

China's Agricultural Modernization and Economies of Scale: Barriers and Solutions*

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Abstract: *This paper identifies three stages in China's agricultural development with reference to macroeconomic development and international experience. While the first two stages focused on ensuring food security and raising farmer's income, the current stage must give priority to modernizing agricultural production. The lack of progress in this area is due to the following reasons: diminishing return to capital as a result of small and scattered farming operation which has compromised agricultural competitiveness; agriculture is overdependent on subsidy and protection under the conventional wisdom of the uniqueness of agriculture. This paper attempts to reveal the barriers to China's agricultural modernization and proposes recommendations on reforming the land and household registration systems to increase the economies of scale and productivity.*

Keywords: *stages of agricultural development, mode of agricultural production, economy of scale, agricultural production function*

JEL Classification Code: Q10, Q18

Correctly identifying the problem is the first step in developing an appropriate theory to guide policymaking. Misled by American scholar Lester Russell Brown, discussions on China's agricultural prospects over the years have been focused on "who will feed China" (Brown, 1995) while neglecting another more important question of "how China should feed its own population." While the former explores whether China has the ability to achieve self-sufficiency of food and its significance to the rest of the world, the latter is more concerned with the path of China's agricultural development and mode of production. It is fair to say that obsession with the first problem has derailed the answer of academia and the policy research community to the second question.

Since reform and opening up in 1978, China's agriculture has been developing along a

correct path. It delivered food security, enhanced production, released agricultural surplus labor and raised the income of farmers. However, the shift of development stage entails different objectives and requirements. Previously effective strategies may not work with the change of times. Sparing no effort in "feeding" itself, China finds the cost of the previous approach to be increasingly unsustainable. Hence, it is imperative for China to transform the pattern of its agricultural development in the new stage with shifting priorities.

This paper divides agricultural development into three stages with the following priorities, including (1) solving food shortage problem, (2)

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increasing farmers' income, and (3) transforming mode of agricultural production. These three stages and priorities are common to all countries and have been experienced or are ongoing for China. Based on empirical analysis, this paper reveals that the primary challenge facing China's agriculture is agricultural efficiency or the mode of production and that the economies of scale must be increased to mitigate diminishing return to capital. On the basis of such analysis, this paper proposes policy recommendations on creating an efficient mode of agricultural production.

1. Development Stage of China's Agriculture

Agricultural development is an important element of economic development and largely determines the latter's success. In economic history, different paths of agricultural development have determined whether a country's agricultural sector is viable and competitive or fragile and reliant on protection. In addition to differences in resource endowments that determine agricultural comparative advantage, policymaking deduced by specific theories is also an influencing factor behind the determinations of countries to follow different paths of agricultural development. To reveal the challenges, we have divided China's agricultural development into the following stages since reform and opening up in 1978.

1.1 Stage 1: Solving Food Shortage (1978-1984)

This stage of China's agricultural development was characterized by lopsided proportions of labor and output, i.e. the former dwarfed the latter, leading extremely low marginal productivity of agricultural labor, and meager supply of agricultural product. We define the times of the implementation of the household responsibility system as the beginning and of the holistic emergence of the effect of enhanced productivity as the end of this stage, i.e. 1978-1984.

This early stage of agricultural development struggled for primary food supply. This stage can be characterized by traditional agriculture defined by Theodore W. Schultz corresponding to the Malthusian trap commonly understood

by development economists. As the stage of agricultural development where subsistence is the first and foremost priority towards its end, surplus labor begins to emerge, giving rise to the formation of a dual economy. In describing the relationship between agriculture and economic development in less developed countries, early literature identified the significant share of agriculture as an important characteristic (meaning that more people must engage in agriculture in order to provide subsistence level of food supply) and the asymmetry between agricultural output and labor, i.e. the share of agricultural labor dwarfs that of agricultural output (e.g. Johnston, 1961). For this reason, the migration of agricultural labor to nonagricultural sectors can increase the comparative labor productivity of agriculture and realize the reallocation of resources, i.e. the so-called "Kuznets effect".¹ The lopsided proportion of agricultural labor is caused by the involution process of agriculture during the subsistence stage (see Cai, 2015).

