Received 25 October 2017
Revised 6 June 2018
Accepted 7 June 2018

Heterogeneous effects of rural-urban migration on agricultural productivity

Evidence from China

Xinjie Shi
Australian Centre on China in the World, College of Asia and the Pacific, Australian National University, Canberra, Australia

Abstract

Purpose – The purpose of this paper is to examine the impacts of rural–urban migration on agricultural (labor) productivity in China.

Design/methodology/approach – This paper closely follows the framework of Rozelle *et al.* (1999), Taylor *et al.* (2003) and Atamanov and Van den Berg (2012)—new economics of labor migration—to demonstrate the heterogeneous effects of migration on agricultural productivity, using simultaneous equations extended by an interaction term of off-farm income and household wealth.

Findings – The results empirically verify two key theoretical predictions: the loss of labor available for agricultural activities decreases rice yield per worker per day, and the off-farm income that may relax liquidity constraints has a positive offsetting effect, which becomes weaker with increasing household wealth. The final calculation based on these two contradictory influences indicates that the lost-labor effect dominates across all levels of household wealth, resulting in a negative net impact of rural–urban migration on agricultural productivity. The key results are shown to hold for land productivity as well.

Originality/value – To the best of the author's knowledge, it is the first paper to examine the impacts of rural–urban migration on labor productivity and the heterogeneity across households with different levels of wealth. A major policy issue facing national leaders is whether the massive and ongoing outflow of labor will be a threat to China's rural development and its food security in the future. This paper provides insightful ideas in a different way.

Keywords China, Labour productivity, Rural-urban migration

Paper type Research paper

1. Introduction

The flow of labor out of agriculture witnessed in world history has been an indispensable feature of economic development both in developed countries and in the developing world. The success story of China's rapid urbanization in recent decades is inextricably meshed with the story of migrant workers toiling for subsistence wages in urban areas (Cai *et al.*, 2009). Since 1979, China has witnessed remarkable agricultural growth (Lin, 1992), and China's urban population has grown by about 440m to reach 666m in 2010 (Chan, 2013). In March 2014, the central government promulgated the National New-type Urbanization Plan to set a target for China's urban population to increase by one percentage point a year to reach 60 percent by 2020 (Bai *et al.*, 2014). The unprecedented scale of urbanization and rural–urban migration has—and will continue to—impact on China's development in profound ways, with Chinese policy-makers facing the dual tasks of facilitating food production for the world's largest population and providing inexpensive labor for emerging industries (Wang *et al.*, 2014). While significant emphasis has been placed on understanding the urban dimension of these changes in the past, less has been said about the impact of massive rural-to-urban migration on China's agricultural capabilities—and the extent to which it might threaten China's food security in the future.

A prolific literature in economics attempts to answer this question from many different aspects. The new economics of labor migration (NELM) literature has played an important

China Agricultural Economic Review
Vol. 10 No. 3, 2018
pp. 482-497

1756-137X
DOI 10.1108/CAER-10-2017-0193

role in emphasizing the household as the decision-making unit, which sends out migrants as a strategy to diversify income sources and overcome credit and risk constraints (Taylor, 1999; Murphy, 2006). Under the NELM framework, Rozelle *et al.* (1999) trace the complex linkages between migration, remittances and agricultural productivity (maize yield per mu). Taylor *et al.* (2003) and Atamanov and Van den Berg (2012) use a similar model to explore the impacts of migration on agricultural income. These all verify the predictions of NELM that labor migration will cause a reduction in agricultural output or income via a "lost-labor effect," but that investment from non-agricultural earnings (including remittances and off-farm income) can compensate for this by allowing households to overcome liquidity and credit constraints.

However, little is known about the net effects of rural–urban migration on agricultural labor productivity (yield per worker per day). Besides, there is little rigorous research that has examined the different effects of non-agricultural earnings for households with different endowments—most obviously, with differences in the number of workers in each household, and household capital as well. To the best of our knowledge, only Atamanov and Van den Berg (2012) have used the amount of owned land to test whether the impact of remittances on agricultural income is distinguished across farming households. And they find that it is: those with more land are less liquidity constrained, so the positive impacts of remittances become weaker with increasing land size.

This paper contributes to the existing realm of migration literature underpinned by NELM by providing new empirical evidence of the effects of lost-labor and non-agricultural earnings on agricultural activities, using Research Center for Rural Economy data. This evidence demonstrates the different effects of non-agricultural earnings on agricultural labor productivity across households with different levels of wealth. The fundamental hypothesis, besides the negative lost-labor effect, is that there is a compensating effect of non-agricultural earnings, which decreases with an increase of household wealth.

To accomplish the objectives, the paper continues as follows. Section 2 reviews the key theoretical considerations and previous empirical findings. Section 3 presents the data and empirical strategy used in the empirical analysis. Section 4 discusses the empirical results, followed by conclusions in Section 5.

2. Background

In the earliest migration models (Lewis, 1954; Todaro, 1969; Harris and Todaro, 1970) that are associated with neo-classical theory, migration decisions are carried out by individuals based on a comparison of expected costs and benefits (Deininger *et al.*, 2014; De Janvry *et al.*, 2015; Tao and Xu, 2007; Yan *et al.*, 2014). Rural–urban migration results in a loss of human resources for rural areas. This labor loss has zero opportunity cost if labor is surplus in the villages (Lewis, 1954). That is, village households can send out migrants without suffering a loss in production, thus labor productivity increases. However, this is not the case in the situation where there are labor shortages in rural areas. In addition, if those who migrate take capital (human or financial) with them, the capital stock in rural areas decreases, reducing the productivity of other inputs, such as labor (Berry and Soligo, 1969; Rivera-Batiz, 1982). Abundant research has pointed out the importance of human capital in determining migrant wages (Adda *et al.*, 2014) and the development of villages (Taylor and Martin, 2001).

The issue of whether migration can promote the development of migrant-sending communities has been a heated debate for decades. On the one hand, "migration optimists" hold the view that rural–urban migration facilitates local development, through enhancing rural investment from the remitted off-farm income, as well as the experience, skills and knowledge that migrants acquire out of the village and that, upon returning, aids their

village's economic take-off (Beijer, 1970; Penninx, 1982). On the other hand, migration pessimists, inspired by the structuralist paradigm, have argued that migration triggers the drainage of human capital (i.e. "brain drain") and the breakdown of traditional stable village communities. They further claim that remitted off-farm income, rather than being the primary source of investment as viewed by the optimists, are instead mainly spent on luxury goods and "consumptive" investment (Adams and Cuecuecha, 2010; Gupta *et al.*, 2009).

