

Annex I: China's Corn Economy, A Brief Introduction

The corn economy in China is currently in the midst of a major transformation. Newly emerging forces of supply, demand, and trade are changing the traditional production, consumption, and marketing patterns of farmers and their buyers. In this section, brief introductions to historic and current production, consumption, and trade sectors of the economy are provided as background for the rest of the study of corn production.

Corn Production in China

Corn first arrived in China in the 16th century, brought by the early European missionaries. After spreading initially through the hilly and mountainous areas of Fujian Province on China's east coast, the crop spread across all regions of China during the next century. By the early twentieth century China's farmers cultivated about 10 million ha of corn, covering 12 to 15 percent of the nation's sown area.

Currently, corn is grown in every province in China, but given the climatic diversity of the nation, there are regional differences in the types of corn grown as well as in the general cropping patterns. About two thirds of corn in China is grown in temperate climatic conditions, with the other third grown in subtropical and tropical conditions. Most of the corn area is primarily the northern and northeastern coastal provinces. The climatic analogues for these regions in North America are Minnesota, Nebraska, and Kentucky.

The role of corn in cropping patterns in China's various agricultural regions also differ. In northeast China, cold temperatures and short growing seasons limit farmers to one crop a year. Corn in northeastern, non-irrigated areas clearly has a comparative advantage over other crops and dominates the landscape, similar to areas in the United States' Midwest. Recent increases in water control and development of new, higher yielding rice varieties, however, have created a formidable competitor to corn on irrigated land.

In the rest of China, corn is most commonly grown as the second crop in tight annual rotations. In north China, especially on the North China Plain, farmers cultivate corn after harvesting a crop of over-wintering wheat. In colder, more harsh environments in north China, wheat crops must be planted in rows with spaces every 0.5 to 1 meter to allow sowing of corn seeds before the wheat crop is harvested. In southern tropical corn areas, climatic conditions make rotations less tight, and corn can be grown in conjunction with many crops, such as potato, rape seed, melons, etc. One of the newest innovations by Yangtze Delta farmers in recent years has been their attempts to extend corn onto early rice area, since the quality of many short-duration, high-yielding early rices are poor, and corn can compete if the paddies can be converted so that waterlogging does not become a problem.

The main source of growth in corn production since the early 1970s has been the yield component. With the spread of modern varieties, yields grew by 3.3 percent annually from 1970 to 1978. During the early reform period, 1978-84, yields maintained their rapid increase, rising 4.1 percent annually. While some of this productivity growth arose from institutional innovation (e.g., the introduction of household farming and the Production Responsibility System -- PRS), much of the increase still came from the spread of new technology. New breakthroughs during this era include the adoption of hybrids and the introduction of insect and disease resistant varieties. Since the mid-1980s, annual corn yield increases have slowed to 2.9 percent. Corn area grew, albeit only slowly, during the 1980s and 1990s (less than 0.5%/year).

This slow down in yield growth, however, should not be examined in isolation; relative to other major staple crops, the yield and area performance of corn (as well as that of aggregate production) has been exceptional. In the late 1980s, while the area sown to corn grew slowly and yields and production continued to rise, the area sown to rice and wheat fell and production was essentially stagnant (less than 1%/year). To keep fine grain production steady and offset the fall in sown area.

yields grew modestly (1.2 percent for rice and 1.7 percent for wheat). Hence, the slow, somewhat disappointing growth of rice and wheat production in China's economy in recent years is completely overshadowed by the rapid rise in corn production. Between 1994 and 1995 alone, corn production rose 12 percent from 99 million metric tons (MMTs) to 111 MMTs. Preliminary statistics for 1996 show another record crop. Corn production now ranks second only to rice production, and passed aggregate wheat production for the first time since the corn yield revolution in the early 1980s.

The relative price of corn on the market and its value as feed has been part of the reason for the crop's recent resurgence (Huang, Rosegrant, and Rozelle, 1996). While all grain prices rose since the early 1990s, corn prices have risen faster and stayed higher than wheat and rice. In real terms the 1995 price of corn is nearly 20 percent higher than the peak price during the 1988-89 grain shortage. The real price of rice and wheat, on the other hand, never exceeded their late 1980s' peaks (Rozelle *et al.*, 1996).

Organization of Farming and Marketing in Reform China

Corn farmers in China share many characteristics of their counterparts in other Asian countries, but also farm under several unique circumstances created from over 15 years of rural reform. Like farmers in other sectors of China's agricultural economy and their Asian neighbors, corn farmers cultivate small farms and use relatively labor-intensive management methods. With per capita land areas limited to less than 1 mu (1/15th of a hectare) in the south and 2 mu in the north, the average corn farmer (in a family of 4-5 individuals) cultivates around one-half hectare (ZGTJNJ, 1995). To compensate for such small farms, farmers apply extraordinarily high levels of labor (about 220 days per hectare in 1994), although this level is less than 60 percent of level in the early 1980s before economic reform. Farmers also use relatively high levels of fertilizer: 492 kilograms of pure nitrogen per hectare in the northeast and 390 kilograms in the south in 1994 (SPB, 1995).