In 1978, the eve of reform and opening up policy, China's agricultural output accounted for 28.2% of the economy yet agricultural labor represented 70.5% of the total workforce. The comparative labor productivity of agriculture (the ratio between the share of agricultural output and the share of labor) was estimated to be 0.40, which was only 14.4% that of the secondary sector (2.77) and 20.4% that of the tertiary sector (1.96). That is to say, laborers in agriculture generated disproportionately less value added than did their counterparts in nonagricultural sectors. Given the disproportionately smaller share of agricultural products relative to its utilization of labor force, China's per capita possession of agricultural output in 1978 was only 316.6 kilograms of grain, 2.3 kilograms of cotton, 5.4 kilograms of oil crops, and 11.0 kilograms of meat. As a result, food had to be

¹ In 1971, Nobel prize laureate Simon Kuznets noted that the key in changes in industrial structure is to transfer resources from less productive sectors to more productive ones and thus increase the overall resource allocation efficiency of the economy. This pattern can be regarded as a "Kuznets-type" evolution of industrial structure.

rationed for urban residents on various coupons and 250 million people in the countryside were below subsistence level.

Although essentially caused by the lack of incentives of People's Communes (numerator effect), at least from a statistical point of view, the low agricultural labor productivity also directly has to do with the high share of agricultural labor caused by barriers of the household registration system to the intersectoral flow of labor (denominator effect). Prior to agricultural reforms, the lack of incentives to work concealed the problem of agricultural surplus labor because more people than necessary were involved in agricultural production. Yet in reality, the degree of involution or surplus labor in China's agriculture was already very serious.

1.2 Stage 2: Increasing Farmers' Income (mid-1980s to 2004)

This stage was defined by the employment of new technology to enhance agricultural supply, the transfer of labor from agriculture to nonagricultural sectors, a declining and more proportionate share of agricultural workforce relative to output, as well as marginal productivity of agricultural labor converging with nonagricultural sectors. The result was an increase in the off-farming income of farmers and narrowing urban-rural income gaps. Since the mid-1980s, the household responsibility system was universally implemented in agriculture to create better incentives for farmers. In addition to boosting agricultural production and productivity, this reform also made surplus labor an explicit issue. As reforms have eliminated institutional barriers deterring labor mobility between rural and urban sectors, the degree of labor surplus in agriculture has been significantly eased and eventually the Lewis turning point arrived around 2004, which marked an end to this stage (see Cai, 2016).

In the previous stage, the share of agricultural labor dwarfed the share of agricultural output. As a result, agricultural productivity was significantly below productivity of nonagricultural sectors. As pointed out by Arthur Lewis in defining the concept of dual economy, the marginal productivity of agricultural labor is so low that it becomes zero or negative, which determines the

low income of farmers. As surplus agricultural labor transfers to secondary and tertiary sectors, the marginal productivity of agricultural labor keeps on the rise. Along with the mitigation of labor surplus in the sector, advances in agricultural biotechnology in the first place and then rising levels of mechanization (induced by the relative scarcity of labor) have simultaneously enhanced labor productivity in agriculture and food security. By 2014, the share of China's agricultural share in gross domestic product dropped to 9.2% while the share of agricultural labor fell to 19.1%². On the other hand, agricultural productivity jumped to 0.48 and per capita possession of agricultural output reached 443.8 kilograms for grain, 4.5 kilograms for cotton, 25.6 kilograms for oil crops, 97.7 kilograms for sugar crops, and 63.7 kilograms for meat. On the average of labor force actually engaged in agriculture, grain output per unit of labor input increased by 2.8 times over the level of 1978.

