3.1. China: Yield of major grain crops, 1949–2000**

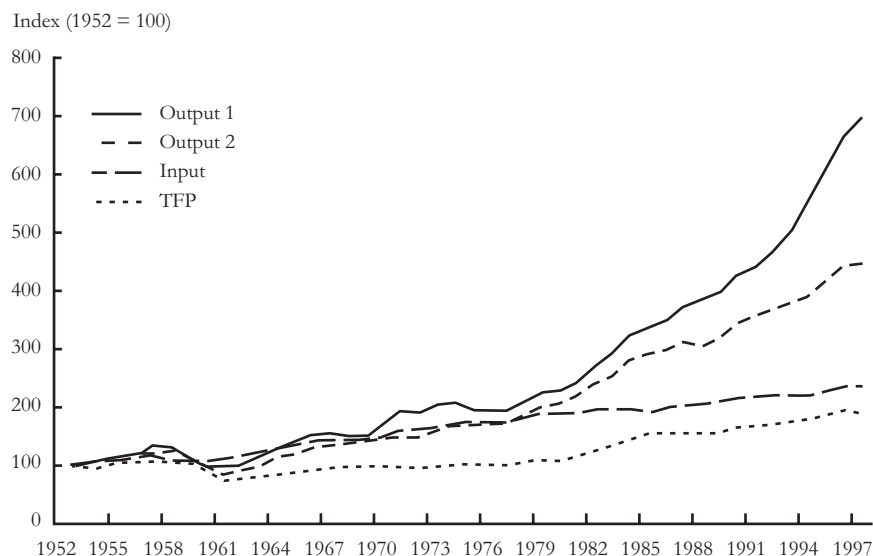
Metric tons per hectare

**Source:** National Statistical Bureau, various years.**Note:** Rice is measured as paddy rice.

a percentage point per year. Labor shifts among sectors have been striking. In 1952, more than 80 percent of the national labor force was in agriculture, only 6 percent in urban industry, and 10 percent in the urban service sector. By 2002, less than half the labor force was engaged in agricultural activities; more than 21 percent worked in the industrial sector and 29 percent in the service sector.

Agricultural production has grown at a much faster pace in China than in most other countries for the past 50 years. The yield of rice, the staple of the Chinese diet, has increased from 1.9 tons to 6.3 tons per hectare, a rate of increase of 2.24 percent per year (Figure 3.1). The yield of wheat, another important crop in China, grew even faster, from 0.6 to 3.9 tons per hectare, or 3.4 percent per year. Overall agricultural production grew by 3.3 percent per year from 1952 to 1997 (Figure 3.2). Growth in grain output and production value has been much higher than the population growth over the same period, so that the amount and value of output per capita has increased.<sup>3</sup>

A large proportion of this growth can be attributed to productivity improvement, which in turn comes primarily from new technologies released by the national agricultural research system. Over the period 1952 to 1997, growth in productivity

**Figure 3.2 China: Agricultural production and productivity growth, 1952–97**

Sources: National Statistical Bureau, various years; Fan and Zhang 2002.

Notes: Output 1 is the official production index reported by the National Statistical Bureau in various issues of China's statistical yearbooks. Fan and Zhang (2002) argue that the National Statistical Bureau may have overreported agricultural production growth in China by using the constant price index in the aggregation, in addition to overreporting the meat and fisheries output. Output 2 is Fan and Zhang's reconstructed production index using the Tornqvist–Theil index and an adjusted meat and fisheries output. Input is the index of total input aggregated using the Tornqvist–Theil approach. TFP is the total factor productivity index, the ratio of total output (output 2) to total input, both constructed using the Tornqvist–Theil index.

accounted for an estimated 47 percent of total production growth in agriculture (Fan and Zhang 2002). Prior to 1979, increased input use accounted for 95 percent of the growth in output, while productivity improvement accounted for only 5 percent. But after 1979, productivity growth accounted for 71 percent of the production growth, while increased input use accounted for less than 30 percent.<sup>4</sup> This trend indicates that future growth in agricultural production will rely on continued productivity improvements.

### The Institutional and Policy Environment

One of the distinguishing characteristics of agricultural research in China is the dominance of public research conducted in national and provincial academies,

prefectural institutes of agricultural sciences, and agricultural universities. Related county-level activities deal with technology transfer issues, such as demonstration trials, farmer education, and other extension-related work. Private agricultural research is minimal, although private agricultural research and development initiatives have begun to emerge in recent years.

Like many other sectors of the economy, the Chinese agricultural research system underwent substantial reforms in the last decade of the 20th century. The objectives (or at least the stated intentions) of these reforms were to make the system more efficient and more responsive to the needs of the agricultural sector in particular, and to the development of the economy more generally, while reducing the core public funding provided to research institutes in the context of increasing demand for government funds. These reforms resulted in the emergence of non-governmental funding for agricultural research. In terms of the ownership of R&D institutes and sources of funding, it is useful to distinguish between five types of agricultural research institutions in China: traditional publicly funded and managed research institutes, development firms owned by public agricultural research institutes, government-owned agribusiness firms, shareholder companies, and multinational companies.

### **Public-Sector Research Institutes**

Public-sector research institutes still form the backbone of the Chinese agricultural research system, despite the rapid emergence of other types of research institutions. Public agricultural research at the national level is conducted mainly within academies and institutes under the Ministry of Agriculture, complemented by the research efforts of various institutes under the administrative control of other ministries. Provincial agricultural academies conduct research targeted primarily at local circumstances. At the prefectural level, the emphasis is on applied and adaptive research and development. The principal research entity is the prefectural agricultural research institute, which is generally administered by the prefectural government. Research at this level is important given the relatively large size of prefectures in China.

The Chinese system is highly decentralized in terms of both management and funding (Table 3.2). Based on 2002 data, only about 12 percent of the scientists and engineers (excluding university personnel) are employed by national institutes. A large proportion of researchers (49 percent) work in institutes administered and often largely financed at the provincial level, while the remaining 39 percent work in prefectural institutes. There is a marked disparity in the average size of the institutes: the national institutes employ an average of 70 scientists per institute, the provincial institutes half this number, and prefectural institutes just 19 scientists

**Table 3.2 China: Vertical structure of agricultural research institutes, 1989 and 2002**

Category	National			Provincial			Prefectural			Total			National			Provincial			Prefectural			Total		
Number of institutes		56			423			620		1,099				59		429			608			1,096		
Number of staff (total)		13,590			65,124			46,562		125,276				11,641		45,086			35,622			92,349		
Number of scientists and engineers		5,676			17,827			10,161		33,664				4,114		16,458			11,355			31,927		
Scientists and engineers per institute		101.36			42.14			16.39		30.63				69.73		38.36			18.68			29.13		
Research expenditures (million yuan, 1999 prices)		270			985			654		1,909				1,378		2,923			1,408			5,759		
Research expenditure per staff member (yuan, 1999 prices)		19,868			15,125			14,046		15,238				118,375		64,832			39,526			62,361		
Research expenditure per scientist or engineer (yuan, 1999 prices)		47,569			55,253			64,364		56,707				334,954		177,604			123,998			180,380		

**Source: Ministry of Agriculture, various years.**

**Note: Data pertain to the nonuniversity institutes within the Ministry of Agriculture system only.**

per institute. The average spending per staff member at the national level for 2002 was about 120,000 yuan, roughly double the provincial level and triple the prefectural level. These data are generally consistent with the notion of larger, more scientist-intensive institutes at the national level that focus on pre-technology rather than site-specific research. Provincial and prefectural institutes are generally smaller, less scientist-intensive, and involved in more localized, adaptive research and technology development activities.

A distinctive aspect of the agricultural research system in China is that research is institutionally separated from education and extension. The Chinese Academy of Agricultural Sciences (CAAS) falls under the administrative jurisdiction of the Ministry of Agriculture; provincial academies are under the jurisdiction of parallel departments in provincial governments. Prior to 2000, there were seven key national agricultural universities (China [formerly Beijing], Nanjing, Shenyang, Northwest, Central, South, and Southwest), also under the jurisdiction of the Ministry of Agriculture. Provincial agricultural universities were managed by their respective provincial governments. But in 2000, the management of all agricultural universities was transferred to the education system. At the national level, three key agricultural universities—China, Nanjing, and Central—are under the jurisdiction of the Ministry of Education, while provincial agricultural universities or colleges come under the supervision of the provincial department of education. Extension is the responsibility of the Department of Agriculture, with very little involvement by provincial agricultural universities or academies of agricultural sciences. This system contrasts sharply with the U.S. land-grant system, which integrates educational, research, and extension activities. The separation between research, education, and extension has inhibited the integration of technology generation and transfer activities into Chinese agriculture.