Familiar as the farming methods may seem to those who know Asian cropping systems, China's farmers undertake cultivation in an environment dominated by a political economy that gives it many unique aspects. While the PRS reforms in the early 1980s dismantled the communes and made the household the primary decision-making unit as well as claimant to residual profits from farming, the village (or collective) still is the formal owner of all cultivated land. Land contracts -- some written, most not--are issued by village leaders (who represent both the local government and the Communist Party) for periods of time ranging from 15 to 30 years. Farmers are supposed to have complete use and income rights to the land during this period, but in many villages, property rights over use, transfer, and gains from investment are not always secure (Johnson, 1994). Currently a lively debate is occurring among scholars and policy makers over the impact that China's land system has on short- and long-run land productivity (Rozelle, Li, and Brandt, 1996).

National procurement policy also affects the way farmers allocate their sown area and market their surplus, and ultimately has an impact on farm production (Lin, 1992). Since the early 1980s, annual delivery quotas have been issued to farmers requiring them to deliver to a government procurement station a fixed amount of grain, for which they receive a state-set, below-market price (Sicular, 1991). The quota-priced grain was primarily used as supply for urban grain rationing, a system which supplied low-cost grain to city residents, essentially placing part of the burden of the urban subsidy on the shoulders of the rural community. Originally, the quota was increased as yields and overall productivity rose, but since the mid-1980s, the level of the quota has been constant in most areas, and has fallen in some advanced coastal regions. As the quota has stabilized, grain system officials in most provinces have required farmers to deliver mainly rice and wheat. Only in regions in the Northeast are corn procurement quotas common. Hence, in some areas, even if farmers would rather cultivate corn, national procurement policy shifts resources toward fine grains.

After satisfying the quota, however, farmers mostly are free to plant their land and sell or use their surplus in whatever way they see fit. In the early years of the reforms, markets were still quite underdeveloped, making government procurement agencies the only channel for marketing. The

procurement parastatals purchased "above-quota" grain at a "negotiated price," which in most cases (especially since the mid-1980s) was set a level that reflects supply and demand forces. In more recent years, there has been a veritable explosion of marketing activity in the grain economy (Watson, 1994). Currently, farmers have a wide choice of marketing opportunities, including selling to newly commercialized parastatals, private traders, buyers in periodic markets, procurement agents in local flour, feed, and food processing mills, etc. While still far from complete and constrained by serious transportation bottlenecks and periodic policy interventions, markets in China's areas have progressed remarkably in terms of competitiveness and integration, especially in the 1990s (Rozelle *et al.*, 1996).

Consumption Trends

The demand for corn has also been experiencing fundamental changes. Most of the corn during the pre-Liberation period (before 1949) was grown for own-household staple production by farmers in the north and poorer mountainous regions. It was consumed as porridge or biscuits. In many parts of China, corn consumption patterns did not change despite 30 years of rule by the Communists. However, since the reforms of the early 1980s, meat demand has soared and the demand for corn as feed has followed this rise.

Since the early 1980s, the production of pork, beef, and poultry has more than tripled (ZGNYNJ, 1995). Annual per capita consumption of red meat has risen from less than 5 kg to nearly 20 kg. While corn was once primarily a food crop (albeit an inferior one) consumed at home or used as feed for farmers' backyard hogs and poultry, by the early 1990s, farmers marketed most of their crop (authors' survey). Moreover, the end uses of the corn crop is rapidly changing; increasingly, corn is being used in large scale commercial hog and poultry operations. CIMMYT (1994) reports that in 1988-90, 57% of corn was used for animal feed and only 33% as a food crop consumed by humans (the rest was used for processing and seed).

Corn Trade Patterns

China's external grain economy has gone through several major shifts in the past three decades. China was self-sufficient in most grains and other food products through the 1970s. During the pre-reform era, China only engaged in the trade of minor volumes of corn and other major staple crops. During the late 1970s and early 1980s, as a harbinger of deeper reform to the rest of the economy, China's leaders finally began to turn to world markets as a way of supplementing national food production (especially to fulfill unmet demand for wheat) and taking advantage of market conditions and regional specialization. Depending on international prices and domestic production, state trading agencies began to export rice and corn during this same period. Thus, China's status as a net importer or exporter has fluctuated dramatically since the late 1970s (ZGTJNJ, 1995).

China's traders began to export larger quantities of corn in the mid-1980s, but the country's participation in world corn markets continued to fluctuate during this period. Most of the 5 MMT of exports came from northeast China, a region which has relatively easy access to the Northeast Asia market but which is fairly isolated from most of China's consumers. After a fall during the grain shortages in the late 1980s, China's role in world corn export markets increased between 1990 and 1993. From 2.5 MMT in 1990, China's exporters shipped over 10 MMT in 1993. Virtually the entire South Korean corn market shifted to China from its traditional sources in the United States (Rozelle *et al.*, 1996).

