Would more extensive out-migration of rural farmers expedite farm mechanization? Evidence from a changing Chinese agricultural sector

Tianyuan Luo
Graduate Student
Department of Agricultural and Applied Economics, University of Georgia
305 Conner Hall, 147 Cedar St., Athens, GA 30602
706-224-7350, luoterry@uga.edu

Dr. Cesar Escalante
Associate Professor
Department of Agricultural and Applied Economics, University of Georgia
315 Conner Hall, 147 Cedar St., Athens, GA 30602
706-542-0740, cescalan@uga.edu

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ABSTRACT

Changes in agricultural population can significantly influence the progress of mechanization, which provides efficient momentum to the further development of agriculture. We examine the effect of the declining agricultural population on mechanization and determine the variables that have decisive power over mechanical adoption decisions. This analysis of a panel data of top six out-migration provinces in China under a fixed effect model, we find that the overly fast and unusual decline in agricultural population actually slowed down the progress of mechanization, and the many years of large scale out-migration encouraged by government actually jeopardized sustainable agricultural development. Results underscore the need for considerable attention on the growth of annual farm incomes and agricultural products import that could have substantial effects on agricultural mechanization decisions.

Key Words: agricultural population; mechanization; farm exit; import

Introduction

Out-migration from rural areas to urban has been a persistent issue in discussions of agricultural development strategies of developing countries. Among the most important consequences of large outflow of agricultural labor force has been the accelerated speed of agricultural mechanization. Recent arguments made supporting the promotion of include the need to further reduce the rural labor force, which is perceived to be in excess supply. However, both the application of new machines and adoption of high technologies require more than simply the decline of agricultural population, which can only encourage labor saving technologies but not the adoption of labor complementary technologies. Therefore a comprehensive study on the effect of changes in farm labor force as well as the determinants of mechanization can help to uncover significant implications for farm technological development, labor surplus/shortage problems and farmer's welfare promotion policies.

Farmers' decisions to leave or abandon their farm businesses in favor of seeking employment in urban areas may encourage a greater degree of agricultural mechanization in two aspects: on one hand, declines in agricultural population lead to a forced replacement of labor for more machines; on the other hand, remittances of income obtained by former rural farm dwellers or operators from other non-farm sectors can further advance the mechanization initiative by providing more available funds that translate to stronger financial support. As a matter of fact, farm mechanization and modern migration away from rural areas seem to be closely related in China as these two initiatives have been actually mutually promoted. With the higher level of mechanization, more farm workers rendered less necessary in agriculture can be offered the chances to look for jobs in other industries. To further amplify the mutually reinforcing effects of the two initiatives, Beijing wants to lift the level of mechanization to 65-70 percent by 2020 (Wang and Chu, 2012). However, observed facts indicate that over the years of large-scale migration between rural and urban areas, agricultural mechanization seems to have been developing in an uncoordinated pace. The outflow of rural farm workers did not affect the rate of mechanization as usually expected, and findings of this paper suggest that the decreasing farm population in China delayed the normal schedule of mechanization.

The goal of this paper is to investigate the impact of decreasing rural population on the mechanization within Chinese agriculture over the years. Besides we are also interested in determining other factors that are influential in the process of agricultural mechanization promotion. After a detailed review of other studies, we find contradicted conclusions and the effect of changing farm labor force is undetermined. Then we start our investigation with a preliminary analysis of migration in China over the years and changes in labor structure of three different industries. The section that follows the data and methodology discussions gives the

primary findings of this article – that the large-scale agricultural population out-migration happened between 2001 and 2008 undermined the progress of mechanization in Chinese agriculture. Meanwhile, increased annual net income of farmers and reduced levels of agricultural product importations further encourage the implementation of farm mechanization efforts.

Literature review

Generally, there are three ways that farmers' out-migration affects farm mechanization: first of all, the remittances earned from doing non-farm jobs enable them to purchase new machines; secondly, increased per capita incomes would raise the probability of establishing larger farms that are, in turn, compatible with highly mechanized operations; thirdly, returning farmers who previously worked in the cities for several years would have more skills and technical information and knowledge while farmers with relatives in non-agricultural industries may also have more access to information about advanced technology, both of which mitigate the difficulties of adopting mechanization.

