The Australian Journal of
Agricultural and
Resource Economics

AARES
AUSTRALASIAN AGRICULTURAL & RESOURCE ECONOMICS SOCIETY

Australian Journal of Agricultural and Resource Economics, 59, pp. 1–20

Agricultural subsidies retard urbanisation in China*

Kaixing Huang, Wenshou Yan and Jikun Huang[†]

Although agricultural subsidies are usually seen in high-income countries with small agricultural labour forces, China started to heavily subsidise agriculture when its per-capita income was very low and more than half of its population was working in agriculture. A concern is that these abnormal agricultural subsidies may have significantly retarded China's urbanisation process by reducing rural–urban migration. Based on a panel of county-level data from 1,878 Chinese counties, we found that agricultural subsidies reduced China's yearly outflow of agricultural labour by 0.68 million people (with a 95 per cent confidence interval of 0.67–0.69) – about 5.7 per cent of the annual rural–urban migration observed during the sample period. We concluded that abnormal agricultural subsidies are a significant cause of China's widely observed under-urbanisation.

Key words: agricultural subsidies, rural, urban migration, urbanisation.

1. Introduction

China has dramatically increased its agricultural subsidies since 2004. Compared to 2003, in 2006 Chinese farmers received extra transfer payments of USD 10 billion: about 4.1 per cent of the agricultural GDP in China in 2006 (Huang *et al*. 2013). According to the OECD's agricultural support estimates (OECD 2019), China has the highest agricultural subsidy rate, measured as the percentage of GDP, of any of the major agricultural-subsidy countries, except South Korea.[1]

* We are grateful to the editor and the anonymous referees for their invaluable comments that helped to improve this paper. This work was supported by the Natural Science Fund Management Committee (Program No. NSFC71742002), the Collaborative Innovation Center for China Economy (Program No. CICCE/2017/09), the National Natural Science Foundation of China (Program No. 71903198) and the Fundamental Research Funds for the Central Universities, Zhongnan University of Economics and Law (Program No. 2722020JCT022). All errors are our own.

[†]Kaixing Huang is at, School of Economics, Nankai University, No.94 Weijin Road, Tianjin,300071,China. Wenshou Yan (email: wenshou.yan@zuel.edu.cn) is at the School of Business Administration, Zhongnan University of Economics and Law, 182 Nanhu Road, Wuhan,430073,China. Jikun Huang is at, Jiangxi Agricultural University, Nanchang Economic and Technological Development Zone, Nanchang,330045,China. Jikun Huang is at, School of Advanced Agricultural Sciences, Peking University, No.5, Summer Palace Road, Beijing,100871,China.

[1] The percentage of GDP spent on agricultural subsidies in China increased from 1.7% to 2.6% from 2000 to 2016, while it was less than 1% in OECD countries and less than 1.5% in Japan during the same period. China's subsidy rate exceeded that of South Korea in 2012.

doi: 10.1111/1467-8489.12391

Figure 1 Urbanisation for countries with per-capita GDPs similar to China.
Note: Per-capita GDP in China in 2010 was USD 4,580. To make the urbanisation levels comparable, we selected all countries with per-capita GDPs (2010 fixed USD) between 4,000 and 5,000 for at least one year from 1980 to 2010. For these countries, we used only the observation years in which the per-capita GDP was between 4,000 and 5,000 and then plotted the average urban population proportion against the average per-capita GDP for each country. The data were derived from the World Development Indicators (The World Bank 2018).

Although agricultural subsidies are usually seen in high-income countries with small agricultural labour forces (Hayami and Anderson 1986; Anderson 2009), China started to heavily subsidise agriculture when its per-capita income was very low and more than half of its population was working in agriculture[2]; therefore, a concern is that the abnormal agricultural subsidies in China may have significantly retarded its urbanisation process by reducing rural–urban migration. This concern is especially relevant considering that persistent under-urbanisation has been observed in China.[3] As shown in Figure 1, China's population in urban areas in 2010 was only 49.2 per cent, which was much lower than in most of the other 20 countries with comparable per-capita GDPs.

