The Impact of Nonfarm Activities on Agricultural Productivity in Rural China

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Abstract. Although evidence abounds that the development of rural non-farm activities have increased rural household income and contributed to rural development, the underlying structure and mechanism of the linkage between agricultural productivity and non-farm activities is poorly understood. Using a unique panel dataset of Chinese villages, this article examines the mechanism by which non-farm activities influence agricultural productivity. I find that Chinese villages' non-farm revenue has a significant positive effect on agricultural land productivity. Although non-farm activities do withdraw labor out of agriculture and therefore dampen land productivity, that negative effect is negligible in comparison with the land productivity improvement brought by nonfarm revenue-financed infrastructure capital investment.

Key words: Rural non-farm activities, labor migration, agricultural productivity, infrastructure capital.

JEL codes: O13, Q18.

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The agricultural sector is the backbone of underdeveloped economies, providing the food supply and labor force for emerging manufacturing and service industries. But agricultural productivity is generally low in underdeveloped economies due to inefficiencies in production and exchange. The most notable hindrance to agricultural productivity growth is the imperfection of labor and capital markets. While employment opportunities are few in rural areas, labor shortages may arise in the peak season as an increasing number of rural residents are withdrawn to cities for better-paid jobs. Farmers in developing countries are frequently facing financial constraints to productive investments. Non-farm activities in rural areas seem to offer a promising solution to these problems by creating local employment opportunities and generating new sources of income for investment. Evidence is abundant that non-farm activities have made significant contributions to the growth of rural economies and to rural poverty reduction (Lanjouw and Lanjouw 2001; De Janvry et al. 2005; Démurger et al. 2010).

Non-farm activities can affect agricultural production through both labor and capital markets. The withdrawal of labor out of agriculture into non-farm activities may or may not negatively affect agricultural output, depending on the presence of surplus labor and the extent of rural labor market perfection (Bardhan and Udry 1999). In the absence of surplus labor, and if the labor market is thin, the labor withdrawal can reduce on-farm labor and agricultural output (Leones and Feldman 1998). If the labor market is functioning well, hired labor can substitute for lost family labor without compromising

output.

The New Economics of Labor Migration postulates that increased non-farm income may relax rural households' financial constraints and increase investment in new farming technologies (Stark and Bloom 1985). Remittances from family members working in cities allow rural residents to purchase high-quality seeds and fertilizers to boost crop yields; agricultural productivity also increases if migrant remittances are invested in technology and infrastructure. However, migrant remittances do not necessarily induce productive investment, especially in the absence of profitable investment opportunities. For example, De Brauw and Giles (2008) have found that migrant remittances have not brought productive investment in China's national rural household survey data.

This article tests these competing hypotheses using a panel of Chinese village data. The economic reform China launched in 1978 has brought new opportunities for rural residents to develop non-farm businesses. Rural China has since seen an unprecedentedly rapid growth of nonagricultural activities. Small manufacturing factories and service businesses in the form of Township and Village Enterprises (TVEs) emerged quickly across China and presently constitute the mainstay of the rural economy in China (De Janvry et al. 2005). TVEs have facilitated China's rural economy in a number of ways. They provide employment opportunities for rural household and raise their income. According to Liang (2006), from 1978 to 2003, TVEs raised the rural employment rate from 9.23 to 28.1 percent; the percentage of income from TVEs in rural households increased from 8 percent to 35.4 percent. He also pointed out half of the per capita income growth in rural China has come from TVEs in recent years and TVEs have

also promoted the growth of infrastructure and agri-business industry in rural China. Such infrastructure as irrigation, transportation, and electricity systems are crucial for agricultural productivity growth (Fan, et al. 2004; Chen and Ding, 2007).