### **Development Firms Owned by Public Agricultural Research Institutes**

Increasing demand for agricultural research funding strained government budgets in the mid-1980s. Moreover, the government was dissatisfied with the performance of the agricultural research agencies. Overstaffing, compartmentalization, lack of coordination, and duplication of research efforts left the impression that agricultural research was an expensive and not very effective form of government investment. In particular, the government was concerned about the weak linkage between research and the needs of producers and the low rate of technology adoption.

In March 1985, the Communist Party's Central Committee called for an overhaul of the Chinese R&D system. Many reforms were proposed in the official government document titled "Decision on the Reform of the Science and Technology Management System," and a similar decision was promulgated by the State Council

in 1987. Since then there have been about 40 government decisions, regulations, and laws involving reforms of the science and technology system. The main initiatives spelled out in the 1985 and 1987 government documents included changing the basis by which research institutes were funded, encouraging the commercialization of technology and the development of technology markets, and rewarding individual scientists based on their performance. The overriding purpose of the reforms was to make the science sector more responsive to rapidly changing market and economic realities. The principal reform was to modify the funding mechanism in ways that encouraged research institutes to establish contacts with technology users and to conduct research and development that would directly support agricultural enterprises. The direct allocation of funds, consisting almost entirely of block grants to research institutes, was replaced by a mixed system of block grants supplemented with mechanisms whereby institutes competed for project funding from the government and international donors, while also marketing various services directly to farmers and others.

After the 1985 reforms, many research institutes began establishing commercial enterprises or firms. However, the impact of these commercial endeavors on Chinese agricultural innovation has been mixed. At first, these firms were not independent legal entities. Moreover, their businesses were not necessarily related to their research but were developed opportunistically, involving any business or commercial activity that seemed likely to generate revenues. For example, the Institute of Taihu and the Institute of Lixiahe in Jiangsu province, both well known in China for their excellent research programs, produced mineral water and manufactured spare parts for automobiles, respectively. Many institutes at the Chinese Academy of Agricultural Sciences own restaurants, grocery stores, and commercial office complexes, but a lack of capital and management skills resulted in low profits and exposed many research institutes to significant business risks, which they are generally ill equipped to handle. An example was the China National Rice Research Institute in Hangzhou, which began manufacturing monosodium glutamate in 1988. It eventually lost more than 10 million yuan and was saddled with many legal and financial problems. The factory recently went bankrupt.

Another limitation was that many researchers were inexperienced in extension or in dealing with farmers about commercial issues. Those who are active and successful in their research resent the diversion because it detracts from their research time, whereas those prepared to become involved in the transfer of research technology often receive little or no financial reward for their efforts. This separation between research and extension remains unresolved, although the commercial activities and spin-offs of many public research institutes have, in part, substituted for the lack of formal links between extension and research.



Finally, many farmers were either unable or unprepared to pay for technology. In some cases, where high-quality seed or propagation material of perennial crops such as fruit trees was offered, payment was less of a problem, but where the advice or technology was related to an activity regarded as public-good research, farmers expected it to be provided free of charge.

Since the mid-1990s, based on the experience of the previous five to ten years, many public agricultural research institutes have focused their business activities on research-related industries (such as seed, chemicals, vaccines, and so on) to strengthen their competitiveness. They have also begun to set up legally independent companies to avoid direct exposure to risk. The operations of the parent institutes and their associated commercial businesses have become more clearly separated. For example, the seed company of the Institute of Vegetables and Flowers (IVF) at the Chinese Academy of Agricultural Science (CAAS) was established in 1990. Scientists at IVF are responsible for developing and field-testing new varieties. As promising new parent lines for hybrid vegetable seeds are developed, they are made available to the seed company of IVF, which then conducts demonstrations in targeted markets, produces hybrid seeds, and finally markets them. Since 1990, the seed company has earned more than 10 million yuan annually, and about 90 percent of the revenue has been returned to the IVF. The IVF allocates 10 percent of this income to the breeders as a bonus, and the balance is used to cover general research and operational costs.

These commercial enterprises have not only been instrumental in transferring and commercializing technology developed by their parent institutes, as was expected and encouraged by the government, but have also generated substantial revenues to help underwrite the operations of their parent institutes. In 2000, 73 companies at CAAS generated 120.5 million yuan in profit, complementing 243.4 million yuan in core funding from the central government.

### **Agribusiness Firms Owned by Governments**

Revenue-generating businesses include state-owned seed, agricultural, food, chemical, and machinery enterprises. In the former planned economy, these companies received technologies free of charge from the public agricultural research institutes. Since the 1985 reforms, many public research institutes have opted to commercialize their own research and generate income to subsidize their costs, leading to significant awareness of the intellectual property rights (IPR) aspects of agricultural R&D (Koo et al. 2003). Consequently it has become increasingly difficult for agribusinesses to freely access technologies from the public research institutes. In response, some large state-owned companies have negotiated research contracts with public research institutes to license the use of their technologies (involving various

up-front, lump-sum payments or per-unit fees based on subsequent sales), while others have opted to develop their own in-house R&D capacities.

An absence of data means that the total R&D investment made by state-owned agribusiness is unknown. A case study of the Chinese seed industry (Qian 1999) indicated that no improved varieties were developed by companies prior to 1985. In contrast, in 1999, 86 improved varieties were released by state-owned and private companies, although these accounted for less than 2 percent of the total varieties released.

### **Shareholder Companies**

Shareholder companies aligned with agricultural technologies have emerged rapidly in recent years. Most of these companies grew out of the development firms founded by public research institutes or agribusiness firms owned by governments. As they grew, many were listed on the stock market to mobilize operating capital. For example, the former Technology Development Company, a very successful development firm owned by the Hunan Academy of Agricultural Sciences, became a listed company in 2000 and mobilized about 700 million yuan from shareholders. The former national livestock company and the fisheries company (both previously owned by the Ministry of Agriculture) also became listed companies in 2000, with a majority holding retained by the government. These three companies each invested several million yuan in agricultural R&D in 2000.

The central government designated 151 of the country's largest agricultural companies as leading companies in agriculture in 2000, most of which were shareholder companies. The government gave these companies preferential policy treatment, including tax exemptions and low-interest loans, conditional on their investing a certain portion of their revenue in agricultural R&D.

### **Multinational Companies**

According to Rozelle, Pray, and Huang (1999), technology flows through multinational firms have led to rapid gains in productivity and output in China's agricultural sector.<sup>5</sup> These firms may play a larger role in the future, given China's recent entry into the World Trade Organization (WTO). For example, modern technology has been introduced in the poultry industry by importing parental genetic stock and breeding materials and by the introduction of superior animal feed milling and mixing methods, coupled with the development of improved poultry genetics.

But the insecure nature of property rights in China means that much potential remains to be realized from the involvement of multinational companies. Various laws and regulations are in place to protect property rights, but their enforcement

is weak (Koo et al. 2003). So far, most of the plant breeding and screening research by foreign firms has been on hybridized vegetables and sunflower seeds, because these varieties are hard to duplicate as long as the hybrid parents are kept confidential. In addition, these seeds are not monopolized by the state-owned seed companies; in contrast, the sale of seeds for principal food crops (especially hybrid rice and maize, in which seed quality is difficult to assure) has been strictly limited to the state-owned seed companies, although these restrictions have been relaxed recently. Large private seed companies are now able to market seed varieties that they have developed or acquired.

The weak enforcement of intellectual property rights is a major concern for corporations with duplicable technologies. Profitable markets have developed for some pesticide firms whose products contain active ingredients that are complex and difficult to duplicate, while other pesticides are readily copied (some illegally) and sold at low prices. Transnational corporations that can prevent technology loss by technical means do so; but agrochemicals are widely reported to be reverse engineered. Even when technology can be protected and market demand is high, fragmented retailing and wholesaling networks limit market penetration (Rozelle, Pray, and Huang 1999).