According to the theory of induced technological change, the adoption of agricultural technology is induced by the relative scarcity of production factors and their relative prices. That is to say, agricultural technology adopted tends to save scarce production factors and make more intensive use of abundant ones (Hayami and Ruttan, 1980). This theoretical hypothesis implies that agricultural development and technological progress can be observed in light of the share of agricultural labor as the defining features of certain development stages. For instance, as explained in the following paragraph, agricultural mechanization reflects the active response of technological change to the change of production factor endowment in a certain stage of China's agricultural development.

According to the characteristics of agricultural machinery, we roughly define large and medium-sized tractors and their auxiliary implements as labor-saving technology and small tractors and their auxiliary implements as labor-consuming

² This figure is an estimate based on more reasonable assumptions, which is obviously below official statistics. See Cai et al. (2016).

technology. We have observed that during 1979-1995, the total power of large and medium-sized tractors grew by 0.84% on an annual average basis and the growth rate for their auxiliary implements was -1.7%. During the same period of time, the total power of small tractors increased by 11.2% and the growth rate for their auxiliary implements was 10.5%. Later, with the massive transfer of agricultural labor into nonagricultural sectors, the relative scarcity of production factor changed, i.e. the shortage of agricultural labor emerged, reversing the direction of technological change. During 1996-2012, the total power of large and medium-sized tractors grew by 11.8% on an annual average basis and the growth rate for their auxiliary implements was 13.2%, while the annual average growth rate of total power of small tractors dropped to 4.7% and the growth rate for their auxiliary agricultural implements was 6.7%.

1.3 Stage 3: Transforming the Mode of Agricultural Production (2004-Present)

This stage is characterized by labor as a relatively scarce production factor, increasing advancement in labor-saving agricultural technology and the replacement of labor by capital. Substitution of production factors requires an expansion in the scale of agricultural operation to prevent diminishing return to capital. In this stage, China is confronted with two correlated institutional constraints. Under China's household registration (*hukou*) system, rural migrant workers are not entitled to urban citizenship. They find odd jobs in cities but return to the countryside when farm work is busy to assist their aging parents and other family members. In addition, impediments to land transfer discourage the concentration of farmland essential to achieving economies of scale. It is fair to say that China's agriculture entered into this stage when the Lewis turning point in 2004.

The first two stages have laid the foundation for agricultural modernization and resulted in the growth of capital input outpacing that of labor input and thus significant improvements of labor productivity. According to survey data (NDRC, various years), we may discern this change from the capital input and labor input for paddy rice, corn and wheat, which account for 81% of grain-

sowing area. As Figure 1 reveals, the actual material and service costs for paddy rice, corn and wheat have been on a steep rise since 2004, yet unit-area labor input dropped sharply. During 2003-2013, the actual material and service costs for the three crops increased by 1.9%, 3.2% and 2.6% on an annual average basis, while labor inputs fell by 4.4%, 3.9% and 5.0% respectively.

Meanwhile, income growth of farmers and narrowing urban-rural income gaps are increasingly less dependent on agricultural profits. In the context of massive labor transfer and the arrival of the Lewis turning point, incomes from nonagricultural business and wages become the lion's share in the household income of farmers. In 2014, nonagricultural income accounted for 63% of disposable cash incomes of farmers and contributed to 75% of their income growth. This reality points to two important issues on agricultural development.

First, with the change in stages of economic development, the previous sources of income growth for farmers became exhausted. According to demographic data, after China's working-age population (16 to 59 years old) began to experience negative growth in 2011 for the first time, the potential migrant worker population aged between 16 and 19 also started to decline in 2015. The growth of migrant worker population will inevitably decelerate. In fact, it already dropped from 4% during 2005-2010 to 1.3% in 2014 and further down to 0.4% in 2015. This change implies that the wages increase as major contribution to rural households' income can no longer sustain the previous growth momentum.