The development of nonfarm activities has been uneven across China. Some TVEs in the coastal areas have been so successful that they have urbanized the surrounding rural areas, while many villages in western China do not have any non-farm activity. Our dataset is a three-year village panel covering most of China's provinces, which permits us to explore the regional variations in farm and non-farm activities. In particular, we examine how agricultural productivity is influenced by the flows of labor and capital between agricultural and nonagricultural activities within rural areas. Our analysis therefore contributes to the literature which has paid insufficient attention to the underlying structure and mechanism of the linkage between agricultural productivity and non-farm activities (Foster and Rosenzweig 2008).

Empirical Framework

Our empirical framework is a simple Agricultural Household Model. Output, Y, is produced with land, labor and capital according to a production function, $Y = Y(l, k, a)$. Assume the household's agricultural production function is Cobb-Douglas,

(1) $$Y = Al^{\alpha} k^{\beta}\ a^{r}$$

where A denotes the efficiency level of technology, determined by production conditions, such as rainfall, soil fertility, and the household's access to irrigation and electricity infrastructure. Symbol l stands for labor employed on farm, k indicates capital stock invested on farm. Assuming constant returns to scale, production function (1) can be

rearranged into the logarithm form:

(2) $$ln(Y/a) = lnA + \alpha ln(l/a) + \beta ln(k/a)$$

where Y/a stands for agricultural land productivity, l/a labor per unit of land area, and k/a capital stock per unit of land area.

If both labor and capital markets are perfect, households can hire labor in the labor market, and borrow money to invest in productive technologies. Labor movements from farm to non-farm activities have no impact on land productivity. However, if the labor is imperfect, labor withdrawal from farm activities to non-farm activities may impact agricultural land productivity.

Formally, we assume the household's total agricultural labor supply is L, and

(3) $$L = l + l^o - l^h$$

where l stands for the amount of time worked on farm, l^o denotes the amount of time worked off farm, and l^h indicates the amount of hired farm labor. In an imperfect labor market, the household may not successfully hire the needed farm worker. This means that in equation (3), l^h may be fixed. Increased off-farm labor employment implies a reduction in agricultural labor supply, thereby reducing the land productivity.

We assume the amount of capital stock invested on farm, k, is a function of the earnings from working on non-farm activities, i^o, money borrowed from the capital market, i^b, and other sources of household income, I.

(4) $$k = f(i^o, i^b, I)$$

where a positive relationship exists between k and i^o and between k and i^b. In an imperfect capital market, the household may not be able to secure the desired amount of credit for on-farm investment. This means that in equation (4), i^b may be fixed.

Increased non-farm earnings imply an increase in on-farm capital accumulation, and therefore higher land productivity.

When nonfarm activities withdraw labor out of agriculture, therefore, on-farm labor would decrease or remain unchanged, depending on the presence of surplus labor and rural labor market perfection; on-farm capital would increase or remain unchanged, depending on the availability of profitable productive investment and rural capital market perfection. Even if the negative labor drain effect and positive investment-inducing effect are each significant, the overall effects of nonfarm activities on land productivity are ambiguous, depending on the relative strengths of the two effects. In the ensuing empirical analysis, we test the following hypotheses: (1) the development of rural non-farm activities decreases agricultural labor employment; and (2) the development of rural non-farm activities stimulate agricultural investment. We then compare the labor drain and investment-inducing effects to assess the overall effect of rural non-farm activities on agricultural land productivity.

Our econometric model is the following three-equation reduced-form system:

$$L = \alpha_0 + \alpha_1 R + \alpha_2 R^2 + \alpha_3 P + \alpha_4 POP + \varepsilon_L \tag{5}$$

$$K = \alpha_0 + \alpha_1 R + \alpha_2 R^2 + \alpha_3 P + \alpha_4 POP + \varepsilon_K \tag{6}$$

$$Y = \alpha_0 + \alpha_1 R + \alpha_2 R^2 + \alpha_3 P + \alpha_4 POP + \varepsilon_Y \tag{7}$$

where the dependent variables in the three equations are time-demeaned data on agricultural labor employment L, agricultural capital stock K, and agricultural land productivity Y, respectively. The independent variables are time-demeaned data on non-farm revenue generated from non-farm activities R, its square term, total population in the villages POP and price of the crops in the village P. All the variables in the above

equations are in logarithm forms and are time demeaned data.