## **Provision and Financing of Agricultural R&D**

### **Spending on Agricultural Research**

*Research expenditures.* The amount of investment in agricultural research was quite modest during the first five-year plan (1953–57), averaging 130 million 1999 yuan, although the national government actively promoted the establishment of a number of agricultural research institutes (Table 3.3). This was followed by the Great Leap Forward, a program by which the government sought to jump-start the development process through the mass mobilization of people and financial resources in large public-works endeavors. As a consequence of these policies, the investment by the central government throughout the Chinese economy ballooned to unrealistic and unsustainable levels, with expenditures on agricultural research more than doubling in just three years, beginning in 1958. The ensuing policy readjustments, instigated in 1961, reduced 1962 agricultural research expenditures to less than 50 percent of those prevailing just two years earlier.

From this lower level, public investment in agricultural research in China steadily increased until the Cultural Revolution, which began in 1966. Research expenditures again contracted sharply, and the earlier growth in research personnel ceased. Not until 1972 did the system return to a more stable and balanced pattern

**Table 3.3 China: Public investment in agricultural research, 1953–2002**

Period	Agricultural research expenditures (million constant 1999 yuan per year)	Number of scientists	Expenditures per scientist (constant 1999 yuan per scientist year)	Share of total government spending (%)	Share of total R&D expenditures (%)	Share of total government spending in agriculture (%)	As a percentage of total AgGDP (%)
1953–57	130	NA	NA	NA	NA	1.49	0.07
1958–60	896	140,789	6,366	0.38	10.17	3.25	0.55
1961–65	766	102,498	7,469	0.56	10.24	3.90	0.41
1966–76	1,158	99,657	11,621	0.45	9.93	4.53	0.36
1977–85	2,429	80,278	30,257	0.56	10.34	5.24	0.44
1986–90	3,085	57,564	53,598	0.51	11.90	6.16	0.38
1991–94	3,808	61,545	61,876	0.54	14.29	6.14	0.39
1995–2000	4,590	83,424	55,016	0.53	12.06	8.42	0.34
2002	7,837	53,461	146,491	0.36	9.75	5.46	0.49

Sources: Fan and Pardey 1992, 1997; National Statistical Bureau, various years; and State Science and Technology Commission, various years. See Appendix Table 3A.1 for annual data.

Note: NA indicates data are not available.

of growth. Particularly since 1979, the central government has made a fairly sustained effort to strengthen the nation's agricultural research capacity, with real expenditures growing at 4.8 percent per year over the ensuing decade. However, expenditures failed to grow further during the first half of the 1990s and did not begin to grow again until 1998. This recent surge in spending reflected a refocused attention on food security concerns and a new thrust directed more generally to high-end technology, including biotechnologies relevant to agriculture. For example, the investment in agricultural biotechnology research increased from 16 million yuan in 1986 to 92 million yuan in 1999 (in 1999 prices), with an annual growth rate of 14 percent per year (Huang et al. 2001). This growth rate was three to four times higher than the growth in overall agricultural research expenditures during the same period.

*Share in total government expenditures.* Agricultural research expenditure as a percentage of total government expenditure was relatively low in the 1950s, ranging from 0.11 percent during 1953–57 to 0.38 percent during 1958–60. Since then it has been quite constant, peaking at 0.56 percent during 1977–85. Expenditure on agricultural research as a percentage of total national R&D expenditure was also quite constant, except during 1966–76 and in 2002, when it was at its smallest for the past several decades. Overall, China's share of total R&D spending directed toward agriculture has fluctuated between 10 to 14 percent. In contrast, research expenditure as a percentage of government spending on agriculture has generally increased over time, from about 1.49 percent during the years 1953 to 1957 to 8.42 percent for the years 1995 to 2000. This indicates that, within the agricultural sector, the government has placed increasing emphasis on research and development. The recent decline in agricultural R&D as a share of government spending on agriculture reflects a more rapid increase in government spending on agriculture relative to the growth in government spending on agricultural R&D.

*Research intensity.* Agricultural research intensity (ARI) ratios, expressing expenditure on public sector agricultural research as a proportion of the value of agricultural product, are commonly used indicators of the support to national agricultural research systems (NARSs). China's agricultural research-intensity ratio (0.55 percent) was above the less-developed country (weighted) average of 0.47 percent in the early 1960s (Pardey, Roseboom, and Anderson 1991). Even during the Cultural Revolution, China maintained a respectable official level of investment in agricultural research. Since then, the ratio has decreased, reflecting an extraordinarily rapid growth in agricultural output and a generally slower growth in agricultural

R&D spending. By the late 1990s, the latest period for which comparative data are available, China's ARI (0.34 percent in 1995–2000) was about half the developing country average (0.62 percent in 1995) and roughly one-eighth of the developed-country average for public research (2.64 percent in 1995). In 2002, China's ARI jumped to 0.49 percent, reflecting a 35 percent increase in agricultural research expenditures since 2000, as against a 5.7 percent increase in agricultural GDP. This rapid increase in agricultural research investment reflects the government's intention of using science and technology as a means of increasing food security and improving agricultural productivity and efficiency under an increasingly open and internationally competitive agricultural trade regime.

## **Funding Mechanism and Sources of Agricultural Research**

### **Funding Mechanisms**

The State Planning Commission finalizes the annual budgets for all ministerial spending at the national level. It also authorizes the disbursement of central government funds to the various ministries, as well as to the State Science and Technology Commission (SSTC). The SSTC is in turn responsible for allocating the science and technology funds at its disposal to the various agricultural and non-agricultural ministries and national research agencies such as the Chinese Academy of Science (CAS) and, to a limited extent, the Chinese Academy of Agricultural Science (CAAS). At these upper levels of government, allocation procedures are largely driven by precedent and political considerations. Within the respective ministries and agricultural research agencies (such as CAAS), there are currently no formally established or transparent mechanisms for setting research priorities and allocating funds. Project funds that support labor and operational costs have been increasingly allocated through competitive funding mechanisms. For example, funds from the National Natural Sciences Foundation, National Social Sciences Foundation, National Young Scientists Foundation, and other government funding agencies are allocated based on peer reviews.

Funding mechanisms at the provincial and prefectural levels parallel those at the national (or, in Chinese parlance, state) level. Some national funds flow to local government agencies, in some instances from the national to the provincial institutes in support of collaborative research activities. But because government financing within China is highly decentralized, the funds available to provincial and prefectural planning commissions are principally generated through locally administered public financing instruments (for example, taxes on industry and commerce, agricultural land taxes, and resource extraction taxes).

Funding for most research institutes consists of both core and project funds. Core funds, which are mainly used for salaries, are allocated to various organizations by central and local finance departments at the various levels of government, on the recommendations of their counterpart Science and Technology Commissions.

### Funding Sources

Prior to the mid-1980s, government funds were the dominant source of support for agricultural research, and even in 1987 they still accounted for more than 70 percent of the total agricultural research expenditures (Table 3.4). Since the reforms of the mid-1980s, research institutes have been encouraged to generate income by providing services to other units or by fulfilling assigned research tasks. Part of these earnings may be retained for use as science and technology research funds by the research units that generate them. As a result, the government's share of total funding has declined dramatically, and development income (meaning income earned from commercial activities) has become almost as important as core government funding. In 1999, only about half the total funding for the system was from the government. Almost 45 percent was income generated by research institutes from services and commercial activities that increasingly draw on the

**Table 3.4 China: Income source shares for agricultural research institutes**

Year/level	Government	Development <sup>a</sup>	Loans	Other	Total
1987					
National	86.2	12.8	0.2	0.8	100
Other	66.7	26.5	4.2	2.6	100
Total	70.5	23.9	3.4	2.2	100
1993					
National	68.1	26.2	3.4	2.3	100
Provincial	45.2	44.1	7.3	3.4	100
Prefectural	42.8	39.2	13.8	4.2	100
Total	47.1	40.2	9.1	3.6	100
1999					
National	52.2	45.7	2.1	0.0	100
Provincial	51.0	43.3	5.7	0.0	100
Prefectural	43.4	46.8	9.8	0.0	100
Total	48.5	44.9	6.6	0.0	100
2002					
National	64.0	31.4	0.6	4.0	100
Provincial	59.5	28.9	2.9	8.7	100
Prefectural	59.5	27.0	8.1	5.4	100
Total	60.7	29.0	3.7	6.6	100

Source: Ministry of Agriculture, various years.