[2] In 2004, per-capita GDP in China was less than 15% of the threshold for high-income countries, and the share of the population employed in agriculture was 58.9% (The World Bank 2018).
[3] The under-urbanization in China has been widely documented (e.g. Whyte 1983; Ebanks & Cheng 1990; Song & Timberlake 1996; Putterman & Dong 2000; Zhang & Zhao 2003; Tan *et al*. 2016).

Although it seems intuitive that agricultural subsidies will reduce the labour reallocation from agricultural to non-agricultural sectors, what should be a major concern for policymakers is the magnitude of this reducing effect; however, most relevant studies have focused on examining the effect of China's agricultural subsidies on farmers' incomes, or on estimating the effect on rural–urban migration in a small sample area (See, e.g. Yu and Jensen 2010; Huang *et al*. 2011b; Xu *et al*. 2012; Meng 2012). Although these studies have generally indicated that agricultural subsidies have reduced rural–urban migration by enhancing farmers' incomes, the overall effect of agricultural subsidies on urbanisation in China is still unknown.

The present article provides the first evaluation of the overall effect of China's agricultural subsidies on its urbanisation. We first developed a theoretical model to illustrate why agricultural subsidies reduce the outflow of agricultural labour. We then estimated the reducing effect by using a panel of county-level data for 1,878 Chinese counties. We found that agricultural subsidies reduced the yearly outflow of labour from agriculture in China by 0.68 million people, with a 95 per cent confidence interval of 0.67–0.69. The reduced outflow of agricultural labour was 5.67 per cent of the observed yearly rural–urban migration during the sample period.

Although previous studies generally believed that the under-urbanisation in China was due to its *hukou* system and communist ideology (Murray and Szelenyi 1984; Fang 1990; Friedmann 2005), we found that the abnormal agricultural subsidies could also partly explain China's under-urbanisation. Although many factors have been used to explain China's under-urbanisation, to the best of our knowledge, quantitative estimation of the overall effect of a specific factor on China's urbanisation has not been reported. Previous quantitative studies mainly focused on identifying the determinants of the regional differences in urbanisation in China or on examining the correlation between urbanisation and economic growth (e.g. Zhang and Song 2003; Chang and Brada 2006; Christensen and McCord 2016). Therefore, the current article contributes to quantitatively evaluate the overall effect of a specific factor (agricultural support) on urbanisation in China. Complementing the literature asserting that the removal of agricultural subsidies can improve economic welfare, boost economic growth, and alleviate poverty and inequality (Harberger 1971; Milanovic 2005; Anderson 2010), our findings suggested that removing agricultural subsidies could improve the level of urbanisation in China. This article also contributes to the literature regarding the determinants of rural–urban migration by exploring the effect of agricultural subsidies on migration.[4]

The rest of this article is organised as follows: Section 2 presents the conceptual framework. Section 3 describes the data sources and summary

[4] The determinants of rural–urban migration typically include income gaps (Carrington *et al*. 1996), local credit and insurance markets (Woodruff & Zenteno 2007), and farmland property rights (Acemoglu *et al*. 2001).

statistics. Section 4 details the econometric model. Section 5 explains the estimation results and sensitivity checks. The final section concludes the article.

2. Conceptual framework

We developed a simple theoretical model to show that agricultural subsidies reduce the labour reallocation from agricultural to non-agricultural sectors. The model assumed a representative agent economy with two sectors – an agricultural sector and a non-agricultural sector – and each agent's objective was to maximise income by allocating labour between these sectors. The agricultural production was according to:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \tag{1}$$

where Y_t is the total agricultural output in year t, A_t is *TFP* in agriculture, L_t is the total agricultural employment, K_t denotes the supply of farmland, and $\alpha \in (0, 1)$.