One of the major reasons that farmers are moving to cities is the need to raise their incomes by working in much better-paying jobs. The payment sent back to rural families called remittance is a substantial complementing source of income for their families. Aided by the remittance, farmers who remained in their farms instead of migrating to cities could afford more expensive agricultural machines as well as buy more land, both of which promote the mechanization of agriculture. However, there are still some controversies over the effect of remittance on agricultural input investment, therefore the income effect toward the mechanical technological adoption is undefined. Murray (1981) and Stark (1980) pointed out that the

remittance flows can be critical for the intensity of agricultural investment. Many empirical works also proved the positive effect of remittance on mechanical technology adoption, especially in developing countries, like the Dominican Republic (Pessar, 1991) and Indonesia (Leinbach and watkin 1998). Many scholars found similar results that the remittance would be used to purchase inputs such as tractors or reapers. The households more extensively engaged in migration activities are more likely to adopt modern farm technology, both biologically and mechanically (Mendola 2006). However, on the other side, many studies cast doubt on the positive effect of remittance. Durand and Massey (1992) pointed out that the remittances are typically devoted to the provision of basic needs such as food and education, and would rarely use such funds in the improvement of agricultural systems. One of the case studies on Kenyan farmers demonstrated that remittance was mainly used in the education investment but not on agriculture (Francis and Hoddinott, 1993). Such results were also supported by the Rempel and Lobdell (1978), Palmer (1985), Collins (1987). The diverse results of the remittance effect thus suggest more than expected uncertainty in the relationship between farm labor migration and mechanical technological adoption.

A decreasing rural population can actually be more conducive to the establishment of large-sized farms, which induces the need for more machines to realize more efficient cultivation. Farm size is another factor that influences the rate of farm mechanization. It is commonly acknowledged that the bigger farm could have a greater capability to adopt new technologies due to less financial constraint and large returns to scale. To increase the farm size is the key to expand the mechanization and thus improve agricultural productivity (Hiroyuki and Sheu 2010). Some people argued that the bigger farm had an intrinsic tendency to introduce large machineries, which would enhance the mechanical adoption but widen the income gap (Harry 1972; Ali 1972).

The empirical research conducted in China, Zhejiang Province also showed that the mechanization is preferred at the farm size of above 0.6 ha (M. Van den Berg 2007). However, the empirical work by Bardhan (1973) raised a different idea and pointed out the negative relationship between farm size and total farm production, which indicates the slow adoption of new machines.

Mechanization can also be affected by the accumulation of human capital. Farmers who have stayed and worked in bigger cities would have greater access to new technological information and become open minded, which could encourage the adoption of new machines and technology. Cotlear (1986), in his World Bank report, pointed out that migration experience has powerful effects as a form of informal education, which further induces farmers to apply more mechanical power.

The undetermined effect of migration on mechanical adoption puzzled the researchers and policy makers for years. Meanwhile there is no general agreement on the factors that are most influential in the mechanical adoption decisions. Moreover, migration hinders the progress of mechanization because of the self-selection in migration that skilled farmers are more likely to leave and less skilled farmers would stay on the farm. Studies in Colombia indicated that a large proportion of the rural migration is young when they move to the cities (Converse 1965). Neymark (1964) concluded that rural-to-urban migrants in Sweden lowered the average intelligence levels of both areas, which would adversely affect the mechanical adoption. Another case study in Colombia showed that further mechanization efforts do not seem possible due to the fact that many potential innovators and adopters of these techniques are migrating out of agriculture (Adams 1969). However, this argument further suggests that the deterioration in the

rural labor force would induce hikes in rural wages, which would actually facilitate farm mechanization in South Korea (Choi and Kang ?).