Note: The data for the national level cover Ministry of Agriculture institutes only; forestry and universities are excluded.

<sup>a</sup>Represents self-generated funds, largely from the sale of goods and services.

technologies arising from R&D. It is likely that an even greater share of the funds available for agricultural R&D will come from such sources, given the incentives to underreport such funding: for example, an institute associated with a national academy such as CAAS must pay a proportion of its self-generated income (perhaps up to 30 percent) to the academy. Development income is often used by research institutes to subsidize researchers' salaries and other benefits, although it is rarely used directly for research.

In recent years the government has ratcheted up its support to science and technology, partly because of improvements in the overall budget situation and partly because it has placed a higher priority on science-based growth strategies. And, perhaps more important, policymakers have begun to realize the public-good dimensions of agricultural research. Consequently, in 2002, government funding jumped to more than 60 percent of the total income received by agricultural research institutes, while the share of development income declined to 29 percent.

#### **Allocation of Research Funds among Subsectors**

China has given top priority to crop research, particularly in grain crops, for the past several decades. In 2002, China spent 51 percent of total agricultural research resources on crop research, declining from a peak of 65 percent in 1989 (Table 3.5). This trend is consistent with the changing contribution of crops to total production value (54 percent in 2002). Livestock research accounts for only about 10 percent of total research resources, but the sector accounts for almost 30 percent of the total production value. The fisheries sector accounts for about 7 percent of total research resources but more than 10 percent of the total production value. On the other hand, the forestry sector accounts for only 3.7 percent of total production value but double that in terms of its share of research resources. Based on congruence between the share of research expenditures and the value of the respective sector, there appears to be a substantial overinvestment in forestry research and underinvestment in the livestock and fisheries sectors. Although a more careful study is needed to make definitive conclusions, it appears that China needs to invest more in livestock and fishery research. This shift will be particularly important in the future, as these two subsectors will be the major sources of growth in agricultural production.

### **Institutional Case Studies**

#### **The Chinese Academy of Agricultural Sciences**

Founded in 1957, CAAS is the national academy engaged in agricultural R&D, excluding forestry and fisheries. It constitutes the largest and arguably most impor-



**Table 3.5 China: Shares of research expenditures among subsectors, 1987–99, 2002**

Year	Crop	Forestry	Animal husbandry	Fisheries	Water conservancy	Other	Total
1987	52	13	9	9	10	7	100
1988	54	10	13	9	9	5	100
1989	65	9	8	6	6	6	100
1990	55	11	10	7	9	8	100
1991	52	10	15	8	9	6	100
1992	51	10	16	7	10	6	100
1993	50	9	15	7	11	8	100
1994	50	8	16	7	11	8	100
1995	53	8	15	7	10	7	100
1996	56	9	13	7	11	4	100
1997	58	10	8	7	12	5	100
1998	58	10	9	8	11	4	100
1999	58	9	10	7	10	6	100
2002	51	10	8	6	10	15	100

Sources: Ministry of Agriculture, various years.

Note: National-level data cover Ministry of Agriculture institutes only; forestry and universities are excluded.

tant agricultural R&D institution in China. To a large extent, the structure and performance of CAAS reflect the government's policies on research in general and are therefore indicative of the future of Chinese agricultural research.

This section reviews key aspects of the reforms of CAAS by analyzing the changes in organizational structure, human resource management, funding sources, research priorities, and development and commercial activities.

*Organizational structure.* CAAS is administratively affiliated with the Ministry of Agriculture (MOA) but is largely influenced by the R&D policy of the Ministry of Sciences and Technology (MOST). In terms of bureaucratic hierarchy, the president of CAAS is ostensibly equivalent to the vice minister of the MOA, but CAAS has no direct administrative control over the provincial academies of agricultural sciences. CAAS is an independent legal entity, consisting of 8 departments at its headquarters, 1 graduate school, 1 publishing house, and 39 institutes (15 located in Beijing and 24 in various provinces across China).

All the institutes under CAAS are independent legal entities, operating autonomously in terms of fund-raising, staff recruitment, and daily operations, but the director general and deputy director general of each institute are appointed by CAAS headquarters. A typical institute has 1 director general, 2 to 4 deputies, 4 management offices—administration, human resources, research management, and development—and 8 to 15 research divisions.

**Table 3.6 China: Composition of CAAS personnel, 1994–2001**

Year	R&D				Retirees	Total
	Research staff	management staff	Business staff	Support staff		
1994	3,340	1,136	927	1,598	2,878	9,879
1995	3,239	1,073	1,563	NA	3,119	8,994
1996	3,351	982	1,187	1,339	3,442	10,301
1997	3,602	1,089	1,283	1,193	3,978	11,145
1998	3,265	904	1,086	1,137	4,010	10,402
1999	3,018	961	1,436	1,208	4,597	11,220
2000	3,133	982	1,534	945	4,581	11,175
2001	3,003	949	1,428	1,037	4,962	11,379

Source: Chinese Academy of Agricultural Sciences, various years.

Note: NA indicates data are not available.

*Human resources.* Table 3.6 presents the personnel structure of CAAS during the period 1994 to 2001. The total number of personnel increased slightly, with reductions occurring in the number of research, management, and support staff. Notably, the business staff increased markedly, and the number of retirees soared from 2,878 to 4,962 in the period observed. Over time, as in most Chinese public institutes, these retirees have taken a larger share of the CAAS payroll and become a significant budgetary burden.<sup>6</sup>

Although the total number of staff fell, the number with higher degrees rose. Staff holding Ph.D.s increased from 136 in 1994 to 371 in 2001 (Table 3.7). The number holding bachelor's and master's degrees also grew in proportion to the total number of R&D staff.

**Table 3.7 China: Education levels of CAAS personnel, 1994–2001**

Year	R&D staff	Ph.D. degrees	M.Sc. degrees	Bachelor's degrees	College
1994	6,074	136	732	922	2,808
1995	5,873	149	728	920	2,774
1996	5,650	204	711	911	2,482
1997	5,884	220	754	978	2,613
1998	5,306	245	688	924	2,269
1999	5,187	292	669	961	2,193
2000	5,060	338	704	1,007	2,090
2001	4,989	371	683	1,006	2,072

Source: Chinese Academy of Agricultural Sciences, various years.

**Table 3.8 China: Allocation of CAAS research expenditure, 1994–2001**

Year	Basic research	Applied research	Experimentation and development	Other	Total
Constant 1994 yuan (thousands)					
1994	7,390	17,463	6,533	4,694	36,080
1996	5,918	24,334	10,670	6,937	47,859
1997	6,336	32,554	13,480	11,057	63,427
1999	11,371	44,003	14,423	17,825	87,622
2000	16,806	49,840	34,571	23,160	124,377
2001	26,062	59,598	40,820	32,165	158,645
Percentage					
1994	20	48	18	13	100
1996	12	51	22	14	100
1997	10	51	21	17	100
1999	13	50	16	20	100
2000	14	40	28	19	100
2001	16	38	26	20	100

Source: Chinese Academy of Agricultural Sciences, various years.

Note: Data for 1995 and 1998 were not available. Percentages do not always sum to 100 given rounding errors.

*Research priorities.* CAAS's mandate is to undertake basic, so-called basic applied, and applied research and development of strategic importance to China. In reality, however, most of the research is quite applied. Table 3.8 shows CAAS's research orientation as reflected by its expenditures between 1994 and 2000. Even in real terms, CAAS expenditures have grown remarkably. Evaluated in 1994 constant prices, total spending increased from 36.08 million yuan in 1994 to 158.65 million yuan in 2000. Although the proportions of CAAS spending directed to other types of research expenditure have increased, applied and developmental research (Table 3.8, data columns 2 and 3) still dominate, accounting for almost two-thirds of the CAAS total.