Just as quickly as China became a major player in Northeast China feed markets, other events led to an almost immediate departure. Rising domestic demand and tight supplies (which triggered price rises throughout China) caused the government to issue an embargo against exports of corn in 1994. According to 1995 interviews in the northeast, the local price in Jilin Province (China's largest supplier of surplus corn) fell dramatically, and provincial officials complained bitterly about losing access to their export markets. In 1995, high domestic prices for corn and unfulfilled demand in

many hog producing areas induced trade officials (who belong to China's monopoly state trading organization, COFCO) to import over 5 million tons in 1995. In 1996, however, facing high world prices and moderating domestic ones, international traders in China are expected to scale back on their exports.

China's Corn Research System

Agricultural research and plant breeding in China is almost completely organized by the government. Reflecting the urban bias of food policy, most crop breeding programs have emphasized fine grains (rice and wheat), and have put less resources into corn (Fan and Pardey, 1992; Fan, 1995). In part because of this, the gap between China's yields and those of the world are significantly larger than the gaps for rice and wheat. The gap represents both bad news and good for those interested in exporting grain to China.

Despite this, China has one of the largest corn breeding programs in the developing world. Corn breeders have shown a proclivity to produce high yielding open pollinated varieties (OPVs) and hybrids that have found their way across large tracts of sown area. In the rest of this section, the structure of the research and breeding sector is examined before looking more closely at hybrid corn breeding.

Structure of Overall Agricultural Research System

New varieties and hybrids of field crops are developed by research institutes at a number of different jurisdictional levels. In the national research system which reports ultimately to the Ministry of Agriculture, the main organizations include the national breeding programs in the Chinese Academy of Agricultural Science, provincial academies of agricultural science, and prefectural research institutes. Agronomy departments in agricultural universities also have a number of breeding programs.

To date in China, there has been almost no non-governmental effort to breed corn varieties, with one notable exception, an exception that might challenge the government's idea of the government monopoly on corn breeding. Li Denghai, a private breeder, has created and extended a series of varieties that cover more than 20 percent of the North China Plain. Some national leaders chalk it up to a fluke, a accidental breakthrough. Others stress its importance in convincing the leadership to liberalize rules on private research. The only other research by private companies has been by multinational companies that have tested their hybrids (brought in from their home countries) for adaptability in China. So far none of their varieties have been released for commercial use.

Before they can be sold commercially, new varieties must go through a fairly comprehensive field testing and certification process. New varieties are tested jointly by research institutions and seed administration stations, which are a division of the county seed companies. The test results are reviewed by scientists and officials at the provincial level and approved for commercial use or rejected. Varieties that are adapted to more than one province are submitted to a national committee for approval at the national level.

Despite weak intellectual property rights and potential conflicts of interest between research institutes (who want to produce and sell new varieties) and seed companies (who get access to new seed stock for testing, which conceivably could be used by the seed company to boost its own revenues without sharing with the original producers), fiscal pressures induced agricultural leaders to implement reform in all sectors of the rural economy, including the research sector (Rozelle, Pray, and Huang, 1996). The government has attempted to increase research productivity by shifting funding from institutional support to competitive grants, supporting mainly scientific research focusing on problems that will be useful for economic development, and encouraging applied research institutes to earn their money by selling the technology they produce.

Unfortunately, while research reforms in some sectors of the economy succeeded (Maddox and Swinbanks, 1995), those in the cropping sector did not (Rozelle, Pray, and Huang, 1996). Empirical evidence demonstrates the declining effectiveness of China's agricultural research capabilities. The authors' previous work found that while competitive grants programs probably increased the effectiveness of China's agricultural research system, the reliance on commercialization revenue to subsidize research and make up for falling budgetary commitment weakened the system. It is possible that imperfections in the corn seed industry partly contributed to the ineffectiveness of research reform measures in crop breeding.

Corn Research. Chinese research on hybrid corn began in 1923. The first double cross hybrids were released in Sichuan in 1943-45. After the Communist government took over, research resumed during the 1950s. Lysenkoism replaced Mendelian genetics as the official plant breeding paradigm in China during the early 1950s and 1960s but does not seem to have affected applied plant breeding much. The first double cross hybrid based on the new breeding program was released in 1958. These hybrids were based on Chinese Flint crossed with U.S. public lines. However, these hybrids were susceptible to corn blight, and major epidemics of the disease occurred in 1961 and 1966. The government stopped selling double cross hybrids in 1967.

At the same time, China's corn breeders also were working on OPVs. Most of this work has been done by researchers in the south and southwest regions of the country. The impact of breakthroughs from this part of the system have never been analyzed. After the shock of a nationwide corn blight epidemic in the early 1960s, scientists started breeding single cross hybrids based on U.S. dent germplasm. The first single cross hybrids were commercially released in 1966. Breeders added multiple disease resistance to these varieties for the first time. As always, however, selection committees stressed high yield potential. According to interviews, since 1974 Chinese scientists have also been breeding for improved protein quality and HOC.

Like the rest of the crop breeding and research sector, China's corn breeding has run into financial and organizational difficulties in recent years. Rozelle, Pray, and Huang (1996) show that for the case of rice, reforms to the research system—making grants more competitive and encouraging institutes to commercialize their products in order to generate earnings to cross-subsidize research—have been a failure. One suspects that recent reforms have adversely affected the ability of corn research institutes to produce and extend new varieties.