Second, the same approach used by China to succeed in raising farmers' income may not work in raising agricultural efficiency and thus strengthening capacity of agricultural production. The insignificance of income from farming operation in rural households' income provides neither incentives for laborers to engage in agriculture nor impetus to build a solid foundation of modernized mode of agricultural production.. In turn an inefficient mode of production cannot guarantee reasonable return to agriculture to support farmers' income growth. This vicious cycle became a barrier to China's agricultural

modernization.

In addition to ensuring food supply and raising farmers' income, we believe that the more urgent task of China's agricultural development in the current stage is to modernize agricultural production featuring economies of scale, efficiency of production, external provision of services, commodity competitiveness, and sectoral viability.

2. Conventional Wisdom on Agriculture As An Industry

Two theoretical traditions feature prominently in discussions on China's agricultural economics. One, according to Theodore W. Schultz, American economist well-influential in China, the uniqueness of agriculture as an industry exempts it from being characteristic of economies of scale. Two, Chinese scholars and policy researchers widely accept the view that agriculture is congenitally an unviable industry. More or less, those views have become conventional wisdom influencing scholarly debates on and misleading policy making of China's agricultural development. This section tries to break those myths so as to reveal alternative direction of China's agricultural development.

2.1 "Pseudo-Indivisibilities" of Production Factors in Agriculture

Theodore W. Schultz (1983) demonstrated that there does not exist the indivisibility of production factor in agriculture as source of economies of scale, as what he terms as "pseudo-indivisibility." Taking tractors as an example, he noted that tractors can be manufactured by different specifications and models according to the size of farmland. Further, he applied "pseudo-indivisibility" derived from tractors to other production factors. For instance, he considered that labor is divisible because farmers can work in cities on a seasonable basis when farming is not intensive. Indeed, he was correct in arguing that the size of farmland is not a decisive feature distinguishing traditional and modern agriculture. He also admitted that small or large tractors are appropriate when labor is relatively cheap or expensive respectively. Yet on the whole, the conclusion that he generalized the uniqueness

of utilization of production factors in agriculture should not serve as the reasoning of exception of economies of scale in the sector.

In debating the legitimacy of introduction of the household responsibility system—namely, breaking down large production teams into individual households, in the early 1980s, this theory that downplays the economies of scale was used to justify reform. However, as the problems of food supply and farmers' income have been primarily resolved, the small size of agricultural operation became an impediment to the use of agricultural machinery and other new technologies. Superficially, it seems that contracted agricultural machinery services may exempt farmers from purchasing agricultural machinery, thus maintaining the "indivisibility" hypothesis for agricultural machinery, the fact that Chinese farmers increasingly demand for machinery services explains that large tractors and auxiliary implements are no longer unimportant and have become essential inputs in agricultural production today. Furthermore, if production and transaction costs are examined in combination, as shown in real cases, we will discover that the size of agricultural operation has more and more become a real barrier to agricultural efficiency.

First, one view about the pseudo-indivisibility of agricultural production factor is that instead of maintaining their own machinery, small farming households should purchase agricultural machinery services. However, small and scattered farmlands have restricted the use of large agricultural machinery. Theoretically speaking, adjacent farmers may share machinery services. Yet individual households may grow very different varieties of crops. Besides, bargaining with adjacent farmers is also difficult and will raise the transaction cost of hiring agent services of agricultural machinery.

Secondly, in addition to the process of farm production, economies of scale also exist in the processes of purchasing the means of production and relevant services and selling agricultural products. It takes certain capabilities and incentives to leverage such economies of scale in order to negotiate deals, collect information, evaluate results and pay the relevant transaction costs.

Small farm operations will inevitably increase the unit costs of transaction and reduce incentives to devote efforts in those processes. For instance, farmers often face multiple options in the seed market. Potentially faced with inferior and even fake seeds, farmers may not have the time and knowledge to effectively screen and select the best seeds.