*Development activities.* Managerial and support staff numbers were cut by 27 percent between 1994 and 2001 as a direct consequence of reforms. Most of these staff were transferred to development or commercial activities, and the income generated from these activities accounted for a larger share of the total income. The number of staff engaged in development and commercial activities rose from 927 to 1,428 over the same period, accounting for 9 percent of total staff. The income from development and commercial activities increased by 56.5 percent to a total of 23.94 million yuan in 2001 (1994 prices).

Most of the commercial undertakings took the form of spin-off companies rather than revenue-raising efforts through technology licensing or royalty arrangements.

**Table 3.9** China: CAAS funding sources, 1994–2001

Year	Government sources		Nongovernment sources	
	Constant 1994 yuan (millions)	Share (%)	Constant 1994 yuan (millions)	Share (%)
1994	192.37	71.21	51.26	18.97
1995	207.10	70.51	63.92	21.76
1996	235.38	69.17	80.50	23.14
1997	270.49	66.83	113.53	28.05
1998	182.58	54.57	130.77	39.09
1999	263.68	51.64	237.29	46.47
2000	270.70	51.04	251.77	47.47
2001	400.76	55.73	313.16	43.55

Source: Chinese Academy of Agricultural Sciences, various years.

Note: Shares do not sum to 100 percent because a third category, bans, is not shown.

As of 2001, there were 72 companies operating within CAAS, with each of the academy's institutes operating about two enterprises. As previously mentioned, these companies are closely linked with their parent institutes, making use of institute staff to commercialize and market the research products of the respective institutes. A share of the profits reverts to the parent institute to subsidize salaries and operational costs. In 2001, the 72 companies generated about 42 percent of CAAS's total revenue. The companies not only generate revenues to supplement public funding but also promote the application of research more relevant to on- and off-farm production needs.

*Funding sources.* Between 1994 and 2001, public funding for CAAS more than doubled, from 192.37 million to 400.76 million yuan (Table 3.9). Nongovernment funding increased fivefold, from 51.26 million yuan to 313.16 million yuan, most of which was generated through commercial activities. The proportion of government funding decreased from 71.2 percent to 55.7 percent, while nongovernment funding increased from 19 percent to 43.6 percent. As the advancing reforms intended, CAAS could no longer rely on public funding alone, and it seems the reforms have effectively diversified the academy's funding channels.

*Research output.* A key question is whether the diversification in funding sources and implementation of new incentive systems have adversely affected research productivity. China has yet to develop an evaluation system to assess the performance of the research institutes. Table 3.10 provides some indications of the general status of CAAS's research output. The volume of published science and technology papers

**Table 3.10 China: CAAS research output, 1994–2001**

Year	Published research papers			Patents	
	Total	Published abroad	Published books	Applications	Authorizations
1994	2,327	206	89	NA	NA
1995	2,835	258	110	NA	NA
1996	2,784	217	131	16	5
1997	2,742	181	123	15	12
1998	2,562	185	104	39	18
1999	2,842	198	211	26	21
2000	2,668	206	145	32	18
2001	2,396	174	167	39	26
1994–2001	21,156	1,625	1,080	167	100

Source: Chinese Academy of Agricultural Sciences, various years.

Note: NA indicates data are not available.

increased only slightly between 1994 and 2000. By 2001, the number of published scientific papers totaled 21,156, including 1,625 published abroad. In contrast, the number of published books has increased dramatically, but in China books are generally not refereed or peer-reviewed and hence are much easier to publish than refereed papers. In the current performance-evaluation system, books are ranked at least as high as refereed articles.

The number of patent applications in China grew steadily between 1994 and 2001. Since 1996, CAAS has submitted more than 167 patent applications to the National Patent Agency, indicating, perhaps, that CAAS researchers are coming to appreciate the implications of protecting intellectual property when commercializing innovations. Each year during this period the CAAS's research projects won about 10 national prizes, 20 regional or local prizes, and more than 50 provincial and ministry prizes.

In summary, in the eight years up to 2001, tracking the number of publications or patent approvals produced no clear indication that research productivity at CAAS has been materially affected by the changed circumstances.

### **The Jiangsu Provincial Academy of Agricultural Science**

Jiangsu is one of the most advanced provinces in China in terms of agricultural production and research. The Jiangsu Academy of Agricultural Science (JAAS) is the largest of the provincial agricultural academies, with more than 2,000 full-time employees in 1998 (Qian, Zhu, and Fan 1997). Because Jiangsu has been a pioneer of efforts to reform China's agricultural research and development system, it is an interesting institution to study in terms of the R&D changes taking place.<sup>7</sup>

*Institutional aspects.* JAAS is a comprehensive public agricultural research institution directly administrated by the Jiangsu Provincial Government. Founded in 1932, it was originally named the National Agricultural Research Institute (NARI) because Nanjing was the national capital at the time. The early organizational structure largely mimicked the Soviet system of the 1950s, but China's transition from a planned to a market economy brought about a demand for institutional change in the agricultural R&D sector. Beginning especially in the early 1980s, the provincial agricultural R&D system in Jiangsu underwent a series of substantial reforms.

In 1982, the provincial government introduced guidelines for reform titled "Opinion on Strengthening Agricultural R&D" (see Wang 2000). The guidelines called for research institutes located at headquarters to focus on projects broadly relevant to the ecology of the province, leaving the regional institutes to focus on more localized, adaptive research. Since then, funds have been reallocated to reflect this intent.

Based on further guidelines in 1985 from the central government for reform of the science and technology sector, the Jiangsu Provincial Government enacted a decree in 1988 to change the system of performance appraisal and promotion. Under the old system, promotions were largely determined by duration of service, whereas now—with a view to providing incentives and enhancing productivity—they are based on performance. Institutions like JAAS proposed detailed guidelines for performance evaluations. For example, single-authored journal articles carry greater weight for evaluation purposes than coauthored articles. Performance evaluation and ranking have profound implications for employees in China: they can affect all aspects of a researcher's life. Public research institutions continue to carry the responsibility for providing employees and retirees with benefits, including housing subsidies, retirement pensions, and medical care, and they allocate such benefits largely according to seniority. Consequently, a senior fellow may be eligible for a three-bedroom apartment, while a fellow may only qualify for a two-bedroom apartment. Naturally this system creates great incentives for researchers to seek promotion through publishing journal articles, preferably as a single or lead author.

Publishing scientific articles is one metric of research output; generating technologies that are commercially successful is another. In 1993, the State Science and Technology Commission and State Reform Commission proposed new guidelines in the wake of financial decentralization under the title "Some Opinions on Staff Management, Structural Adjustment, and In-Depth Reform" (see Wang 2000). The document recommended that research institutions respond to market signals by producing outputs with more immediate economic consequences. The document also encouraged research institutes to generate revenues from development

**Table 3.11 China: Composition of JAAS personnel, 1988–98**

Year	Research staff	Support staff	Business staff	Retirees	Total	
					Excluding retirees	Including retirees
1988	1,105	1,691	164	743	2,960	3,703
1989	1,058	1,653	201	774	2,912	3,686
1990	1,067	1,649	216	839	2,932	3,771
1991	1,104	1,584	219	854	2,907	3,761
1992	1,131	1,573	179	914	2,883	3,797
1993	1,137	1,466	165	1,078	2,768	3,846
1994	1,216	1,412	214	1,148	2,842	3,990
1995	1,206	1,404	230	1,207	2,840	4,047
1996	1,163	1,387	240	1,277	2,790	4,067
1997	1,084	1,381	264	1,357	2,729	4,086
1998	1,114	1,259	393	1,447	2,766	4,213
Percentage change, 1988–98	0.8	–25.5	139.6	94.8	–6.6	13.8

Source: Jiangsu Academy of Agricultural Sciences, various years.

and other commercial activities. The original aim of this reform was to subsidize R&D with revenues from businesses, but many institutes passed on their development revenues to staff members, leaving little for R&D. Nevertheless, commercialization has become a major feature in Jiangsu's agricultural R&D system.

*Personnel.* Several features are apparent from Table 3.11. First, the number of JAAS research staff changed little between 1988 and 1998: numbers rose from 1,105 in 1988 to 1,216 in 1994, then dropped to 1,114 in 1998. Second, responding to policy reforms, the number of managerial and support staff was cut by about 26 percent. At the same time, the number of employees involved in activities generating business income more than doubled, from 164 to 393. Third, with an aging population of researchers, the number of retirees rose from 743 to 1,447.