Crop price and the village's population are evidently exogenous to agricultural population choices. Revenue generated from non-farm activities in a village is arguably exogenous to agricultural production as well, because returns to most non-farm activities are much higher than returns to agriculture. China's rural nonfarm activities are frequently resource- or labor-intensive, and their development depends on natural resource endowments and such market access factors as transportation conditions and geographic locations.

Non-farm activities' effect on agricultural labor employment is measured by the elasticity of agricultural labor demand (5) with respect to non-farm revenue changes:

(8) $$\delta_{LR} = \alpha_1 + 2\alpha_2 R$$

The effect on capital accumulation is measured by the elasticity of agricultural capital demand (6) with respect to non-farm revenue:

(9) $$\delta_{KR} = \beta_1 + 2\beta_2 R$$

The overall effect on agricultural land productivity is measured by the elasticity of land productivity with respect to non-farm revenue:

(10) $$\delta_{YR} = \gamma_1 + 2\gamma_2 R.$$

Data

Our dataset is a panel derived from a nationwide village-level survey conducted by the Research Center for Rural Economy at China's Ministry of Agriculture. The panel includes more than 300 villages across all 31 provinces of China for years 2004, 2005, and 2006. The RCRE Survey Offices across China coordinated the survey. The heads of

the surveyed villages each year submit their village-level data to the local RCRE Survey Offices. The surveyed villages were chosen in a way that the survey covers villages in all economic development stages. After deleting observations with missing values, we are left with an unbalanced panel of 384 valid observations for 136 villages from 2004 to 2006. The map of China in figure 1 shows the geographic distribution of the village observations in our dataset. All China's provinces but Bei Jing, Hai Nan or Xi Zang provinces are covered in our sample. There are more than 90 villages from provinces with strong agricultural development, including Shan Dong, He Nan, Hu Bei, An Hui, Hu Nan, He Bei, Shan Xi, Si Chuan, Shan Xi, Gan Su, Ji Lin, Hei Longjiang, and Liao Ning. There are 27 villages from provinces with strong industrial development, such as Guang Dong, Zhe Jiang, Jiang Su, Shang Hai, Fu Jian, and Tian Jing.

Table 1 contains the descriptive statistics of the key variables used in our analysis. Agricultural labor employment (L), capital stock (K), and output (Y) are each expressed on a per mu basis (1 acre = 6.07 mu). Agricultural labor employment is measured as the number of people working in crop production. Agricultural capital stock is measured by the total value of farm machinery, cattle, and irrigation and electricity infrastructure in the village. Revenue generated from non-farm activities (R) is calculated by the sum of manufacturing, construction, transportation, commercial and other service revenues generated in a village. Crop price, P, is a weighted aggregate of crop prices with weights being the crop acreage shares in individual villages. The crop prices data are the agricultural price indices reported in the Chinese Agricultural Statistics Year Book. We grouped various crops into three categories: grains, cash crops and fruits. Agricultural land productivity Y is measured by total crop revenue per mu of land. The village's total

population POP exhibits some variations over the three years, and therefore included in the regressions. Such variations likely reflect labor migration, birth, marriage, or death.

Our key explanatory variable, revenue generated from non-farm activities exhibits a large cross-sectional variation. The minimum is 8,560 Yuan, and the maximum is 0.87 billion Yuan. The standard deviation is about 4.5 times the mean. In the eastern coastal provinces such as Zhe Jiang, Guang Dong, Jiang Su, there are many large township and village enterprises in the manufacturing, textile and service sectors, while in such western provinces as Gan Su and Qing Hai, non-farm activities are sparse and have much lower revenue generated from non-farm sources. The spirit of our empirical analyses is to explore the extent to which such large regional variations in non-farm revenue account for the differences in production choices and agricultural productivity.