The NELM framework provides new insights into the impact of labor migration on the agricultural activities in rural areas. It has shifted the migration debate toward several key points: it offers a more subtle view, in which both positive and negative effects are possible, it perceives migration as the risk-sharing behavior of households, not individuals, and it stresses that non-agricultural earnings from migration can play a pivotal role in providing a potential source of investment capital, which is especially important in the context of imperfect markets for relaxing credit (capital) and risk (insurance) constraints (De Haas, 2006; Taylor, 1999).

Rozelle *et al.* (1999) were among the first to present a formal model of NELM. In this model, a household may invest a fixed resource in either a low-productivity or high-productivity technology. Migrants play the role of financial intermediaries, enabling rural households to overcome credit and risk constraints on investing in the high-productivity technology. The model was further extended when a household faces more than one production choice (Atamanov and Van den Berg, 2012; Taylor *et al.*, 2003). In this case, rural households can choose between low-return agricultural activities, high-return agricultural activities, and migration. Specifically, the impact of migration is twofold as it triggers lost-labor effects for agricultural activities but may also result in more investment from non-agricultural earnings.

In the NELM framework, the lost-labor effect is regarded as the decrease in the number of family workers. This is often the case in rural areas of developing countries where a household relies on family labor and there are seasonal labor shortages, so it may be difficult to replace the lost family labor by hired labor (Atamanov and Van den Berg, 2012). This negative lost-labor effect has been shown in several empirical studies (Rozelle *et al.*, 1999; Taylor *et al.*, 2003; De Brauw, 2010). However, there are at least two more mechanisms that should be emphasized. In the case of rural–urban migration in China (and presumably elsewhere as well), when we consider the lost-labor effect on agricultural productivity due to the changes in human capital, it is necessary to assess this with an understanding of the productivity of left-behind residents, for example, the elderly and women, who have tended to be less educated and skilled than their migrant counterparts (Hunt, 2004). In this case, the lost-labor effect is likely to be even larger—i.e. with a more negative impact on productivity.

Building on this point, "ageing" issues caused by labor outflow may affect agricultural productivity. Li and Zhao (2009a) use a dummy variable "whether the farm workers are mostly controlled by the elderly" as a proxy to analyze the effects of ageing, based on data collected from the Office of Fixed Investigation Points in Rural Areas in Liaoning Province from 2003 to 2006. Their results indicate that the ageing of rural labor has negative effects on agricultural production owing to the reduction of productivity. Others question this judgment about the disadvantages of old workers' physical power and human capital (Li *et al.*, 1999; Hu and Zhong, 2012), and maintain that group decision making and mechanization can offset any possible negative effects (Yang and Zhong, 2010). Using standard regression techniques, De Brauw (2014) also finds that when younger rural residents find employment outside the village, agricultural productivity is not affected or, in other words, that there is no lost-labor effect.

Similarly, the distinctive effects of the "feminization" of rural labor have sparked heated debates. Mu and Van de Walle (2011) uses a regression model with data from the China

Health and Nutrition Survey to find that the "left behind" (*liu shou*) women are doing more farm work than would have otherwise been the case. That is, the productivity of women for farm work plays a pivotal role in determining the agricultural production. Chang *et al.* (2011) hold that the notion of "men working while women farm (*nan gong nv geng*)" will be beneficial for agricultural production in rural China, while some others insist that agricultural feminization goes against the rural economy—that is, that output and productivity suffer when only women are left on the farm (Li and Zhao, 2009b; Bindlish *et al.*, 1993).

Besides the lost-labor effect triggered by migration, the potential impact of non-agricultural earnings can also help mitigate the credit or financial constraints faced by poor rural households. In most of the relevant studies, remittances, as a portion of the off-farm income, are widely used. The term "remittance" refers to the money that migrant workers send back to their communities of origin, that is, their home villages (Murphy, 2006). The associated research examines several related issues including what determines migrants' propensity to remit and the amount they remit (Cai, 2003); how remittances are used, such as for productive investment and consumptive investment (Adams and Cuecuecha, 2010; De Haas, 2006; De Brauw and Rozelle, 2008); and the impacts of remittances on local development, such as poverty reduction (Gupta *et al.*, 2009; Jimenez-Soto and Brown, 2012), income inequality and re-distribution (Barham and Boucher, 1998; Garip, 2014) and living standards of families (Bouoiyour and Miftah, 2015).

Meanwhile, some studies focus on the effects of total off-farm income on farm economic performance and food security (Fernandez-Cornejo *et al.*, 2007; Babatunde and Qaim, 2010; Pfeiffer *et al.*, 2009). By estimating the scale economies for corn and soybean farms for 1996–2000, Fernandez-Cornejo *et al.* (2007) find that households operating smaller farms may compensate for the scale disadvantages of their farm business activities with the advantages of off-farm income-generating activities. Babatunde and Qaim (2010) find a positive net impact of off-farm income on household food security, using farm survey data from Nigeria, confirming that off-farm income contributes to higher food production and farm income by easing capital constraints. Pfeiffer *et al.* (2009) explore the effect of off-farm income on agricultural production activities in Mexico, using data from the 2003 Mexico National Rural Household Survey. The results illustrate that off-farm income has a negative effect on family labor in crop production, but a positive effect on the use of purchased inputs. This indicates a slight efficiency gain, which they assume to be an effect on total factor productivity.

Looking deeper into the impacts of migration on agricultural development, there is much more detail to be found from three key papers that use NELM as the principal framework and simultaneous equations as the primary method. First, focusing on agricultural productivity, Rozelle *et al.* (1999) construct a recursive system of three equations and, using a data set of 787 farm households from 31 villages in China, find that remittances can offset the negative effects of lost labor on land productivity (maize yield per mu). Second, looking instead at agricultural income, Taylor *et al.* (2003) use a similar model to show that migration has a negative effect on household cropping income in China although it does not have a negative net impact on yields. And third, following a similar approach, Atamanov and Van den Berg (2012) use a unique representative household budget survey to test two additional hypotheses derived from NELM: the positive impact of remittances is not expected to be homogeneous across farmers with different land size, and the negative lost-labor effect is not likely to be equal for seasonal and permanent migration. In their examination of the determinants of crop income in the Kyrgyz Republic, they find that the negative lost-labor effect is only significant for permanent migrants and the offsetting effects of remittances decrease with farm size.