Migration flows in China

Migration in China has been long subjected to government regulation. During the period 1949 to 1978, the flow of the rural labor force to urban areas was strictly constrained as farmers had no choice but to continue to make a living in their land for all their lives. The allocation of the labor resources was manipulated by the government which led to severe problems of low agricultural productivity. During 1978 to 1991, there was a slight loosening in the migration policy, but it is usually conditional and restrictive, therefore the time is defined as experimentation period. Then after 1991, lots of restrictions are gone and farm labor was allowed to be allocated according to the market rule. Even though the Household Register System is still prevalent all over the country, the domestic flow rate of labors has greatly increased. After around 20 years of large scale out-migration, a huge change has happened in China's society. More and more farmers moved to urban area and left agriculture. Meanwhile, the agricultural productivity was also accelerated.

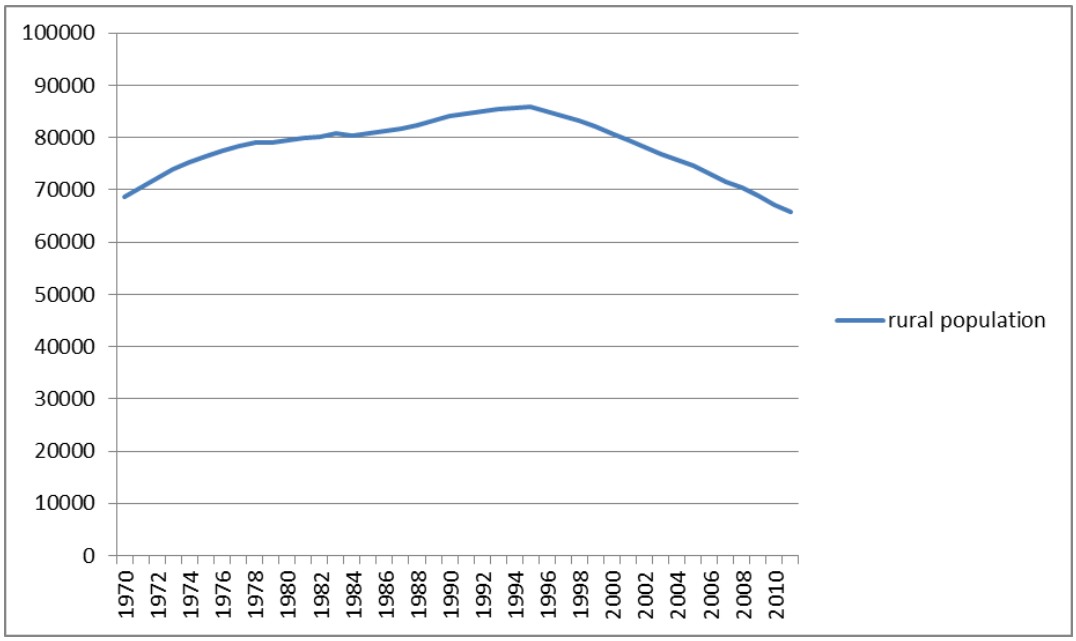

Figure 1 Rural population trend, 1970-2011

During the period of restrictive migration control before 1991, rural population increased at a steady pace. Farmers are confined within the agriculture and rarely have to the opportunity to change their occupations. Started from 1992, farm labor force reduced continuously and consistently over the years, and we expect that the initiation of market-directed agricultural mechanization also happened around this time.

Figure 2 shows us the proportion of work force in three different industries. As we can see, the population that works in the primary industry declined sharply over the years. Besides, it is notable that the proportion of the tertiary industry exceeded the secondary industry after year 1994. This can be explained by the fact that the job in secondary industry maybe more demanding of high skills so that farmers with limited educational level or less experience might be more willing to enter the tertiary industry. The sharp drop of the labor force proportion in agriculture would definitely affect the agricultural production, and if we assume the total arable

farmland areas is fixed over the years, the increased land-labor ratio in the wake of shrinking agricultural population would bring about changes in agriculture.