Results

Table 2 presents the regression results on land productivity, labor and capital demand. The SUR model is used to account for correlations between the three equations. All the variables are demeaned to account for unobservable village-specific variables. Columns (1), (3) and (5) show the results from the three-equation model including the square term of non-farm revenue in each equation. The quadratic term of non-farm revenue is not significant in the labor and capital demand equations. Columns (2) and (4) show respectively the labor and capital demand regressions without the quadratic non-farm revenue term.

Regression (2) shows that villages with higher non-farm revenue tend to have a lower labor use per mu; that association is significant at the 1 percent level. Labor

demand's response to nonfarm revenue, however, is highly inelastic; a 10% increase in a village's non-farm revenue reduces agricultural labor use per mu by 0.4%, ceteris paribus. It seems that agricultural labor in rural China has responded to price signals and moved to the non-farm sectors for higher wages. But this result alone does not necessarily imply that agricultural land productivity will be compromised by the withdrawal of labor to non-farm activities. In the presence of surplus labor in China's populous agricultural sector, the withdrawal of family labor to nonfarm activities does not affect agricultural production (Lewis 1954). That result, however, does indicate the imperfection of labor markets in rural China. This is because if the rural labor market is perfect, labor withdrawal from agriculture to nonagricultural activities can be substituted for by hired workers (Benjamin 1992).

Regression (4) shows that non-farm income has a significant positive effect on agricultural capital investment. A 10% increase in non-farm revenue boosts per mu capital stock by 4.2%. This result is consistent with the New Economics of Labor Migration: nonfarm income relaxes financial constraints the farmers face and facilitates productive investments. Since village-level agricultural capital in our data is a mix of private capital, such as machinery and cattle, and collective goods, such as irrigation and electricity infrastructure. It is interesting to further investigate which of the two types of investment has been induced by increased non-farm income. I examine this problem in the next subsection.

Regressions (2) and (4) show that crop price's effects on labor and capital demands are not significant. Regression (5) shows its effect on agricultural land productivity is significant and positive. A 10% increase in crop price boosts agricultural

land productivity by 1.4%. Regressions (2) and (4) show more populous villages have higher on-farm labor employment and higher agricultural capital stock. However, agricultural land productivity seems independent of village population.

Regression (5) indicates a U-shape relationship between agricultural labor productivity and non-farm revenue. That is, agricultural land productivity first decreases with non-farm revenue, then increases after a threshold. That threshold is estimated at 17,072 Yuan (2,630 US dollars). In light of non-farm activities' negative effects on agricultural labor employment and positive effects on agricultural capital accumulation, this result indicates that the negative labor effect dominates the positive capital effect when non-farm revenue is below the threshold, and the opposite is true when it is above the threshold. Because about 99% of villages in my sample have a non-farm revenue exceeding 17,072 Yuan, and because 17,072 Yuan is an extremely small amount for non-farm revenue, the overall contribution of non-farm activities to land productivity is strongly positive and mainly occasioned through capital investment.

Distinguishing Private and Public Investments

Although the table 2 results ascertain that non-farm activities have significantly stimulated agricultural investment in rural China, it is not clear whether the investment is made at the individual household or collective village level. This is because agricultural capital used in table 2 is a mix of private capital, such as machinery and cattle, and public goods, such as irrigation and electricity infrastructure. In China, the provision of such public goods as irrigation and electricity infrastructure is frequently organized by the village government. The funding source includes government appropriations and subsidies, village members' contributions, and tax revenue from Township and Village

Enterprises.

Table 3 presents the results from a four-equation SUR system where the aggregate capital demand in table 2 is replaced with the private and public capital demands, denoted by PK and CK, respectively. Columns (1), (3), (5) and (7) are the regressions including squared non-farm revenue as an independent variable. Because the quadratic terms in regressions (1), (3) and (5) are nonsignificant, we focus our discussion on regressions (2), (4), (6) and (7).