Lastly, the small scale of agricultural operation impedes the adoption of new technology. The relative scarcity of production factors can change at any time, and so can market demand. Under large-scale operation, such changes in relative prices of production factors and operation costs that serve as market signals will induce technological progress to the direction of saving scarce factors and meeting market demand. However, as the size of farm operation is small as it is, it leaves no capacities for farmers to respond to such market signals. For instance, while raising tax may reduce pesticide consumption, it will also increase the cost of agricultural production, especially in the case of small-sized farming. Large farms have the resources to kill pests by luring them with killer lamps. However, no small farmer would agree to lure pests to his own field parcel.

2.2 “Weak Nature” of Agriculture As An Industry

Over the years, most Chinese agricultural economists have used the “vulnerabilities” of agriculture as a self-evident justification for the protection of agriculture without conducting empirical tests. In general, the following justifications are offered (e.g. Gao Fan, 2006). First, agriculture is a process of intertwined natural and economic reproduction and labor cannot be fully utilized during production. Second, agriculture is more strongly affected by natural factors, causing uncertainties in the result of production. Thirdly, while agricultural supply is subject to the “cobweb effect” to some extent and the income elasticity of demand for agricultural products is smaller than 1 after entering a certain stage, the income of producers cannot be assured in both short- and long-run. Obviously, the above justifications are both theoretically and practically outdated. With modern financial and insurance

systems, a more sophisticated product market and necessary government regulations, these justifications for the “vulnerabilities” of agriculture cannot hold.

Shifting focus away from above outdated discussions that focus on justifying the universality of agricultural “vulnerabilities”, a more convincing argument compares economies characterized by high labor-land ratio with those characterized by superior arable land endowment, leading to a static justification, i.e. the theory of agricultural comparative advantage, as well as a dynamic justification, i.e. the share of agricultural labor. Combining these justifications can seem to conclude the uniqueness of China’s agriculture (e.g. Chen Xiwen, 2015). Based on that view, first, China can never compete with countries like the United States and Australia given the substantial difference in endowments of agricultural resources. Second, it is hard to re-employ labor force released by expanding farmsize. Hence, simply expanding the scale of operation does not seem to be a plausible option for China and subsidies and protection for agriculture based on international rules are still necessary.

International empirical studies offered mixed conclusions on the arguments of uniqueness of agriculture. For instance, according to an econometric analysis (Anderson and Hayami, 1986, Chapter 4), economies holding less comparative advantage in agriculture tend to implement policies protecting their agriculture more intensely. Meanwhile, as a declined share of agricultural labor or output means that the nonagricultural populations are more capable and willing to subsidize agriculture, the level of protection naturally increases as the process moves forward. However, since implementing agricultural protection policies undeniably causes inefficiencies, the level of protection cannot be increased forever. International experiences show that protection will cease to rise when the share of agricultural labor falls to 6%-8% or the share of agricultural output declines to around 4%. That implies that agricultural subsidy is in essence a transitory phenomenon of a certain development stage. While the argument of “agriculture as a vulnerable industry” is reasonable justification

for shifting policy orientation away from taxing agriculture, it should be avoided to take it as a law of development and to make subsidy or protection permanent policies.

According to Hayami (1988), Japan's agriculture experienced stages of solving food shortage problem and poverty problem successively. Instead of moving to strengthen the mode of agricultural production duly, Japan turned to strongly implementing an agricultural protection policy, which persisted even after crossing the critical point of a declining share of agriculture. By empirically concluding the significant loss in efficiency and welfare by implementing protection policies, Anderson and Hayami (1986) and (Hayami, 1988) suggest that economies like Japan should strive to strengthen mode of agricultural production instead of offering protection. Studies also offered some lessons that a handful of economies that were once considered to lack comparative advantage in agriculture have eventually built efficient and competitive production mode of agriculture.