Excluding retirees, the total number of full-time employees at JAAS was 2,766 in 1998, a decline of 6.6 percent from 1988. Including retirees, however, the number of staff on the payroll increased by 13.8 percent from 3,703 to 4,213, with researchers accounting for only 26.4 percent of the 1998 total.

*Funding and expenditures.* Core government funding increased more than threefold from 1988 to 1998, from 9.2 million to 37.7 million yuan, evaluated at 1988 constant prices (Table 3.12). Project funding fluctuated around 4.5 million yuan for the first half of the 1990s, then increased significantly in 1997 and 1998.

**Table 3.12 China: Major JAAS revenue and expenditure shares, 1988–98**

Category	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Major revenues (constant 1988 yuan, millions)											
Core	9.2	8.9	9.6	10.3	11.1	10.6	18.9	19.7	22.8	29.5	37.7
Project funding	4.9	5.4	6.0	4.1	4.7	4.2	4.1	4.0	4.8	6.3	8.0
Net development income	1.1	2.3	2.9	3.8	4.6	5.3	5.7	6.2	10.1	12.8	14.2
Major expenditures (constant 1988 yuan, millions)											
Wages	10.2	8.9	9.8	13.1	11.9	15.7	17.4	16.8	23.4	29.8	35.4
R&D	6.4	4.1	4.5	9.2	5.4	7.1	2.3	2.3	4.3	10.6	12.2
Development	10.3	5.7	5.2	11.1	13.0	24.3	22.4	20.4	44.1	47.0	47.1

Source: Jiangsu Academy of Agricultural Sciences, various years.

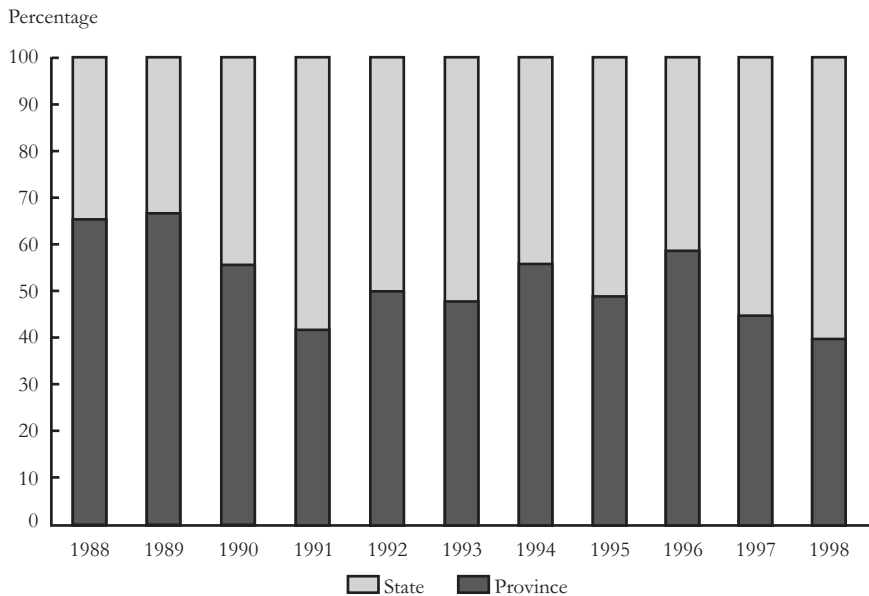


With increased commercialization, net income from business activities rose sharply, from 1.1 million to 14.2 million yuan over the same period.

In terms of expenditure, core funding was used largely to finance wages; hence the two sets of data show similar upward trends between 1988 and 1998, in response to the growth of retiree numbers. JAAS expenditure declined from 6.4 million yuan in 1988 to 2.3 million yuan by 1995, then soared to 12.2 million yuan by 1998, when the government pumped significant new funding into the agricultural R&D system following the large spike in grain imports in 1994 and 1995. Development expenditures increased markedly, from 10.3 million to 47.1 million yuan. Because of the incentive mechanisms that directly link staff incomes—particularly staff bonuses—with business revenues, researchers, managerial staff, and support staff all benefit from profit-making research activities.

In line with the national trend toward decentralizing government services, JAAS became increasingly dependent on funding from within the province rather than from the central government (Figure 3.3). In 1988, state funding accounted for over 70 percent but by 1998 dropped to less than 50 percent. Because Jiangsu is one of the richest provinces, it was able to supplement its shrinking share of state

**Figure 3.3 China: JAAS funding sources, 1988–98**



Source: Jiangsu Academy of Agricultural Sciences, various years.

**Table 3.13 China: Average size of JAAS research projects, 1988–98**

Year	Research funding per capita	Number of researchers per project
1988	5.8	2.5
1989	3.9	2.2
1990	4.3	1.7
1991	8.3	1.6
1992	4.8	1.6
1993	6.2	1.6
1994	1.9	1.6
1995	1.9	1.5
1996	3.7	1.6
1997	9.8	1.5
1998	10.9	1.4

Source: Jiangsu Academy of Agricultural Sciences, various years.

funding. But in many poorer provinces, agricultural research institutions face more severe budget restrictions (Fan, Zhang, and Zhang 2004).

*Size of research projects.* Table 3.13 indicates the scale of research activities through funding per researcher and the average number of researchers per project. Because the total number of full-time researchers remained relatively stable, funding per researcher closely correlates with total funding, decreasing dramatically from 1988 to 1995 and increasing thereafter. The average number of researchers per project fell from 2.5 in 1988 to 1.4 in 1998, indicating minimal researcher collaboration. This trend is largely the result of the emphasis on first authorship in professional evaluation and promotion; however, achieving results with far-reaching significance will be particularly challenging with the majority of researchers now undertaking such small-scale research projects. In informal interviews with researchers, most expressed concern that the current incentive system inhibited larger-scale cooperative research projects, which are perceived as more uncertain in terms of funding, promotion and recognition, and outputs.

*Research performance.* Changes in funding sources and incentive mechanisms also affect research outputs (Table 3.14). The benefits of sole authorship are reflected in the dramatic increase in the number of published papers and books. At the same time, large peer-reviewed research outputs, indicative of more significant, long-term projects, declined from 70 to 42.

Awards, and royalties for papers and books, can serve as an intermediate indicator of the productivity of research staff. Figure 3.4 plots research productivity based

**Table 3.14 China: JAAS research output, 1988–98**

Year	Papers	Books	Other		Prizes <sup>c</sup>		Model demonstration plots <sup>d</sup>
			peer-reviewed outputs		State 1 and 2	Province 1 and 2	
			Evaluated variety <sup>a</sup>	Prize- winning <sup>b</sup>			
1988	546	2	70	76	1	14	535
1989	636	14	68	82	3	5	675
1990	674	18	111	75	1	21	1,018
1991	648	17	57	97	2	10	661
1992	619	20	75	71	5	18	859
1993	701	17	43	69	4	9	709
1994	581	15	55	59	0	10	1,207
1995	608	21	48	43	2	5	685
1996	497	27	36	80	1	15	846
1997	605	15	44	65	5	12	761
1998	652	21	42	75	3	13	709

Source: Jiangsu Academy of Agricultural Sciences, various years.

<sup>a</sup>Indicates released crop varieties subject to evaluation.

<sup>b</sup>Indicates that the research output has won a peer-reviewed prize.

<sup>c</sup>Includes class 1 and class 2 prizes awarded by state and provincial agencies.

<sup>d</sup>Represents the number of demonstration plots established for side-by-side comparisons of new and old crop varieties or to demonstrate new agricultural technologies to farmers.