Neither Rozelle *et al.* (1999) nor Taylor *et al.* (2003) consider the possibility that the impact of remittances, or other forms of off-farm income, are likely to vary across households with different levels of wealth, capital or land. Atamanov and Van den Berg (2012) improve on this shortcoming by exploring these heterogenous impacts using land size as a proxy for household assets. However, this is not a perfect proxy for household assets that can help to relax credit constraints in the Chinese context, since rural land cannot be sold (or effectively converted into spendable cash).

Furthermore, while the NELM framework has been applied to the issues of agricultural production, land productivity (yield per mu) and rural household incomes, very little attention has been paid to the impact of migration on labor productivity (yield per worker per day), which is not only associated with how much yield is achieved, but also linked with how much and what kind of labor migrates out of the agricultural sector. Two key hypotheses are hence raised, based on the extension of the NELM framework, to focus on labor productivity and consider heterogeneity across households with different assets: the loss of labor available for agricultural activities decreases rice yield per worker per day, and the off-farm income that may relax liquidity constraints has a positive offsetting effect, which becomes weaker with increasing household wealth. This indicates that the net effect of migration on labor productivity will depend on the magnitudes of the opposite effects of lost-labor and non-agricultural earnings and is likely to differ in cases depending on whether migrants with high or low productivity depart from rural areas.

3. Data and empirical method

3.1 Data description

The above background represents the reality in China from a national perspective. To look more closely at the micro underpinnings of the national data, we wish to investigate the impacts at the household level. Some of the data sets used in some of the most rigorous research on this topic are now out of date (Rozelle *et al.*, 1999; Taylor *et al.*, 2003). The data used in this research are from cross-section household data in 2012 from a National Fixed Point Survey in China. After matching individual information with household attributes, the survey consists of 19,094 household samples across 334 villages. One of the key advantages of this data set is that input and output were collected for each crop rather than all crops, which allows for more detailed analyses.

Table I shows the descriptive statistics of the main variables used in this study. The mean value of rice yield for the households in the sample is 2,267 kilograms. Means for rice yield per worker per day[1] and per unit area (mu) are 19.0 and 513.8 kilograms, respectively. The mean value of the number of migrants is close to 1 while the maximum is 9. On average, a household has 27,702 yuan of fixed assets and migrants generate 18,554 yuan off-farm income by working in urban areas, of which 5,163 yuan will be sent back to their hometown as remittances. The average family size in the sample is close to four, three of whom contributing to the agricultural production activities. Female workers account for a relatively large proportion of each household, averaging 60 percent. Among these households, an average of 4.7 mu of land and 1973 yuan of fertilizers were used for rice production.

3.2 Empirical strategy

For the empirical strategy, the issues of reverse causality and sample selection bias are important concerns. In particular, it is possible that households with migrants may be more productive than those without and that the most productive workers migrate away from agricultural work, which would create an upward bias on the coefficient of migration in an OLS regression seeking to explain labor productivity. Conversely, it is possible that households with migrants are less productive, with the bias then working in the opposite direction.

Variable	Obs	Mean	SD	Min	Max
Rice yield	5,477	2,267.4	2,769.0	0	2,9425
Yield per worker	5,332	911.8	1,198.3	0	9,940
Yield per mu	5,354	513.8	235.0	0	5,522
Yield per worker per day	4,877	19.0	22.43	0	425
Wealth	19,094	27,701.9	159,441.6	0	1.130e + 07
Number of migrants	19,094	0.9	1.1	0	9
Remittance	1,235	5,163.4	15,142.1	0	310,000
Off-farm income	19,094	18,554.4	36,860.0	0	2.000e + 06
Education	18,538	7.0	2.5	0	18
Experience	18,532	41.6	12.1	0	88
Family size	19,062	3.9	1.6	0	33
Total workers	18,490	2.7	1.6	0	31
Number of old workers	19,094	0.4	0.7	0	4
Share of old workers	18,007	0.2	0.3	0	1
Number of female workers	19,094	1.6	0.7	1	10
Share of female workers	18,007	0.6	0.2	0.03	1
Number of children	19,094	0.7	0.8	0	5
Total land	16,104	9.0	13.6	0	350
Fertilizer expenditure	14,261	1,972.5	2,845.5	0	119,000
Rice land	5,490	4.7	7.0	0	321

Table I.
Descriptive statistics

This could be the case, for example, if households were essentially "forced" to send members to the city because their household productivity (and hence income) was too low—that is, low agricultural productivity acting as a migration "push" factor. In other words, we may be worried about the results of the lost-labor effect is due to the fact that less productive households are "selected to migrate." It suggests a concern about whether productivity (the dependent variable) will affect migration (the main independent variable). According to the raw survey data, this latter outcome appears more likely: households without migrants produce, on average, 7 kg more rice per day than those with migrants. We deal with this problem by using a three-stage least squares (3SLS) estimator, which applies an IV procedure to produce consistent estimates (Scharf and Rahut, 2014).

We closely follow the methods of Rozelle *et al.* (1999), Taylor *et al.* (2003) and Atamanov and Van den Berg (2012), who estimate the impacts of migration based on simultaneous equations. We further extend their methods (Rozelle *et al.*, 1999; Taylor *et al.*, 2003; Atamanov and Van den Berg, 2012) and use a specification in which we add an interaction term of off-farm income and household wealth:

$$Y = \alpha_0 + \alpha_1 M + (\alpha_2 + \alpha_3 A)R + \alpha_4 Z_y + \varepsilon_y, \tag{1}$$

$$R = \beta_0 + \beta_1 M + \beta_2 Z_r + \varepsilon_r, \tag{2}$$

$$M = \delta_0 + \delta_1 Z_m + \varepsilon_m, \tag{3}$$

where Y denotes labor productivity. As the households in the sample directly report the total number of workers and days for rice production, it is possible to calculate rice yield per worker per day. This includes the days worked in rice production by those who are classified as migrants, but may have spent a considerable part of the year working on the farm at home. M is the number of migrants per household who work outside of the village for more than six months and α_1 represents the lost-labor effects. R is the amount of non-agricultural earnings while A represents the amount of household wealth (value of

fixed assets) in yuan. Non-agricultural income will play a role in relaxing the credit and risk constraints in an NELM context by enabling households to invest more in agricultural production. However, we expect that the effects of non-agricultural earnings will become weaker with increasing wealth, that is, α_2 and α_3 to be positive and negative, respectively.