True, how to develop agriculture in countries lacking comparative advantage is not simply a question concerning with industrial policy, but it also involves social, livelihood and food security issues, however, creating a modern mode of agricultural production lays the foundation for resolving all above problems. In particular, whether agriculture can be protected as a vulnerable industry is not solely determined by farmers' expectations and government preferences but constrained by a host of objective factors including international price as a ceiling, domestic production cost as a floor, World Trade Organization rules as amber box policy limit and arable land resources as redline. In exploring all possible solutions, China must expand the scale of agricultural operation and mitigate diminishing return to capital.

3. Breaking the Constraints to Farm Size of China's Agriculture

With China's introduction of the household responsibility system in the early 1980s, individual farming households replaced production teams to

become the basic unit of agricultural operation. A mixture of arable land plots of different quality was allocated to each and every household according to the number of family members. To make the reform permanent and legitimate, the Chinese government identified household-based agricultural operation as a basic system and guaranteed a long-standing period for the land contract. Under this system, farmland was segmented into narrow plots and scattered across individual households. Numerous roads, ridges and ditches compromised the utilization of arable land as well. Under the current household registration system, although many farmers migrated to find jobs in cities, because it was difficult for migrant workers to change their permanent residency, their land could not be transferred and was thus left uncultivated or inefficiently cultivated. Land could not be concentrated despite growing demand for concentration.

American writer Henry David Thoreau described a self-sufficient mode of agricultural production in *Walden*: "*if one would live simply and eat only the crop which he raised, and raise no more than he ate, and not exchange it for an insufficient quantity of more luxurious and expensive things, he would need to cultivate only a few rods of ground (a rod squared is equivalent to 25.3 meters squared), and that it would be cheaper to spade up that than to use oxen to plough it.*" As shown in Figure 1, the average size of land for each farming household in China is much smaller compared with the developed and developing countries in various regions of the world. In addition to the small size of land, on average, each farming household is allocated with more than five arable land plots scattered across different locations (Gao et al., 2012). Such a pattern of farm size indeed is not much different from what Thoreau described.

According to Chen Xiwen, the policy counter measures that allow farmers to subcontract their contracted land to other households, large-sized farms, and agribusiness corporations have promoted land concentration. However, only 26% of farming households have completely or partially transferred their farmland, involving 28% of 92 million hectares of total contracted

farmland in China being transferred (Yao Yuan, Han Miao, 2015). According to a sample survey, the ratio between the original contract land and transferred land cultivated by farming households changed from 97:3 in 1996 to 81:19 in 2008 (Gao et al., 2012). whereas land transfer increased its concentration, the size of China's agricultural operation is still very small, by international standards. The World Bank defines farms with arable land of less than 2 hectares as small land owners, the average size of Chinese farms with 0.6 hectares, therefore, can be identified as subminiature type.

This situation has impeded China's agricultural efficiency and modernization. Based on their estimate of agricultural production function, the authors arrived at the following stylized facts on China's agricultural development stages and challenges (Cai and Wang, 2016).

First, until the agricultural system reforms produced their desired results in the mid 1980s, China had been preoccupied with tackling food shortage. This stage was characterized by mass pool of surplus labor and thus very low marginal labor productivity in agriculture. Our estimates show that marginal labor production the period of 1978 to 1984 was negative for paddy rice and

wheat productions and zero for corn production. This situation was consistent with the doctrine of agricultural labor of zero-value, which was asserted by Arthur Lewis and denied by Theodore Schultz. Due to the lack of modern production factors in this stage, as can be expected by theory, the marginal product of capital in agriculture was high.

Secondly, trends of diminishing marginal product of capital and increasing marginal product of labor for those grain crops were both very significant. Comparing to the average level of 1978-1990, the average marginal product of capital dropped by 27% for paddy rice production, 29% for corn production, and 19% for wheat production in 2007-2013. On the other hand, marginal product of labor jumped by 50 times for paddy rice, seven times for corn and 55 times for wheat. It is worth of noticing that for all three grain crops, the margins of increase in marginal product of labor were far greater than the margins of reduction in marginal product of capital.