We assumed that the supply of farmland in China would increase with economic returns to land. This assumption was valid, even though the total available farmland remained constant, because it has been reported that remote and low-quality farmlands in China, with high management costs, were abandoned when the returns to land became too low (Long and Liu 2016; Li and Li 2017). Increases in returns to land (due to such factors as agricultural subsidies) may put these abandoned lands back into production. For simplicity, we denoted the *additional* cost of managing remote and low-

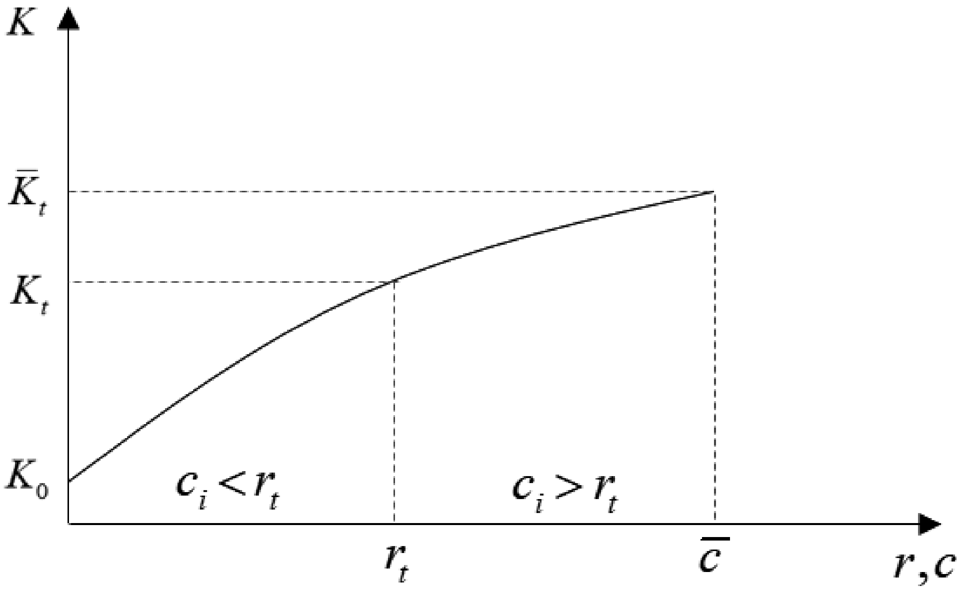

Figure 2 The supply of farmland.

quality farmland as the cost of farmland supply, considering that these costs would be reflected in the real land rents received. Figure 2 illustrates this by assuming the costs of supply of a unit of farmland as $c_i \in (0, \overline{c})$, and the supply of farmland as $K_t \in \left(K_0, \overline{K}\right)$. Only lands with supply costs lower than land rents (i.e. $c_i < r_t$) would be in production, so we had the following:

$$\frac{dK}{dr} > 0 \tag{2}$$

Agricultural profits were as follows:

$$\Pi_t = Y_t + \tau_t K_t - w_t L_t - r_t K_t \tag{3}$$

where τ_t is the rate of agricultural subsidy, w_t is the agricultural wage, and r_t is the marginal rent of the farmland. Here, the price of the agricultural output was normalised into one. We assumed that the agricultural subsidy was based on the amount of farmland ($\tau_t K_t$), which was consistent with the reality in China (see Section 3 for details).

In a competitive agricultural sector with zero profits, the agricultural wage and land rent were as follows:

$$w_t = \alpha A_t L_t^{\alpha-1} K_t^{1-\alpha} \tag{4}$$

$$r_t = (1-\alpha) A_t L_t^{\alpha} K_t^{-\alpha} + \tau_t \tag{5}$$

Similarly, we assumed the non-agricultural production function was.

$$\hat{Y}_t = \hat{A}_t \hat{L}_t^{\alpha} \hat{K}_t^{1-\alpha} \tag{6}$$

Because the model was used to analyse the effect of agricultural subsidies only, we assumed that there was no subsidy for non-agricultural output; therefore, the non-agricultural wage was as follows:

$$\hat{w}_t = \alpha p_t \hat{A}_t \hat{L}_t^{\alpha-1} \hat{K}_t^{1-\alpha} \tag{7}$$

where p_t is the relative price of non-agricultural to agricultural output. We assumed that the relative price was determined by the world market and was exogenous to agricultural subsidies in China; relaxing this assumption would complicate the model, but would not affect its qualitative implications.