The variables Z control for distinguished demographic, human capital and physical capital attributes across households. The most pivotal demographic variables hypothesized to affect the rice yield per worker per day include the ratio of old workers to overall workers and the ratio of female workers to overall workers. As noted in the literature review, there is no consensus about how ageing and feminization will affect agricultural productivity in the case of China. In the migration equation, we also control for family size and the number of children as households with larger family size have a higher probability of sending out more migrants. The effects of the number of children depend on the magnitude of two different sides of the impacts—a "push" side that is associated with more migrants to earn more money to support the children, and a "pull" side that is associated with fewer migrants as the children need to be taken care of by the adults.

To control for differences in human capital characteristics, we follow Rozelle *et al.* (1999) and Taylor *et al.* (2003) and include measures of education and experience in all equations. An extensive literature finds evidence of the impacts of schooling and other human capital on crop production (Begum *et al.*, 2012) and migration (Taylor and Martin, 2001; Fu and Gabriel, 2012). In this case, we use the household head's years of schooling and years in the labor force, which is calculated by the formula $E = A - S - 6$, where E represents experience, A years of age, and S years of schooling (Mincer, 1974). It is possible that more educated and experienced household heads are likely to have more educated household members, who may be more likely to migrate. However, while this is possible, it is by no means certain—and indeed, the results on this coefficient are mixed, and ultimately insignificant in what follows. Besides, there is a high potential that education and experience of the head may stimulate agricultural productivity if he or she plays an essential role in the production process.

To measure the physical capital differences across households, we include two capital-related variables in all equations: land holdings and household wealth. Note that we use the size of land for rice production in the productivity equation and the total land size in the other two equations. Expenditure on fertilizer is also included in the productivity equation. There should be no controversy that land and fertilizer will have positive effects on the rice productivity. Unfortunately, we have no details for the village information. Instead, we use the village dummies[2] to control for potential differences across households.

4. Results and discussion

4.1 Migration equation

As the number of migrants in a household is not a continuous variable, Taylor *et al.* (2003) uses a Poisson functional form to estimate the migration equation. Here, we follow their idea and mainly focus on the OLS results, while we also provide the estimated results from Poisson regression and zero-inflated Poisson regression (ZIP) that is more appropriate if the sample contains too many zero outcomes.

It is clear that the main results are consistent among these regressions (Table II). A larger family is more likely to send out more labor (row 3). The share of the old has a negative effect, which indicates that they are less likely to migrate (row 4). With regard to the number of children, we find a result consistent with Rozelle *et al.* (1999)—a negative and significant coefficient, although with a much smaller magnitude. This suggests that the "pull" side of migration noted above is dominant in the survey year. There are two potential explanations for the negative effect of land size. The first, and most obvious, is that more land requires more labor. The second, supported by Atamanov and Van den Berg (2012), is that small farms with less land are more liquidity constrained than households with a

	(1) OLS	(2) Poisson	(3) ZIP
Education	−0.00588* (−1.70)	−0.00695 (−1.59)	−0.00695 (−1.59)
Experience	−0.00282*** (−3.52)	−0.00461*** (−4.45)	−0.00461*** (−4.45)
Family size	0.228*** (29.50)	0.198*** (27.52)	0.198*** (27.52)
Old	−0.204*** (−17.55)	−0.244*** (−15.47)	−0.244*** (−15.47)
Female	0.189*** (14.37)	0.219*** (15.98)	0.219*** (15.98)
Children	−0.208*** (−17.85)	−0.173*** (−13.65)	−0.173*** (−13.65)
Land	−0.00473*** (−5.56)	−0.00593*** (−3.56)	−0.00593*** (−3.56)
Wealth	−0.000000393*** (−5.99)	−0.000000710*** (−4.70)	−0.000000710*** (−4.70)
Constant	−0.246 (−1.28)	−1.947*** (−3.86)	−1.947*** (−3.86)
Village fixed effect	Yes	Yes	Yes
n	15,626	15,626	15,626

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table II. Migration equation

relative abundance of land—and hence need more migrants to relax those constraints. Conversely, the finding that wealthier households are less likely to send out migrants (row 8) suggests that rich households are less liquidity constrained and push factors are not that important to them.

One of the effects beyond our expectation is that the experience of the household head negatively affects the migration decision in all of these four equations. Generally, a more experienced worker is more likely to migrate. But we do not think it will have a large influence on the number of migrants in the household. Actually, when we regress the equation with a 3SLS method in a cursive system, the effect is insignificant (Table IV).

4.2 3SLS results

As shown in the literature review, there is a wealth of relevant literature that uses remittances as the measurement for the investment on agricultural activities from non-agricultural earnings (Rozelle *et al.*, 1999; Taylor *et al.*, 2003; Atamanov and Van den Berg, 2012). We first run a baseline regression without the interaction using 3SLS method, with the results reported in Table AI (column 1). For the key coefficients of interest, we find a negative effect of lost-labor, but there is no evidence for the offsetting effect of remittances as the coefficient is not significant. We further include the interaction term of remittances with wealth and run the regression again. The results in Table AI (column 2) do not show large changes and the coefficient of remittances is still not significant. Note, however, that our original sample consists of 19,094 households, but there are only 278 observations left for the regression. After checking the data set, we find that remittances have 17,858 missing observations, which is the main reason for this substantially reduced sample size. Respondents may be very sensitive when answering questions that are associated with money. Some of the respondents may not even know what remittances mean and how much they send back in different ways in a year. These factors may well contribute to either missing or inaccurate information regarding remittances. Fortunately, our data allows us to use another proxy for non-agricultural earnings—off-farm income that is earned by the migrant workers in urban areas. This is arguably a better measure as migrant workers know more about how much they earn than how much they send back in a year. It also, importantly, provides many more observations (a subsample of 4,671 households) for the analysis, and turns out to be an important determinant of productivity, as seen below.