Lastly, we have observed that after the arrival of the Lewis turning point, marginal product of capital for China's agriculture kept on the decline. With the labor becomes relatively scarce factor and capital becomes relatively abundant factor, as

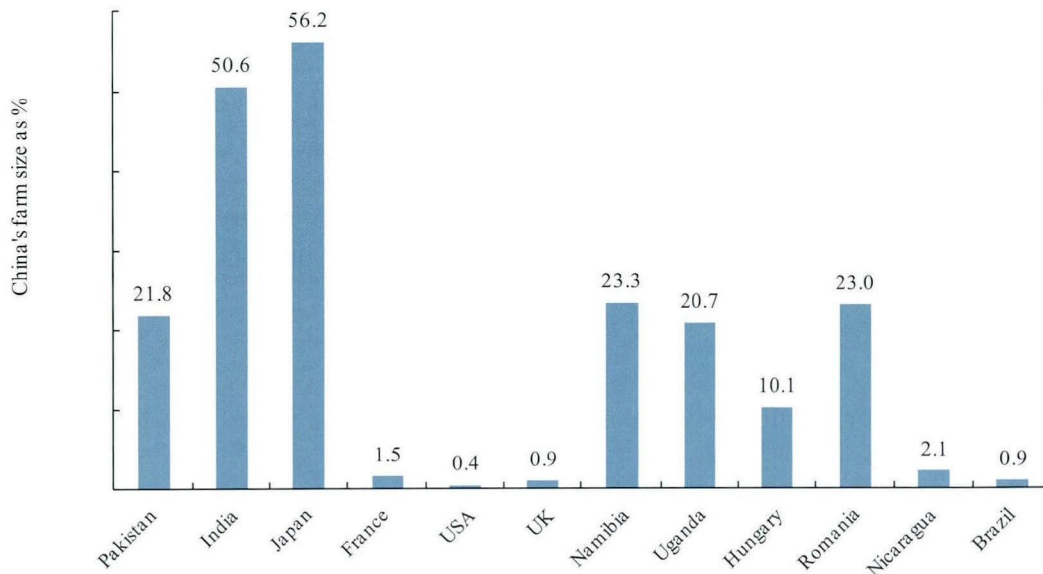


Figure 1: International Comparison of Farmland Size in China

Source: FAO (2010)

the result of rapid substitution of capital for labor, the small scale of agricultural operation has led to diminishing return to capital, making agriculture even less profitable. According to the Schultz theory and its policy implication, the key in transforming traditional agriculture is to introduce modern production factors, which require a critical minimum operation scale to achieve efficiency.

Since the reform initiated in the late 1970s, China's agriculture has experienced a remarkable journey. In addition to resolving the problem of food shortage and raising farmers' income, agriculture has supported China's spectacular economic growth and received generous support from industrial and urban sectors afterwards. After crossing the Lewis turning point, as China's resource endowments change, labor is increasingly replaced by machines in agriculture and the capital-to-labor ratio significantly increased. However, due to the limitation of small sized farmland and agricultural operations, return to capital began to diminish, which prevents further improvement of efficiency and market competitiveness. Ultimately, subsidy and protection are not capable of supporting the modernization of the mode of production.

With right incentives and market signals, Chinese farmers, who have been proven to be creative entrepreneurs in both institutional and technological innovation, are poised to choose the appropriate technology and factors input to maximize production and minimize cost. The problem is that institutional factors such as the land system and the household registration system continue to impede the expansion of farmland operation and the modernization of agricultural production mode. Institutional reform and policy adjustments therefore will not only enhance potential growth rates of the macro economy (see Cai and Lu, 2013), they will also unfetter the achievement of agricultural development objectives in the next stage. As part of supply-side structural reforms, China must eliminate all institutional barriers deterring enlargement of farmland side so as to modernize its agricultural production. ■

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