The equilibrium migration in each period,m_t, was determined by the following:

$$w_t = \alpha A_t (L_{t-1} - m_t)^{\alpha-1} K_t^{1-\alpha} = \alpha p_t \hat{A}_t \left(\hat{L}_{t-1} + m_t\right)^{\alpha-1} \hat{K}_t^{1-\alpha} - q = \hat{w}_t - q \tag{8}$$

where q is the cost of labour reallocation. The existence of $q > 0$ implied the possibility of wage gaps between sectors in the equilibrium. If non-agricultural technology ($\hat{A}_t$) grew faster than agricultural technology (A_t), farmers would migrate to off-farm sectors ($m_t > 0$) and equation (8) would hold.

1: Agricultural subsidies would reduce the labour reallocation from agricultural to non-agricultural sectors.

Proof: from equations (2) and (5), we had the following:

$$\frac{dK}{d\tau} = \frac{dK}{dr}\frac{dr}{d\tau} > 0 \tag{9}$$

The first-order derivative of (8) with respect to τ led to.

$$\frac{dm}{d\tau} = -\frac{wL\hat{L}}{K\left(w\hat{L} + \hat{w}L\right)}\frac{dK}{d\tau} < 0 \tag{10}$$

The reason for the negative effect of agricultural subsidies on the outflow of agricultural labour was clear: agricultural subsidies increased the return to farmland and led to greater land supply, which in turn raised agricultural wages (according to (4)) and agricultural employment. Previous studies regarding China's agricultural subsidies found a positive effect of agricultural subsidies on planting areas (Yi *et al*. 2015; Chen *et al*. 2015). We also confirmed this fact, as shown in column (4) of Table 3, by estimating the effect of agricultural subsidies on farmland areas.

3. Data and summary statistics

As shown in Figure 3, China has dramatically increased its agricultural subsidies since 2004. The overall agricultural subsidy in China increased from 57 billion CNY in 2003 to 344 billion CNY in 2016, and production support, as a percentage of the total value of agricultural production, increased from 6.57 per cent to 16.19 per cent during the same period. As detailed in the OECD Agricultural Support Dataset, more than 20 types of agricultural subsidies have been introduced in China, and the four major subsidies are direct subsidies, comprehensive input subsidies, high-quality seed subsidies and agricultural machinery subsidies.[5] In spite of numerous types of subsidies, in practice, they have mainly been based on the contracted land areas, due to the difficulty of monitoring the yearly inputs and outputs of households (Huang *et al*. 2011a; Yi *et al*. 2015)[6]; therefore, farmers with larger areas of per-capita farmland received higher per-capita subsidies.

[5] Agricultural price subsidy was not included in our empirical analysis. The agricultural price subsidy rate in China usually changes according to the world market price in order to stabilize the price received by farmers; therefore, a higher price subsidy does not necessarily imply higher profit for farmers (or a greater effect on farmers' migration decisions).

[6] An exception to the four major subsidies is the machinery subsidy, which is only given to the buyers of medium- or large-sized machines. The fact that most rural households have small farming areas dictates that only a few farmers apply for the machinery subsidy (Yi *et al*. 2015), with the machinery subsidy constituting less than 10% of the four major subsidies.