The results show that non-farm revenue's effect on private agricultural capital stock is insignificant, but its effect on agricultural collective capital stock is positive and significant at the 1% level. Indeed the parameter on non-farm revenue in table 3's regression (6) is equal to that in table 2's regression (4), indicating all the non-farm revenue-induced investments are public goods. This result is consistent with the observation that most Chinese farmers are small land holders with limited profitable investment opportunities. Between the private capital such as machinery and public capital such as irrigation and electricity infrastructure, the latter seems to have a much greater contributions to productivity improvements.

Figure 2 plots the public and private investments in agriculture rural China from 1981 to 2006. Before 1993 public investments in rural China were at a lower level and grew more slowly than private investments. This is due likely to the immaturity of non-farm activities in rural China in the 1980s and early 1990s. With the rapid development of non-farm activities in rural China in the 1990s, public investments have rapidly caught up private investments.

Conclusions

Rural non-farm activities are an important driving force for sustained income growth and economic development in the rural world. The importance of rural non-farm activities to income diversification and poverty reduction has been well recognized in the literature. Their impacts on agricultural productivity, however, remain at most elusive to researchers and policy makers. Policy makers in developing countries are frequently concerned that the development of non-farm activities may compromise agricultural production and threaten food security. Using a panel of village data from China, we have examined the extent to which non-farm activities influence agricultural productivity in rural China. An important contribution of our analysis is an improved understanding of the underlying structure and mechanism of the linkage between agricultural productivity and non-farm activities.

Our analysis suggests that the policy makers' concerns mentioned above are unnecessary. Non-farm activities do seem to withdraw labor out of agriculture and therefore reduced land productivity, other things equal. This is a rational response of labor to higher earnings in non-farm sectors. But non-farm revenue is found to strongly increase agricultural capital stock, indicating that increased household income and village tax revenue from non-farm activities have been invested to increase agricultural productivity. The negative labor drain effect is overwhelmingly dominated by the positive investment-inducing effect. Altogether, non-farm activities contribute greatly to agricultural productivity growth.

Furthermore, I have found that the growth in non-farm income has induced investment in infrastructure capital through collective provision, but has not increased

private capital such as machinery and livestock power. Land is in small tracts for rural Chinese households, so investment in large machinery may not be profitable. But irrigation, electricity, and transportation infrastructure had been in poor conditions in rural China, so that upgrading them boosted agricultural productivity significantly.

Maintaining a balanced, sustained economic growth is a great challenge for policy makers worldwide. Our study suggests that governments should create more non-farm employment opportunities to increase and diversify household income. Non-farm activities not only are the engine of economic growth, but also help reduce poverty and income inequality. The paucity of private investment in my dataset indicates that China's agricultural productivity growth has been held back by fragmented farmland and limited profitable investment opportunities for farmers. Therefore, land reform and increased research and extension efforts are needed in China to stimulate agricultural productivity growth.

Although our study is based on a panel of Chinese villages, the results apply to other developing countries. Besides the commonly adopted poverty reduction policy, such as input subsidy, policy makers in poor countries should support development of non-farm activities and improve infrastructure in rural areas.

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Figure 1. Geographic Distribution of Village Observations