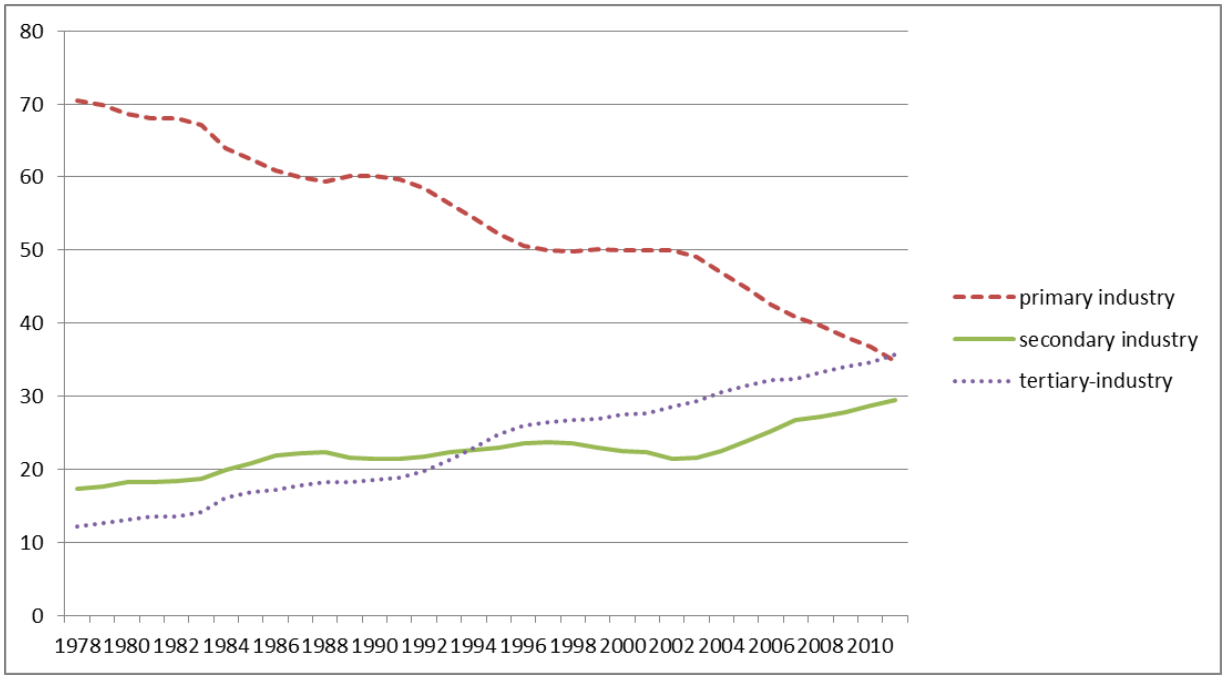

Figure 2 Percentage of labor force in three industries, 2011

Nowadays, it is a popular idea among the policy makers that rural population should reduce at a fast pace so that the high level of urbanization can be achieved quickly. The figure suggests exactly the case whereby by the year 2010, the proportion of labor force in each type of industry would reach around 30%. The trend lines predict that the size of the labor force in the primary industry will keep dwindling down, which brings about both opportunities and challenges to agricultural mechanization.

Data and econometric method

Data used in the paper are extracted from the China agriculture yearbook. China agriculture yearbook is edited by the Ministry of Agriculture of China and released annually. It summarizes

abundant and detailed information on the development of modern Chinese agriculture and provides comprehensive statistics on the agricultural sector. To examine the effect of rural labor force migration on agricultural mechanization, we choose six provinces that have the largest farm labor outflows and create a panel data by selecting the periods from 2001 to 2008. Among the varied means to measure the level of mechanization (Napasintuwong, 2004), we choose the measure of total power of agricultural machinery as dependent variable. The total power of agricultural machinery captures the sum of all mechanical power used for agriculture, which reflects the general development level of agricultural mechanization, and is the main planning index for the development of agricultural mechanization (Ju et al., 2013). The explanatory variables can be categorized into two kinds: the first are the factors on the agricultural resources, such as farm land, agricultural inventory price and gross domestic product of agriculture. The other group of variables represents factors related to human resources, i.e. number of agricultural labors, educational level of farmers.