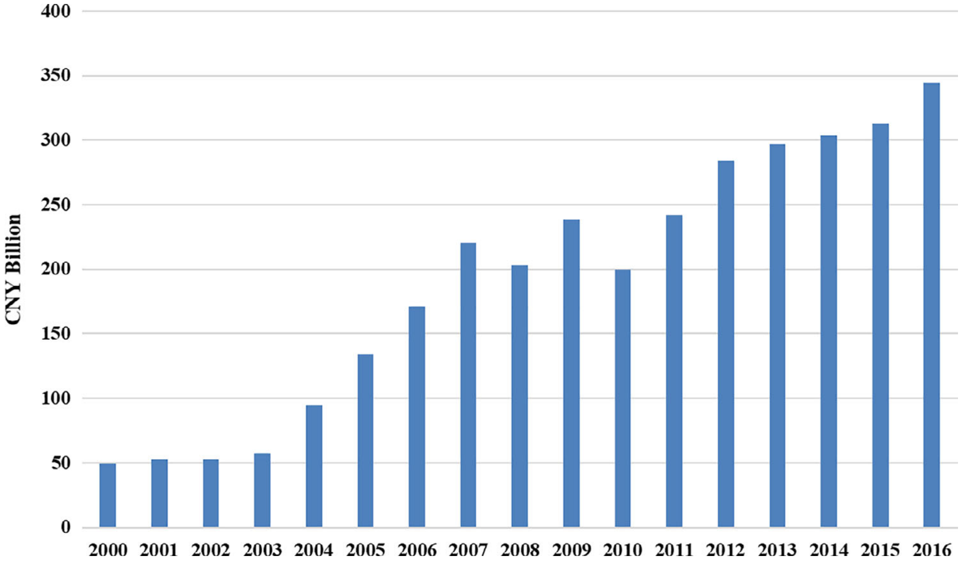

Figure 3 Agricultural subsidies in China (2010 prices).
Data source: OECD Agricultural Support Data (https://data.oecd.org).

We calculated the national average agricultural subsidy per hectare and combined it with county-level agricultural production and employment values to investigate the effect of China's agricultural subsidy on the reallocation of agricultural labour. We depended on national subsidy data, because nationally representative data at the province and county levels were not available. This data limitation was not a major concern, considering that agricultural subsidies are provided by the central government and the rate of the subsidies is similar across regions (Huang *et al*. 2013; Huang and Yang 2017).

County-level agricultural production and employment data were derived from the China Statistical Yearbook for Regional Economy (CSYRE). The data were available for 1,878 counties from 2002 to 2008.[7] County-level data before 2002 were not reported in China; although the CSYRE did publish county-level agricultural production data until 2016, agricultural employment was no longer reported after 2008 (having been replaced by rural employment, which also contained rural non-agricultural employment and was unsuitable for our analysis).

A potential concern is the quality of the yearly data on county-level agricultural employment (as well as other county-level measures). Intuitively, it is extremely difficult to collect yearly employment data in county-level. According to CSYRE, the county-level yearly agricultural employment

[7] In 2008, mainland China contained 293 prefectural-level cities, 940 county-level urban districts and 1,909 counties. We excluded data from prefectural-level cities and county-level urban districts, because agricultural labour accounts for an extremely small proportion in these regions. In addition, we excluded 31 counties with missing values.

comes from annual statistical reports of various level of governments or relevant sampling surveys. It has been well recognised that regional employment data in China are imprecise (e.g. Gibson and Scharping 2001; Li 2017). However, as long as the measurement error of the county-level employment is not systematically correlated with the intensity of agricultural subsidies, the estimated effect of agricultural subsidy on agricultural employment should not be biased.[8]

We used the *changes in agricultural employment* to approximate the labour that was reallocated from agricultural to non-agricultural sectors, because nationwide fine-scale statistics on labour reallocation were unavailable.[9] A potential concern was that changes in agricultural employment reflected, not only labour reallocation, but also the natural growth in rural labour (because of changes in fertility and mortality); however, as long as the natural growth in rural labour was uncorrelated with agricultural subsidies, the estimated effect of agricultural subsidies would be unbiased. Even if they were correlated, the small natural growth in rural labour during this period implied a limited effect of the measurement error.[10] In addition, the slight increase in total labour indicated that our estimates tended to underestimate – rather than overestimate – the reducing effect of agricultural subsidies. As a robustness check, we also measured the labour reallocation by the changes in the proportion of agricultural labour, which was less likely to be affected by natural labour trends, and we found comparable results.