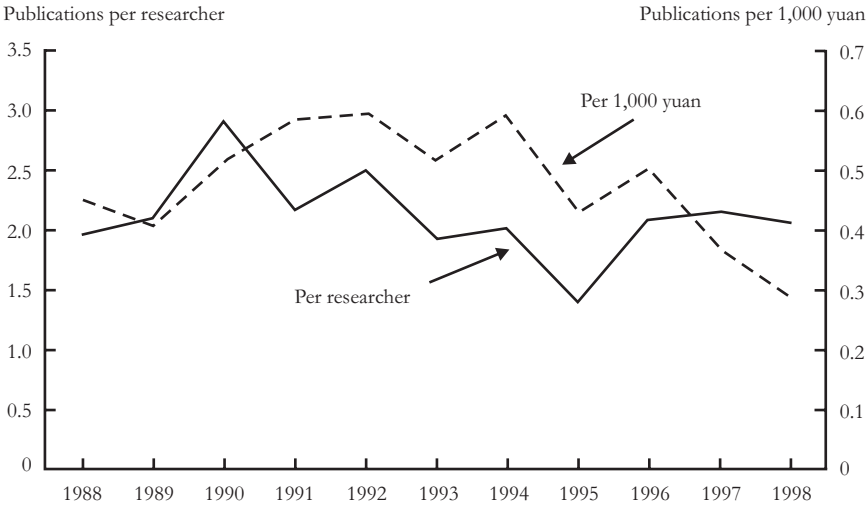
on labor and investment input. The first indicator is output value per researcher, and the second is output value per 1,000 yuan of input. Both indicators show that productivity has changed little during the survey period despite the increase in overall funding to JAAS.

Given that one of its original purposes was to supplement government funds for R&D, commercialization has been successful. However, research output (at least to the extent revealed by publication and related measures) has changed little, suggesting that the commercial revenues have not significantly increased the funds used for R&D, as originally envisioned.

## **A Prospective Look at China's Research Reforms**

Agricultural research has played a key role in meeting the national food demand and reducing poverty, as many studies have shown (Alston et al. 2000; Fan 2000; Fan, Zhang, and Zhang 2004). However, much remains to be achieved. China's demand for agricultural products will continue to expand (in terms of both the quantity and quality of products and shifts in the composition of food, feed, and

**Figure 3.4 China: Publication performance of JAAS researchers, 1988–98**



Source: Compiled by authors.

fiber demands) in ways that remain heavily reliant on improvements in productivity. How China’s agricultural research system responds to these demands will be critical; so will the research policies that can help or hinder these developments.

**Increasing Public Investment in Agricultural Research**

A further increase in investment in agricultural R&D is needed. Despite its comparatively rapid overall growth, China’s agricultural R&D spending—relative to the size of the agricultural sector it serves—lags well behind that of many other countries. But do significant scale and scope economies go unrealized as a result of the parallel national, provincial, and prefectural systems? As of 2002, agricultural research expenditure as a percentage of agricultural GDP averaged around 0.50 percent, well below the corresponding developed-country average and even lower than in most developing countries (which averaged 0.62 percent). Various evidence shows that agricultural research investment not only yields high economic returns but also significantly reduces rural poverty and regional income inequality (Fan 2000). Moreover, according to recent evidence, agricultural research has contributed to a large drop in urban poverty by lowering food prices (Fan, Fang, and Zhang 2003). Absent agricultural research, China would have many more urban poor today. Finally, increased agricultural research investment is one of the most

efficient ways to solve China's long-term food-security problem (Huang, Rozelle, and Rosegrant 1999). All these factors suggest that increased investment in agricultural research is a "win-win-win" (growth-poverty and equity-food security) national development strategy.

### **Reforming the Public Research Institutes**

After more than 15 years of reform, the Chinese public agricultural research system now faces new challenges. The coexistence of public research and commercial activities has played an important role in mobilizing resources to support agricultural research and in enhancing the link between agricultural research and those who ultimately use its outputs. As the system evolves, however, these symbiotic activities are often in conflict because public agricultural research aims to provide public goods and carry out basic, strategic, and not-for-profit research, whereas revenue-generating businesses provide private goods and engage in commercial activities. Hence, the two operations would likely benefit from even more distinct and separate institutional arrangements. A more focused, efficient, and effective research system is urgently needed to achieve the multiple goals of agricultural growth, food security, and poverty reduction. The commercial activities, which are not always compatible with these goals, need to be hived off from the public research agencies.

On the one hand, the government should increase its investment in public research; on the other, the current public research institutes need further reform. The major (and interrelated) problems currently confronting most of the research institutes are overstaffing, the heavy financial burden imposed by retirees, the lack of an effective incentive system, and lack of coordination between national and regional research institutes.

To avoid overstaffing, all research and administrative positions should be created on the basis of need, and all positions should be filled through public announcements and open competition. Redundant staff should be encouraged to retire and provided assistance in seeking employment elsewhere. The reform of the agricultural research system should be considered in the larger social and financial context. These challenges are largely similar to the problems of the state-owned enterprises (SOEs). Hence, some of the future reforms required for research are likely to proceed in step with the overall economic and institutional reforms of China's SOEs. Several schemes to reform the Chinese pension system have been proposed. For example, current and newly hired staff could be required to contribute a share of their salary to a retirement account, while contributions for retired staff could be covered by government funds. Incentive structures for researchers should be performance based. Promotion and annual salary increases should be based on more rigorous performance assessment.

The current organizational structure for agricultural research strictly parallels the country's administrative system rather than being based on agroecological or other relevant considerations. In Gongzhuning City, Jinglin Province, for example, the provincial academy of agricultural sciences and a prefectural agricultural research institute both carry out R&D on maize. Similar duplications exist in almost all provinces in China. If research resources are to be allocated more efficiently and appropriately across agroecological zones, professional linkages and coordination between institutes at different levels must be improved. One solution would be to merge institutes with similar mandates within agroecological zones—particularly within cities.

### **Private versus Public Research**

In recent years, the focus has been on privatizing the funding for publicly performed research rather than privatizing research *per se*. Several factors have contributed to this trend. A high proportion of the agricultural research carried out by the Ministry of Agriculture's agencies is directed toward production. But if China continues to develop as it has over the past decade, the demand for agricultural technologies will increasingly move off-farm. Further increases in the use of off-farm inputs in agriculture, such as fertilizers, pesticides, and machinery, will stimulate increased demand for new technologies and know-how aimed at the input supply sector. Rising per capita incomes are resulting in a rapid increase in the demand for processed agricultural products; this in turn will stimulate the demand for postharvest technologies related to the storage, processing, packaging, and marketing of agricultural produce. China's existing research capacity in input supply and, particularly, postharvest technology is embryonic. Private research could fill much of this gap, given that much of the required technological and market development is more amenable to private initiatives.

Considering the increasing fiscal constraints facing the Chinese national agricultural research system, multinational agribusiness and R&D firms can be called upon to play a greater role in the growth of Chinese agriculture. But this will not happen spontaneously. A number of significant policy and administrative changes are needed to improve the environment for these firms before they are likely to play a larger role. These include strict and transparent enforcement of IPR protection for agrochemicals, veterinary pharmaceuticals, plant and animal genetics and biotechnology, and other agricultural technologies, to reassure investors that theft of proprietary technology will not be tolerated. The legal framework is in place, but its enforcement remains uncertain (Koo et al. 2003). The restrictions on foreign direct investment in improving grain, oilseed, and cottonseed varieties also need to be removed. These restrictions have hindered investment and technology transfer

and prevent Chinese farmers from accessing the newest internationally developed seed varieties. The current policy also requiring that Chinese partners must have a majority share in domestic marketing enterprises makes transnational firms reluctant to manufacture high-technology products because they cannot control product distribution. Firms that manufacture agricultural inputs need the opportunity to market their products directly to farmers. Market competition would improve distribution efficiency.

Regulations dealing with foreign direct investments by transnational firms should be more transparent. Domestic taxation schedules, import tariffs, and foreign exchange rules are adequately defined. However, application and approval procedures are complex, requiring separate negotiations with officials in each province in which investment and operations are proposed. There is also a problem of changing the rules after investments have been made: while such changes may be necessary for equity or other reasons, provision should be made for grandfathering the foreign enterprises over an adjustment period.

The Chinese agricultural research system has experienced dramatic change over the past several decades and now represents one of the world's largest public agricultural R&D institutions. For the past 15 years, the system has also pursued an aggressive reform agenda and has achieved substantial success. However, further reforms are still required to transform the system into a modern and efficient powerhouse propelling Chinese agriculture into the new century.