Before turning to the formal regression to test our hypotheses, we run a baseline regression without the interaction term using 3SLS and find that the basic results are

consistent with the theory (Table III). There are no significant differences for the coefficients in the migration equation in this simultaneous system compared to the results noted above, with the exception of the experience of the head, which is no longer significant. Controlling for other household variables and village characteristics using a set of dummies, we find statistically significant effects of migration and off-farm income in the productivity equations, providing preliminary evidence in support of the key hypothesis of NELM theory. Households that send out migrants can expect that off-farm income, on average, will contribute positively to agricultural productivity. Specifically, the results imply that a one yuan increase in off-farm income raises rice productivity by 0.00049 kg per worker per day. With a mean off-farm income of 18,554 yuan in the sample, this amounts to a substantial impact overall, of 8.98 kg. The lost-labor effect on rice productivity significantly declines by 23.17 kg per worker per day with each additional migrant. It appears large, but it is reasonable when we calculate the net effect of migration that consists of the lost-labor effect and the compensating effect of off-farm income in the last part of this research. This result indicates that migrants in the household are likely to have higher labor productivity than non-migrants and that the off-farm income is beneficial to increase the productivity.

Another interesting result from Table III is that the share of old labor is negatively associated with agricultural productivity. This concords with Li and Zhao (2009a), who illustrate the hindering effects of old labor with disadvantages of physical power and human capital. As for female labor, they appear to have even higher productivity than males. This suggests that in rural China the absence of male labor is not necessarily a threat to agricultural production. Land and fertilizer expenditure are also shown to be positively associated with rice productivity, as expected.

Based on the baseline regression, we further explore the effects of household wealth. Table IV reports results that include the interaction term. Compared to Table III, the main results remain robust. As expected, off-farm income is positively related to migration (Table IV, column 2, row 2), with each additional migrant being associated with a 22,116 yuan increase in off-farm income. Obviously, the cost of leaving the agricultural sector is high for rice productivity. Each additional migrant decreases rice productivity by 20.89 kg per worker per day. One explanation for the negative effect is that when a worker with higher productivity leaves the household, productivity for the whole household falls.

	Yield per worker per day	Off-farm	Number of migrants
Number of migrants	−23.17*** (−6.48)	19,598.2*** (27.21)	
Off-farm income	0.000484*** (2.65)		
Wealth	−0.0000237*** (−3.87)	0.0206*** (3.58)	−0.00000101*** (−4.42)
Education	0.159 (1.21)	108.0 (0.66)	0.00371 (0.57)
Experience	0.0734** (2.41)	0.613 (0.02)	0.00200 (1.31)
Family size			0.201*** (15.22)
Old share	−3.307*** (−3.10)	−657.2 (−0.49)	−0.195*** (−9.25)
Female share	20.62*** (16.72)	−745.6 (−0.48)	0.339*** (14.47)
Children		1,308.9*** (3.18)	−0.137*** (−7.10)
Rice land	0.205*** (4.98)		
Total land		6.120 (0.09)	−0.0124*** (−5.30)
Fertilizer	0.000280* (1.73)		
Constant	3.296 (0.37)	10,505.0 (0.96)	−0.843* (−1.93)
Village fixed effect	Yes	Yes	Yes
n	4,671	4,671	4,671

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table III.
3SLS regression results using off-farm income without interaction

	Yield per worker per day	Off-farm	Number of migrants
Interaction	−5.62e-10* (−1.71)		
Number of migrants	−20.89*** (−5.88)	22,116.1*** (30.59)	
Off-farm income	0.000367** (1.97)		
Wealth	−0.00000424 (−0.57)	0.0221*** (3.79)	−0.00000100*** (−4.37)
Education	0.161 (1.22)	66.30 (0.40)	0.00380 (0.58)
Experience	0.0729** (2.41)	−16.79 (−0.43)	0.00203 (1.33)
Family size			0.196*** (15.00)
Old share	−3.513*** (−3.31)	787.4 (0.58)	−0.194*** (−9.22)
Female share	20.65*** (16.75)	−1,883.4 (−1.20)	0.335*** (14.46)
Children		1,087.8*** (2.61)	−0.136*** (−7.02)
Rice land	0.198*** (4.84)		
Total land		2.135 (0.03)	−0.0122*** (−5.18)
Fertilizer	0.000245 (1.52)		
Constant	4.704 (0.52)	11,340.3 (1.02)	−0.820* (−1.87)
Village fixed effect	Yes	Yes	Yes
n	4,671	4,671	4,671

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table IV. 3SLS regression results using off-farm income with interaction

Whereas migration itself has a direct negative effect on agricultural productivity, through off-farm income it also has a positive effect. Each yuan earned by a migrant is associated with 0.00037 kg per worker of additional rice yield. More importantly, we find a negative moderating effect due to different levels of household wealth that is consistent with our hypothesis that poor households are more liquidity constrained than households with a relative abundance of wealth. In fact, with large magnitudes of off-farm income and wealth variables[3], it is not surprising that the coefficient of the interaction term is small. Atamanov and Van den Berg (2012) have already found that remittances may have a negative effect on work incentives for households that are already well off. However, the proxy used for wealth in their paper is land size, which is obviously not a perfect variable to measure how rich a household is.

Other results that are consistent with the findings in Table III include the negative association between labor productivity and the share of old workers, and the positive association of female workers and land size with labor productivity.

4.3 Group regressions

The correlation between the interaction term and off-farm income, and between the interaction term and wealth are both close to 0.3 (0.35 and 0.32, respectively). This indicates that there is not a serious multicollinearity problem due to the interaction term. To further check whether the results are robust, we divide the samples into three groups based on household wealth. Households in the first group own less than 1,500 yuan fixed assets, in the second group between 1,500 and 9,500 yuan, and in the third more than 9,500 yuan.

The results are displayed in Table V. As expected, the positive effect of off-farm income is largest in the sample of poorest households (0.00254), smaller in the middle-income group (0.000412) and close to zero in the rich group. This decreasing trend across the three groups provides supplementary evidence for the hypothesis that the positive impact of off-farm income will become weaker with increasing household wealth.

4.4 Net impacts of migration on agricultural productivity

Since migration has multiple effects on agricultural productivity, the net effect is the sum of the direct and indirect effects of migration on rice productivity, where the indirect effects

occur through off-farm income. To calculate the net effects of migration in each group, we use the average number of migrants, the mean of off-farm income and the coefficients from Table V. We also calculate the net effects using the full sample both with and without interaction term. The results are reported in Table VI.