Table 1 descriptive statistics of variables

Variable	definition	Mean	Std. Dev.	Min	Max
agpop	Total population working in agriculture (ten thousand)	1754.201	742.6717	887.1	3472.3
agpower	total power of agricultural machinery (Million KW)	4468.605	2723.695	1002.04	9525.4
netinc	average net annual income of farmer (yuan)	3101.845	801.4268	2020.04	4795.5
vegarea	cultivated land of vegetables and fruits (1000 ha)	1127.081	397.8256	569.9	2075.5
croparea	cultivated land of crops (1000 ha)	5563.327	1996.077	2692.2	9600
townent	number of township enterprises[a]	32927.13	72770.96	2010	519094
agland	total cultivated agricultual land (1000 ha)	5409.796	1737.795	2826.75	8110.3
agimp	total import of agricultural products ($ ten thousand)	283198.1	389134.2	7270	2163296
agexp	total export of agricultural products ($ ten thousand)	349390.5	219478.6	80060	1000429
Ill[a]	illiterate	5.603542	2.900589	1.46	12.6
primary	primary school	26.35938	5.437838	16.1	36.66
middle	middle school	54.18417	4.307511	46.92	63.08
high	high school	11.01854	2.409281	6.59	16.6
secondtech	technical secondary school	2.092083	0.352021	1.3	2.8
college	college and equivalence	0.792917	0.371059	0.31	1.6

agexpend	agricultural expenditure (100 million yuan)	65.55187	51.68529	9	209.59

[a] township enterprises are market-oriented public enterprises located in villages which are established by local government

[b] measures the percentage of farmers with denoted educational level.

The educational attainment level of over 50% of farmers is middle school level, and 26% of farmers obtained educational level at primary school. Generally speaking, the overall educational attainment of farm workers is not ideal which may undermine the adoption of advanced technologies. Farmers who work in agriculture are about 17.54 million, which is large even though the farm labor force decreases continuously over the years. Below is the trend of agricultural labor force decrease over the years in six provinces respectively.

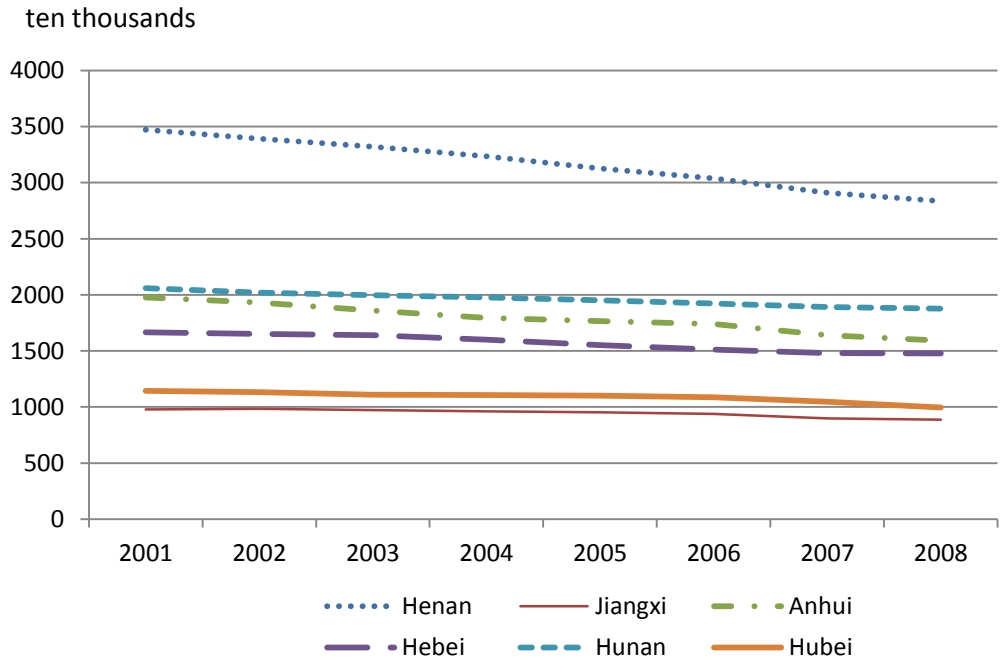

Figure 3 Decreasing trend of agricultural population 2001 to 2008

All the provinces show a descending trend in agricultural population over time. Most provinces have the relatively flat slope because of the large base. However, the decline in the absolute value is significant. For example, agricultural labor force has shrunk by 1.47 million

over the eight year period. Moreover, there is a high probability that the majority of those who left the farm is more educated and mostly younger farm workers, thus, the large-scale out-migration of farm workers would slow down the progress of mechanization.