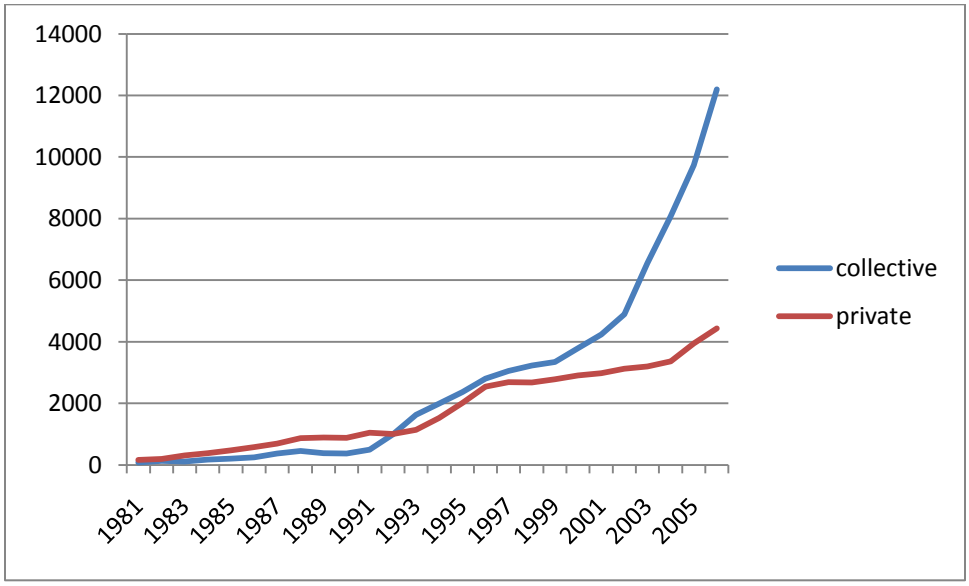

Figure 2. Growth of Public Investments and Private Investments

Table 1. Summary Statistics of Key Variables Analyzed

Variable	Definition	Unit	Mean	Std. Dev.	Minimum	Maximum
L	Agricultural labor employment per mu	Headcount	0.28	0.59	0.01	9.35
K	Agricultural capital per mu	100 Yuan	5.60	24.92	0.01	301.37
Y	Agricultural land productivity	100 Yuan	25.67	127.34	0.19	1,852.17
R	Non-farm Revenue	100 Yuan	184,481	859,415	86	8,714,151
P	Price for the crops planted in the village	Yuan	6.94	4.34	0.1	18.39
POP	Total population in the village	Headcount	1,811.01	1,180.93	217.00	9,487.00

Table 2. The Impacts of Non-farm Revenue on Labor and Capital Demands and Land Productivity

	Agricultural Labor Employment		Agricultural Capital Stock		Agricultural Land Productivity
	(1)	(2)	(3)	(4)	(5)
Nonfarm Revenue	-0.12	-0.04***	0.39*	0.42***	-0.72***
	(0.09)	(0.02)	(0.23)	(0.04)	(0.19)
Revenue Squared	0.00		0.00		0.07***
	(0.00)		(0.01)		(0.01)
Crop Price	0.05	0.04	0.07	0.07	0.14*
	(0.03)	(0.03)	(0.08)	(0.08)	(0.07)
Village Population	0.45***	0.45***	0.80***	0.80***	0.20
	(0.11)	(0.11)	(0.31)	(0.31)	(0.29)
R-Square	0.06	0.06	0.21	0.21	0.46

* Significant at 10 percent;
** Significant at 5 percent;
*** Significant at 1 percent.

Table 3. Estimation Results on Four-equation System

	Agricultural Labor Employment		Agricultural Private Capital Stock		Agricultural Collective Capital Stock		Agricultural Land Productivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nonfarm Revenue	-0.12	-0.04***	0.23	0.06	0.40	0.42***	-0.72***
	(0.09)	(0.02)	(0.34)	(0.07)	(0.27)	(0.05)	(0.20)
Revenue squared	0.00		-0.01		0.00		0.07***
	(0.00)		(0.02)		(0.01)		(0.01)
Crop Price	0.05	0.04	0.09	0.09	0.07	0.08	0.14*
	(0.03)	(0.03)	(0.11)	(0.11)	(0.09)	(0.09)	(0.07)
Village Population	0.45***	0.45***	-0.37	-0.37	0.86**	0.86**	0.20
	(0.11)	(0.11)	(0.46)	(0.46)	(0.36)	(0.36)	(0.29)
R-Square	0.06	0.06	0.01	0.01	0.16	0.16	0.46

* Significant at 10 percent;
** Significant at 5 percent;
*** Significant at 1 percent.