Although the indirect positive effect of off-farm income is large, we still find that the net effect of migration on rice productivity is negative for all households. For the poorest households, migration will, on the average, decrease the rice yield per worker per day by 9.17 kg. The number becomes larger in the second and third groups (11.99 and 13.41 kg, respectively). As for the full samples with and without the interaction term, the calculated net effects using coefficients from Tables III and IV are 11.57 and 12.01 kg per worker per day, respectively. These results imply three key points: first, rural–urban migration certainly appears to impact on rice productivity in complex ways, with the lost-labor effect and off-farm income offsetting effect playing contradictory roles; second, the lost-labor effect dominates, which results in a negative net impact on rice productivity; and finally, the negative net effects are smaller for the poor households, which is consistent with the group regression results that they are more credit constrained and off-farm income will play a greater role in stimulating the rice productivity.

The focus of this paper has been on the impacts of rural-urban migration on labor productivity, which has rarely been discussed in the literature. However, we are also interested in the impact of migration on land productivity. In particular, as noted in Section 2, Taylor *et al.* (2003) show a positive net impact of migration on rice yield per mu. To make the results of this paper more comparable, we calculate the net impact of migration on rice yield per mu as well.

We, first, show the results of the impact on land productivity without and with interaction term, respectively, in Tables AII and AIII[4]. For the lost-labor effect,

Table V.
Effects of off-farm income on rice productivity across wealth groups

	Yield per worker per day	Yield per worker per day	Yield per worker per day
Number of migrants	−67.28*** (−3.85)	−19.03*** (−4.88)	−17.43*** (−4.15)
Off farm	0.00254*** (3.04)	0.000412** (1.99)	0.000111 (0.53)
Wealth	0.000570 (0.17)	−0.000481*** (−2.88)	−0.0000127* (−1.86)
Education	0.00236 (0.00)	−0.0433 (−0.24)	0.386* (1.82)
Experience	0.148 (1.02)	0.0568 (1.47)	0.0738 (1.48)
Old share	4.786 (0.86)	−0.676 (−0.51)	−7.649*** (−4.20)
Female share	20.94*** (3.17)	15.81*** (8.61)	23.76*** (13.48)
Rice land	1.478*** (3.81)	0.197 (1.59)	0.171*** (3.49)
Fertilizer	0.000449 (0.62)	−0.000133 (−0.43)	0.000775*** (3.41)
Village fixed effect	Yes	Yes	Yes
n	879	1,928	1,865

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table VI.
The net effects of migration on rice productivity

Groups	Mean number of migrants	Mean off-farm income	Mean wealth	Elasticity of off-farm income	Net effects on rice productivity
I	0.88	19,764.99		2.36	−9.17
II	1.07	20,222.27		0.47	−11.99
III	0.77	16,127.99		0	−13.41
Full sample without interaction	0.89	18,554.39		0.47	−11.57
Full sample with interaction	0.89	18,554.39	27,700.87		−12.01

the coefficient on the number of migrants is 214 in Table AIII, reasonably close to the equivalent figure of 221 in Table AII, and also remarkably close to the coefficient in Rozelle *et al.* (1999) as well[5]. As Rozelle *et al.* (1999) only use remittances as the proxy for the offsetting effect, we cannot directly compare the coefficient of off-farm income (0.01) to remittances (0.44). However, given the high level of significance in both cases, it seems reasonable to assert that off-farm income (be it in the form of remittances or otherwise) continues to play a large role in determining land productivity. Most importantly, the wealth of households has a moderating effect—the impact of off-farm income for poorer households is larger compared to richer households—which results in the heterogeneity between wealthy and poor households, an issue not considered in Rozelle *et al.*'s (1999) earlier analysis.

Using the coefficients from Table AIII, we calculate the net impact of migration on land productivity and find a small but negative number −6.55 kg (per mu). This result indicates that migration, on the average, will not only decrease labor productivity, but will also reduce land productivity. This finding contracts with the earlier finding of Taylor *et al.* (2003), in which the net effect on land productivity was shown to be positive.

5. Conclusions

This paper has explored the link between migration, off-farm income and agricultural productivity in rural China. Using household survey data, we find that the loss of labor due to migration has a direct negative impact on rice productivity (rice yield per worker per day). This appears to be primarily the consequence of the loss of labor with higher productivity that cannot easily be replaced by hired workers. In line with NELM, we also provide evidence that the off-farm income earned by migrants in urban areas partially compensates for the negative lost-labor effect. Contrary to most existing studies, we allow these effects to differ with household wealth. Our results confirm the heterogeneity of migration effects. Off-farm income leads to an increase in agricultural productivity for most households, but not for those with the most household wealth. In other words, the compensating effects of off-farm income fall with the increase of household wealth. Separate regressions based on three wealth groups make the result more robust by confirming the largest off-farm income effect in the poorest group and a downward trend as the income increases.

Using the coefficients from the regressions, we calculated the net effects of migration using both the full sample and three separate samples. The results show that the lost-labor effect is larger than the compensating impact, which results in the negative net effects on the rice productivity. The negative net effects are greater for richer households that are less credit constrained, implying that off-farm income plays a smaller role in stimulating their labor productivity. Further calculation indicates that migration, on the average, will also reduce land productivity.

These conclusions would have been quite different had we ignored some important issues. Remittances, which are widely adopted in other studies, may be inadequate due to the complexity of channels for remitting and many other uncertain factors. As shown here, off-farm income earned by migrants in urban areas may in fact be a better proxy for assessing the capacity of households to mitigate against liquidity constraints.

A major policy issue facing national leaders is whether the massive and ongoing outflow of labor will be a threat to China's rural development and its food security in the future. Given the negative net effect of rural migration on rice productivity, combined with dramatically few workers—assuming that the central government's National New-type Urbanization Plan proves effective—the implication for China's aggregate rice output is clear: it will fall. As off-farm income can mitigate against the lost-labor effect to some extent, policy makers should consider ways to encourage

households to invest more off-farm income in agricultural production, for example, by investing in mechanization or the upgrading of the left behind workers through education or professional training. The positive impact of off-farm income also indicates the importance of establishing financial institutions that could help relax the liquidity constraints facing rural households.

Finally, understanding the relationship between rice productivity and migration is only one small piece of the complex linkages between migration and rural development in China (and elsewhere). Understanding the impact of migration on household income and the allocation of household members' time between on- and off-farm activities is also essential, as are the consequences of migration for inequality, both within rural areas and across the urban–rural divide. These remain the task of future research.