Mechanical harvesting of fruits and vegetables generally lagged behind compared with crops (Huffman 2012). Therefore more hectares of vegetable and fruits may require more agricultural labor instead of machines, and the general advances in the machinery will be affected negatively. In addition to the domestic aspect, we believe that the international food trade also has impact on agricultural mechanization. With more crops and vegetables imported from overseas, there may be two-sided effects: on one hand, domestic farmers may reduce the production because of the decreasing domestic demand, therefore the incentives for mechanization gradually disappear; on the other hand, the pressure from international competition will motivate domestic farmers to adopt new production technologies so as to maintain the original benefit. However, the export of agricultural products may push the level of agricultural mechanization upwardly because of the higher foreign demand for agricultural products. In a centralized system, agriculture should be hugely affected by government policies. Through building new infrastructures, providing subsidy to the farmers and regulating the price of inputs, government can invest in agriculture in all kinds of ways. As to the mechanization, farmers who purchased new machines are encouraged by the government and enjoy a discount. At last, township enterprises promote agricultural mechanization in two ways: township enterprises and factories provide employment opportunities for these farmers who leave the agriculture, which creates a necessary condition for new technologies adoption. Meanwhile, employment in township enterprises increases the farm household income and provides financial support for purchasing the machines.

We use a fixed effect model to account for the effect of decreasing agricultural population on the level of mechanization with the following specification:

$$y_{it} = \beta_1 x_{it} + a_i + \varepsilon_{it} \tag{1}$$

where $t = 1,2, \dots \dots T$ and a_i is the unobserved effect that is constant over time. With fixed effect transformation, we can remove a_i along with other time-invariant independent variables. Now, by averaging the variables in the equation over time we get

$$\overline{y_i} = \beta_1 \overline{x_i} + a_i + \overline{\varepsilon_i} \tag{2}$$

Then the time-demeaned data are derived through the equation by subtracting (2) from (1)

$$y_{it} - \overline{y_i} = \beta_1 (x_{it} - \overline{x_i}) + \varepsilon_{it} - \overline{\varepsilon_i} \tag{3}$$

The unobserved effect a_i has disappeared and then we estimate (3) by pooled ordinary least squares (OLS) method.

Empirical results analysis

In the following part, we investigate the effect of changes in agricultural population on the application of total machinery power as well as the effect from other factors.

Table 2 Fixed effect model estimates of independent variables

	Coef.	Robust Std. Err.	t	P>t
lnagpop	1.760763	0.530353	3.32	0.021
lnaggdp	-0.18054	0.050402	-3.58	0.016
lnnetinc	0.995478	0.207808	4.79	0.005
vegarea	-0.00045	9.32E-05	-4.85	0.005
croparea	2.43E-05	1.94E-05	1.25	0.266
ruralent	1.85E-07	8.64E-08	2.14	0.085

agland	0.000218	0.000117	1.86	0.122
lnagimp	-0.05335	0.016802	-3.18	0.025
lnagexp	0.154567	0.087928	1.76	0.139
ill	0.019659	0.016302	1.21	0.282
primary	0.022791	0.021829	1.04	0.344
middle	0.026375	0.026422	1	0.364
high	-0.00695	0.027999	-0.25	0.814
secondtech	0.086893	0.065296	1.33	0.241
college	0.179914	0.076234	2.36	0.065
lnagexpend	0.025627	0.034222	0.75	0.488
_cons	-16.1394	4.795574	-3.37	0.02

The coefficient for agricultural population is positive and significant at 5% level, which means that when agricultural population decreases by 1%, the total machinery power would decrease by 1.76% as well. The estimate above suggests that the decrease in agricultural population does not raise mechanical usage and discourages the mechanization. Large scale of out-migration that started from late 80s is represented by continuous movement of farmers into cities. The declining rural labor force enhanced the demand for machines and high technologies in agricultural sector to replace labor. However, the migrant workers are more likely to be younger, adventurous as well as more educated. All of these characteristics are quite important for advanced technology adoption and new machines application, especially for these technologies which are labor-complementary. The out-migration of large amounts of more educated and adventurous farmers in their prime ages would have adverse impact on agricultural mechanization.