**Appendix Table 3A.1 China: Agricultural research expenditures, 1961–2002**

Year	Current prices (million yuan)	1999 prices (million yuan)	1999 prices (million international dollars)
1961	199.3	630.9	336.5
1962	142.3	456.2	243.3
1963	190.8	623.6	332.5
1964	247.3	802.9	428.2
1965	276.0	876.7	467.6
1966	254.7	822.9	438.9
1967	157.4	505.2	269.4
1968	151.9	481.3	256.7
1969	245.3	807.6	430.7
1970	303.2	1,025.5	546.9
1971	280.7	943.2	503.0
1972	365.4	1,227.9	654.8
1973	350.6	1,176.5	627.4
1974	351.7	1,177.4	627.9

(continued)

Appendix Table 3A.1 (continued)

Year	Current prices (million yuan)	1999 prices (million yuan)	1999 prices (million international dollars)
1975	408.6	1,384.1	738.1
1976	399.9	1,357.2	723.8
1977	425.0	1,426.9	761.0
1978	546.2	1,809.7	965.1
1979	641.3	2,051.9	1,094.2
1980	667.5	2,057.7	1,097.3
1981	639.4	1,926.8	1,027.5
1982	657.1	1,983.8	1,057.9
1983	827.9	2,473.2	1,318.9
1984	990.6	2,821.3	1,504.5
1985	1,077.4	2,785.8	1,485.6
1986	1,140.5	2,819.2	1,503.5
1987	1,126.5	2,650.4	1,413.4
1988	1,476.4	3,098.0	1,652.1
1989	1,703.9	3,286.0	1,752.4
1990	1,627.6	2,970.3	1,584.0
1991	1,862.1	3,183.8	1,697.9
1992	2,357.7	3,736.0	1,992.4
1993	2,809.9	3,887.0	2,072.9
1994	3,596.7	4,149.5	2,212.9
1995	4,049.8	4,128.2	2,201.5
1996	4,450.2	4,283.0	2,284.1
1997	4,145.4	3,957.2	2,110.3
1998	4,804.1	4,698.7	2,505.8
1999	4,895.0	4,895.0	2,610.4
2000	5,841.5	5,787.0	3,086.1
2001	NA	NA	NA
2002	7,958.6	7,837.0	4,179.4

Sources: Data compiled by authors from Fan and Pardey 1992, 1997; State Statistical Bureau, various years; and State Science and Technology Commission, various years.

Note: Expenditures include spending by relevant institutes from all levels of governments and agricultural research spending in the universities. NA indicates data are not available.

## Notes

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1. The impact of and returns to research investment in Chinese agriculture have been measured by numerous scholars, including Huang and Rozelle (1996); Fan and Pardey (1997); Huang, Rozelle, and Rosegrant (1999); Fan (2000); and Fan, Zhang, and Zhang (2004).

2. The U.S. system spends more in total (that is, from both public and private sources) on agricultural R&D but employs fewer scientists. Measured in terms of new knowledge and technologies produced versus resources committed to research, the U.S. system is most likely considerably larger.

3. The population growth rate was 1.6 percent per year between 1952 and 2000.

4. The contribution of productivity increases comes from technical change, technical efficiency improvement, and allocative efficiency improvement.

5. Rozelle, Pray, and Huang (1999) argue that foreign technology transfer has played a key role in promoting agricultural productivity for the past several years and can continue to do so, given greater transparency in government regulations and greater security in property rights generally and, specifically, those applying to technologies.

6. Unlike most developed countries, China has yet to develop national pension and social-security systems; thus the institutes are required by the government to provide a pension, housing, and medical care coverage to all their retirees.

7. A survey of all research institutes at the Jiangsu Academy of Agricultural Sciences (JAAS) was conducted jointly by IFPRI, CAAS, and JAAS in August and September 2000. The survey, which included 15 provincial and 9 regional institutes for the period 1988–98, compiled details on personnel, expenditures, funding sources, and research achievements. The 15 provincial research units consisted of the headquarters, research center, training center, veterinary institute, horticulture institute, food institute, modernization institute, grain crop institute, fertilizer institute, genetic institute, vegetable institute, plant protection institute, cash crop institute, and information institute. The 9 regional institutes were Xuzhou, Huaiyin, Taihu, Yanjiang, Yanhai, Lixiahe, Zhenjiang, Nanjing, and Lianyungang.

## References

- Alston, J. M., C. Chan-Kang, M. C. Marra, P. G. Pardey, and T. J. Wyatt. 2000. *A meta-analysis of the rates of return to agricultural R&D: Ex pede Herculem*. IFPRI Research Report No. 113. Washington, D.C.: International Food Policy Research Institute.
- Chinese Academy of Agricultural Sciences. Various years. *Agricultural science and technology indicators of CAAS*. Beijing: Chinese Academy of Agricultural Sciences, Department of Sciences and Technology Management.
- Fan, S. 2000. Research investment and the economic returns to Chinese agricultural research. *Journal of Productivity Analysis* 14 (92): 163–180.
- Fan, S., and P. G. Pardey. 1992. *Agricultural research in China: Its impact and institutional development*. International Service for National Agricultural Research, The Hague.
- . 1997. Research, productivity, and output growth in Chinese agriculture. *Journal of Development Economics* 53: 115–137.

- Fan, S., and X. Zhang. 2002. Production and productivity growth in Chinese agriculture: New national and regional measures. *Economic Development and Cultural Change* 50 (4): 819–838.
- Fan, S., C. Fang, and X. Zhang. 2003. Agricultural research and urban poverty: The case of China. *World Development* 31 (4): 733–741.
- Fan, S., L. Zhang, and X. Zhang. 2004. Investment reforms and poverty in rural China. *Economic Development and Cultural Change* 52 (2): 395–422.
- Huang, J., and S. Rozelle. 1996. Technological change: Rediscovering the engine of productivity growth in China's agricultural economy. *Journal of Development Economics*. 49 (2): 337–369.
- Huang, J., S. Rozelle, and M. W. Rosegrant. 1999. China's food economy to the twenty-first century: Supply, demand, and trade. *Economic Development and Cultural Change* 47 (4): 737–766.
- Huang, J., S. Rozelle, C. Pray, and Q. Wang. 2001. Plant biotechnology in the developing world: The case of China. Paper presented at the International Conference on Rural Investment, Growth, and Poverty Reduction, Beijing, November 5–6, 2001.
- Jiangsu Academy of Agricultural Sciences. Various years. Unpublished finance and budget documents, Department of Sciences and Technology Management.
- Koo, B., P. G. Pardey, K. Qian, and Y. Ziang. 2003. *The economics of generating and maintaining plant variety rights in China*. Environment and Production Technology Discussion Paper No. 100. Washington, D.C.: International Food Policy Research Institute.
- Ministry of Agriculture. Various years. *Agricultural science and technology statistical materials*. Beijing: Ministry of Agriculture.
- National Statistical Bureau. Various years. *China statistical yearbook*. Beijing: China Statistical Press.
- Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991. Regional perspectives on national agricultural research. Chapter 7 in *Agricultural research policy: International quantitative perspectives*, ed. P. G. Pardey, J. Roseboom, and J. R. Anderson. Cambridge, U.K.: Cambridge University Press.
- Qian, K. 1999. To share IPR of plant germplasm together with public and private sector and farmers: Analysis of social welfare and incentives to innovation. Report to the Drafting Groups of the National People's Congress for China Seed Law, Beijing. Mimeo.
- Qian, K., X. Zhu, and S. Fan. 1997. *Analysis of research priorities in Jiangsu agricultural research: The case of rice, wheat, rapeseed, and cotton*. Beijing: China Agricultural Science and Technology Press.
- Rozelle, S., C. Pray, and J. Huang. 1999. Importing the means of production: Foreign capital and technologies flows in China's agriculture. Paper presented at the International Agricultural Trade Consortium Conference, San Francisco, June 25–26.
- State Science and Technology Commission. Various years. *China statistical yearbook on science and technology*. Beijing: China Statistical Press.

- Wang, Q. 2000. Incentive mechanisms and agricultural R&D performance in China. Paper presented at workshop "Public Investment in Chinese Agriculture," funded by the Australian Centre for International Agricultural Research (ACIAR), Wuxi, China, November 1–4.
- World Bank. 2004. *World development report 2004*. Washington, D.C.