Acknowledgment

The author is deeply grateful to Dr Jane Golley for her valuable time, advice and corrections to this paper and also for the insightful comments made by Professor Bruce Chapman. The author would also like to thank Professor Tamara Jacka, Dr Kailing Shen, Dr Ligang Song and other participants in seminars given at Australian Center on China in the World of The Australian National University on April 11, 2017; Crawford School of Public Policy of The Australian National University on June 2, 2017; and the 29th CESA Annual Conference at University of Western Australia, Perth, Australia, July 12-14, 2017.

Notes

1. This is calculated using the number of workers and days for rice production in the survey.
2. In total, 334 villages and 333 dummies.
3. The mean of off-farm income and wealth for the households are 18,554 and 27,702 yuan, respectively.
4. For simplicity, we just report the main coefficients of the regression based on the similar econometric strategy in Section 3.
5. In their paper, the coefficient is 462 jin per mu, that equals to 231 kg per mu.

References

Adams, R.H. Jr and Cuecuecha, A. (2010), "Remittances, household expenditure and investment in Guatemala", *World Development*, Vol. 38 No. 11, pp. 1626-1641.

Adda, J., Dustmann, C. and Görlach, J.S. (2014), "Migrant wages, human capital accumulation and return migration", available at: https://economicdynamics.org/meetpapers/2014/paper_679.pdf (accessed June 5, 2018).

Atamanov, A. and Van den Berg, M. (2012), "Heterogeneous effects of international migration and remittances on crop income: evidence from the Kyrgyz Republic", *World Development*, Vol. 40 No. 3, pp. 620-630.

Babatunde, R.O. and Qaim, M. (2010), "Impact of off-farm income on food security and nutrition in Nigeria", *Food Policy*, Vol. 35 No. 4, pp. 303-311.

Bai, X., Shi, P. and Liu, Y. (2014), "Society: realizing China's urban dream", *Nature News*, Vol. 509 No. 7499, pp. 158-160.

Barham, B. and Boucher, S. (1998), "Migration, remittances, and inequality: estimating the net effects of migration on income distribution", *Journal of Development Economics*, Vol. 55 No. 2, pp. 307-331.

Begum, I.A., Alam, M.J., Buysse, J., Frija, A. and Van Huylenbroeck, G. (2012), "Contract farmer and poultry farm efficiency in Bangladesh: a data envelopment analysis", *Applied Economics*, Vol. 44 No. 28, pp. 3737-3747.

Beijer, G. (1970), "International and national migratory movements", *International Migration*, Vol. 8 No. 3, pp. 93-109.

Berry, R.A. and Soligo, R. (1969), "Some welfare aspects of international migration", *Journal of Political Economy*, Vol. 77 No. 5, pp. 778-794.

Bindlish, V., Evenson, R.E., Gbetibouo, M. and Mundial, B. (1993), *Evaluation of T & V-Based Extension in Burkina Faso*, World Bank, Washington, DC.

Bouoiyour, J. and Miftah, A. (2015), "The impact of migrant workers' remittances on the living standards of families in Morocco: a propensity score matching approach", *Migration Letters*, Vol. 12 No. 1, pp. 13-27.

Cai, F., Du, Y. and Wang, M.Y. (2009), "Migration and labor mobility in China", available at: https://mpra.ub.uni-muenchen.de/19187/ (accessed June 5, 2018).

Cai, Q. (2003), "Migrant remittances and family ties: a case study in China", *Population, Space and Place*, Vol. 9 No. 6, pp. 471-483.

Chan, K.W. (2013), "China: internal migration", in Ness, I. and Bellwood, P. (Eds), *The Encyclopedia of Global Human Migration*, Blackwell Publishing, pp. 1-15.

Chang, H., Dong, X.Y. and MacPhail, F. (2011), "Labor migration and time use patterns of the left-behind children and elderly in rural China", *World Development*, Vol. 39 No. 12, pp. 2199-2210.

De Brauw, A. (2010), "Seasonal migration and agricultural production in Vietnam", *The Journal of Development Studies*, Vol. 46 No. 1, pp. 114-139.

De Brauw, A. (2014), *Migration, Youth, and Agricultural Productivity in Ethiopia*, International Food Policy Research Institute, Washington, DC, available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.652.2213&rep=rep1&type=pdf (accessed June 5, 2018).

De Brauw, A. and Rozelle, S. (2008), "Migration and household investment in rural China", *China Economic Review*, Vol. 19 No. 2, pp. 320-335.

De Haas, H. (2006), "Migration, remittances and regional development in Southern Morocco", *Geoforum*, Vol. 37 No. 4, pp. 565-580.

De Janvry, A., Emerick, K., Gonzalez-Navarro, M. and Sadoulet, E. (2015), "Delinking land rights from land use: certification and migration in Mexico", *American Economic Review*, Vol. 105 No. 10, pp. 3125-3149.

Deininger, K., Jin, S., Xia, F. and Huang, J. (2014), "Moving off the farm: land institutions to facilitate structural transformation and agricultural productivity growth in China", *World Development*, Vol. 59, pp. 505-520.

Fernandez-Cornejo, J., Mishra, A.K., Nehring, R.F., Hendricks, C., Southern, M. and Gregory, A. (2007), "Off-farm income, technology adoption, and farm economic performance", No. 7234, United States Department of Agriculture, Economic Research Service, Washington, DC.

Fu, Y. and Gabriel, S.A. (2012), "Labor migration, human capital agglomeration and regional development in China", *Regional Science and Urban Economics*, Vol. 42 No. 3, pp. 473-484.

Garip, F. (2014), "The impact of migration and remittances on wealth accumulation and distribution in rural Thailand", *Demography*, Vol. 51 No. 2, pp. 673-698.

Gupta, S., Pattillo, C.A. and Wagh, S. (2009), "Effect of remittances on poverty and financial development in Sub-Saharan Africa", *World Development*, Vol. 37 No. 1, pp. 104-115.

Harris, J.R. and Todaro, M.P. (1970), "Migration, unemployment and development: a two-sector analysis", *The American Economic Review*, Vol. 60 No. 1, pp. 126-142.

Hu, X.Z. and Zhong, F.N. (2012), "The rural population aging's effect on agricultural production—based on the data collected from rural fixed watch points", *Chinese Rural Economy*, No. 7, pp. 29-39 (in Chinese).