To execute and maintain new and high technology machines requires specific operation skills as well as maintenance and repairing knowledge. Farmers in older ages might be discouraged in adopting new and maybe more efficient machines because of skills inadequacy and physical incompetence. On the other hand, the aged people tend to be more conservative and have less

financial capacity to bear the loss if the adoption was not realized, which also would hinder them from accessing new mechanical powers. Moreover, when young farmers move to urban areas, they take away the core family. Under such circumstances, income from non-agricultural work may not go back to agriculture for acquiring new machines. Given the higher living cost in cities, migrant workers are more likely to spend on education for their children, health care or recreational activities.

It is known that smaller farm population creates chances to enlarge farm size and stimulates the progress in mechanization, but that is not necessarily the case in China due to cultural reason. Even though rural migrants have already established stable families and businesses in cities, they nonetheless still continue to keep the land as backup plans in case they experience failures in their urban careers. Some land is simply lying fallow, as farmers find better payment elsewhere but still prefer not to give up their land (David Stanway 2012). Therefore, small farms could not merge into large-sized farms and, as a result, mechanization could be delayed as well.

The positive effect comes from the net annual income of farmers. The annual net income includes income from agriculture, transfer payments from the government and non-farm employment revenues. Income from non-agricultural jobs enables farmers to invest more mechanical power in agriculture. While export of agricultural products does not have impact on the mechanization, the 1% increase in the import would decrease total machinery power by 0.05%. The negative effect indicates that the domestic farm production was reduced due to the competition of foreign agricultural products, which reduce the demand for agricultural machines consequentially. The last statistically significant estimate is the cultivated areas of vegetables. The negative sign demonstrates that the larger hectares of vegetable cultivation, the less application of machines. First of all, compared with crops, vegetable and fruits harvesting does

not require as much mechanical inputs compared to crops. Most of the machines used in vegetable and fruits sector are relatively small-sized. Secondly, as mentioned before, the progress of mechanization is relatively slow in vegetable and fruit harvesting, especially when the cost of human labor is lower than mechanical harvesting. However, the estimate is not economically significant and the effect is negligible.

Conclusion

The large out-migration of farmers generates demand for more agricultural mechanical usage and technology adoption. Thus, many researchers tend to regard the decrease of the agricultural population as a typical sign of mechanization progress. However, while the quantity of the farmers is declining, the quality of the farm labor force might diminish as well. A large proportion of farmers who contemplate and decide on migration are with higher educational level and more adventurous. Their exit could harm the mechanization process, therefore would make the effect of farm out-migration unambiguous. This paper focuses on the farm population out-migration effect upon the agricultural mechanization and tries to determine the dominating variables that affect the Chinese agricultural mechanization.

Smaller agricultural population is not a guarantee for attaining a higher rate of mechanization. On the contrary, overly fast outflow of agricultural labor force would jeopardize the mechanization progress due to the loss of prime-aged and educated farmers. Increase in the annual net income raises the total machinery power input. Farmers are more willing to apply more machines when equipped with stronger financial support, especially when the financial sources are varied and more stable. One more factor that deserves notice is the level of agricultural product importation. Competition from foreign agricultural goods reduces the

mechanical application and undermines the mechanization indirectly. In other words, the foreign agricultural goods are crowding out the domestic products in the market and thus, reduce the demand for locally produced food so that farms would start to eliminate machines.

References

Adams, D. 1969. Rural Migration and Agricultural Development in Colombia. Economic Development and Cultural Change 17(4): 527-539.

Ali, F. 1971. The Green Revolution, An Appraisal. Monthly Review 2 xxiv(2): 112-120.