Hunt, J. (2004), "Are migrants more skilled than non-migrants? Repeat, return, and same-employer migrants", *Canadian Journal of Economics*, Vol. 37 No. 4, pp. 830-849.

Jimenez-Soto, E.V. and Brown, R.P. (2012), "Assessing the poverty impacts of migrants' remittances using propensity score matching: the case of Tonga", *Economic Record*, Vol. 88 No. 282, pp. 425-439.

Lewis, W.A. (1954), "Economic development with unlimited supplies of labour", *The Manchester School*, Vol. 22 No. 2, pp. 139-191.

Li, M. and Zhao, L.G. (2009a), "Rural labor's aging and the effects on agricultural production—empirical evidence from Liaoning China", *Issues in Agricultural Economy*, No. 10, pp. 12-18 (in Chinese).

Li, M. and Zhao, L.G. (2009b), "Rural labor's feminization and the effects on agricultural production—empirical evidence from Liaoning China", *Chinese Rural Economy*, No. 5, pp. 61-69 (in Chinese).

Li, Y.Y., Lan, H.T. and Fang, X.J. (1999), "Different peasant household's management behavior with distinguished scale", *China Rural Survey*, No. 4, pp. 39-45 (in Chinese).

Lin, J.Y. (1992), "Rural reforms and agricultural growth in China", *The American Economic Review*, Vol. 82 No. 1, pp. 34-51.

Mincer, J.A. (1974), "Schooling and earnings", *Schooling, Experience, and Earnings*, National Bureau of Economic Research, New York, NY, pp. 41-63.

Mu, R. and Van de Walle, D. (2011), "Left behind to farm? Women's labor re-allocation in rural China", *Labour Economics*, Vol. 18 No. S1, pp. S83-S97.

Murphy, R. (2006), "Domestic migrant remittances in China: distribution, channels, and livelihoods", IOM Migration Research Series No. 24, United Nations, New York, NY.

Penninx, R. (1982), "A critical review of theory and practice: the case of Turkey", *International Migration Review*, Vol. 16 No. 4, pp. 781-818.

Pfeiffer, L., López-Feldman, A. and Taylor, J.E. (2009), "Is off-farm income reforming the farm? Evidence from Mexico", *Agricultural Economics*, Vol. 40 No. 2, pp. 125-138.

Rivera-Batiz, F.L. (1982), "International migration, non-traded goods and economic welfare in the source country", *Journal of Development Economics*, Vol. 11 No. 1, pp. 81-90.

Rozelle, S., Taylor, J.E. and De Brauw, A. (1999), "Migration, remittances, and agricultural productivity in China", *American Economic Review*, Vol. 89 No. 2, pp. 287-291.

Scharf, M.M. and Rahut, D.B. (2014), "Nonfarm employment and rural welfare: evidence from the Himalayas", *American Journal of Agricultural Economics*, Vol. 96 No. 4, pp. 1183-1197.

Tao, R. and Xu, Z. (2007), "Urbanization, rural land system and social security for migrants in China", *The Journal of Development Studies*, Vol. 43 No. 7, pp. 1301-1320.

Taylor, E.J. (1999), "The new economics of labour migration and the role of remittances in the migration process", *International Migration*, Vol. 37 No. 1, pp. 63-88.

Taylor, J.E. and Martin, P.L. (2001), "Human capital: migration and rural population change", in Rausser, G. and Gardner, B. (Eds), *Handbook of Agricultural Economics*, Elsevier Science, New York, NY, pp. 457-511.

Taylor, J.E., Rozelle, S. and De Brauw, A. (2003), "Migration and incomes in source communities: a new economics of migration perspective from China", *Economic Development and Cultural Change*, Vol. 52 No. 1, pp. 75-101.

Todaro, M.P. (1969), "A model of labor migration and urban unemployment in less developed countries", *The American Economic Review*, Vol. 59 No. 1, pp. 138-148.

Wang, C., Rada, N., Qin, L. and Pan, S. (2014), "Impacts of migration on household production choices: evidence from China", *Journal of Development Studies*, Vol. 50 No. 3, pp. 413-425.

Yan, X., Bauer, S. and Huo, X. (2014), "Farm size, land reallocation, and labour migration in rural China", *Population, Space and Place*, Vol. 20 No. 4, pp. 303-315.

Yang, Z.W. and Zhong, F. (2010), "Externality of peasants' planting decisions", *Journal of Agrotechnical Economics*, No. 1, pp. 27-33 (in Chinese).

Appendix

	Yield per worker per day	Yield per worker per day
Interaction		4.54e-08 (0.50)
Number of migrants	−18.07*** (−4.30)	−18.23*** (−4.42)
Remittance	−0.00357 (−1.19)	−0.00313 (−1.16)
Wealth	0.0000825 (1.23)	0.0000750 (1.10)
Education	−0.902 (−0.91)	−0.780 (−0.68)
Experience	−0.0956 (−0.49)	−0.0851 (−0.43)
Old share	5.335 (0.79)	5.033 (0.75)
Female share	36.78*** (4.51)	35.75*** (4.53)
Land	1.007 (1.62)	0.777 (1.18)
Fertilizer	−0.000405 (−0.37)	−0.000438 (−0.39)
Village fixed effect	Yes	Yes
n	278	278

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table AI. 3SLS regression results using remittances

	Yield per mu	Off-farm income	Number of migrants
Number of migrants	−220.9*** (−4.40)	19,769.6*** (28.08)	
Off-farm income	0.0110*** (4.25)		
Wealth	−0.000142** (−2.32)	0.0179*** (3.26)	−0.000000977*** (−4.46)
Other control variables	Yes	Yes	Yes
n	4,946	4,946	4,946

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table AII. The impacts of rural–urban migration on land productivity without interaction

	Yield per mu	Off-farm income	Number of migrants
Interaction	−8.86e-09* (−1.72)		
Number of migrants	−213.5*** (−3.85)	22,233.3*** (31.47)	
Off-farm income	0.0101*** (3.43)		
Wealth	0.000127 (1.19)	0.0194*** (3.47)	−0.000000969*** (−4.42)
Other control variables	Yes	Yes	Yes
n	4,946	4,946	4,946

Notes: *t*-statistics in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table AIII. The impacts of rural–urban migration on land productivity with interaction

Corresponding author
Xinjie Shi can be contacted at: xinjie.shi@anu.edu.au