Bardhan, P. 1973. Size, Productivity, and Returns to Scale: An Analysis of Farm-Level Data in Indian Agriculture. Journal of Political Economy 81(6): 1370-1380.

China, People's republic of, National Emblem of the PRC. A research report on Chinese migrant workers, 2006. Beijing: China Yanshi Publishing House.

China, People's republic of, National Bureau of Statistics of PRC. Statistical Communique on the 2012 national economic and social development, 2012. Beijing: China Statistic Press.

Collins, J. 1987. Labor Scarcity and Ecological Change, Little, P., Horowitz, M., and Nyerges, A, eds. Lands at Risk in the Third World: Local Level Perspectives. Boulder: Westview: 19-37.

Cleaver, H. 1972.The Contradictions of the Green Revolution. The American Economic Review 62(1): 177-186.

Cotlear, D. 1986. Farmer-Education and Farm efficiency in Peru: The Role of Schooling, Extension Services & Migration. World Bank, Discussion Paper, Education and Training Series Report No. EDT49.

Converse, J. 1965. Some aspects of the adjustment of rural-to-urban migrant in Bogota, Colombia. Unpublished, Department of Agricultural, the Ohio State University.

Choi, K. and Kang, S. ?. “Agricultural mechanization and post-harvest technology in Korea” Unpublished.

David Stanway and Niu Shuping. 2012. “Analysis: China turns to machines as farmers seek fresh fields.” Available at: http://www.reuters.com/article/2012/11/13/us-china-agriculture-mechanisation-idUSBRE8AC15P20121113, accessed March 24, 2013.

Duran, J. and Massey, D. 1992. Mexican Migration to the United States: A Critical Review. Latin American Research Review 27(2): 3-42.

Francis, E. and Hoddinott, J. 1993. Migration and differentiation in western Kenya: A tale of two sub-locations. The Journal of Development Studies 30(1): 115-145.

Hiroyuki and Sheu. 2010.Agricultural Mechanization and the Smallholder Farmers in Nigeria. Policy note NO.22, International food policy research institute.

Ju Jinyan，Zhao Lin，Wang Jinfeng. Forecasting the total power of China’s agricultural machinery based on BP neural network combined forecast method. Computer and Computing Technologies in Agriculture VI,2013,392:85-93.

Leinbach, T. and Watkin, J. 1998. Remittances and Circulation Behavior in the Livelihood Process: Transmigrant Families in South Sumatra, Indonesia. Economic Geography 74: 45-63.

Murray, C. 1981. Families divided: the impact of migration labour in Lesotho. Cambridge: Cambridge University Press.

Mendola, M. 2008. Migration and technological change in rural households: Complements or substitutes? Journal of Development Economics, 85(1-2): 150-175.

M.M. Van den Berg et al. 2007. The impact of increasing farm size and mechanization on rural income and rice production in Zhejiang province, China. Agricultural Systems 94(3): 841–850.

Napasintuwong, Orachos. “Immigrant Workers and Technological Change: An Induced Innovation Perspective on Florida and U.S. Agriculture.” Dissertation 2004. University of Florida.

Neymark. 1964. migration differentials in education, intelligence and social background: Analysis of a cohort of Swedish males. Bulletins of the international statistical institute. University of Toronto Press.

Pessar, P. 1991. “Caribbean emigration and development.” In Padademetrious, D. Martin, G., and Philip,L, ed. The unsettled relationship: Labor migration and economic development. New York: Greenwood Press: 201-210.

Palmer, I. 1985. The impact of male out-migration on women in farming. West Hartford, CT: Kumarian Press.

Rempel, H. and Lobdell, R. 1978. The role of urban-to-rural remittances in rural development. The Journal of Development Studies 14(3): 324-341.

Stark, O. 1980. On the role of urban-to-rural remittance in rural development. The journal of development studies 16(3): 369-374.

Wei,Wang and hang,Chu. 2012. “China will realized the basic mechanization of main crops by 2020.” Available at: http://news.xinhuanet.com/politics/2012-09/26/c_113216868.htm, accessed March 22, 2013.