Data relating to county-level average agricultural employment, and the percentage of labour in agriculture, are presented in Figure 4. Over the seven investigated years, the county average agricultural employment declined from 157 thousand to 135 thousand, and the percentage of agricultural employment declined from 60.4 per cent to 50.9 per cent. A notable observation was that the declining trend of agricultural employment slowed somewhat after 2004, when China dramatically increased its agricultural subsidies.

[8] According to the regulation of the National Bureau of Statistics of China, each township within a county has to report detailed economic data to the county bureau of statistics at the end of each year. Similarly, the civil servants (village leaders) in each community (village) within a township are in charge of collecting and reporting their data to the township in each year. The data collected by this procedure are certainly subjected to measurement errors, and the errors may be non-random. However, it is unlikely that these errors can be systematically correlated with the intensity of agricultural subsidies (measured by per-capita farmland and the national subsidy rate), and therefore, the estimated effect of agricultural subsidies is not likely biased by the errors. In addition, in our estimation, we will cluster the error term and provide spatial autoregressions as robustness checks to address the concern of serially correlated error.

[9] The best nationwide migration data available was province-level, urban-based data, and this data did not include information about the source of migrants. Because a migrant in an urban region may come from another urban region, this urban-based data was not suitable for our analysis.

[10] Because of China's one-child policy, which started in 1978, the natural growth of labour was very small in our sample period: from 2002–2008, the total labour increased by only 1.6 million, while the total agricultural labour declined by 36.2 million, and the total non-agricultural labour increased by 37.8 million.

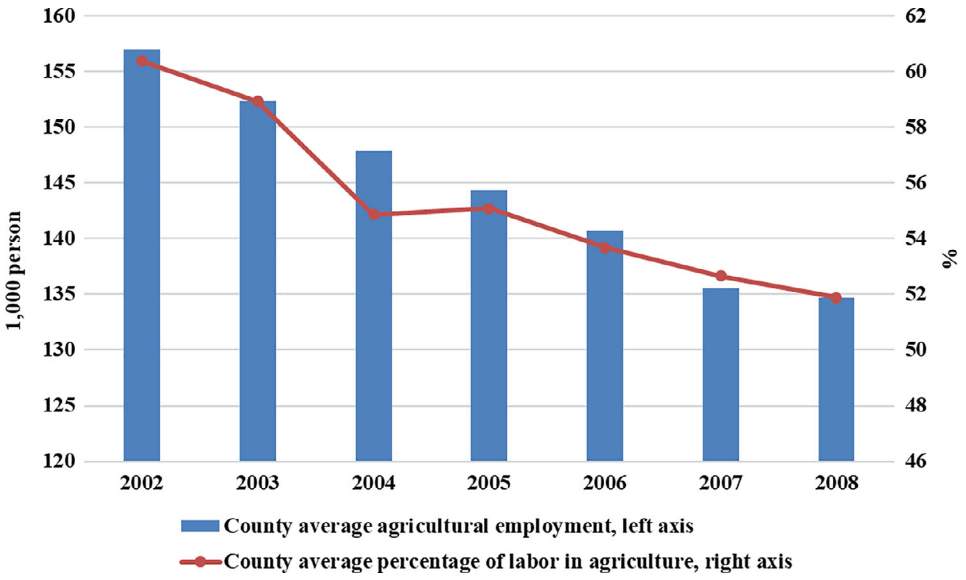

Figure 4 County average agricultural employment (1,000 people) and percentage of labour in agricultural (%).
Data source: China Statistical Yearbook for Regional Economy.

Table 1 presents the definitions and summary statistics of the variables that were used in our econometric analyses. The per hectare subsidy was calculated by dividing the yearly national subsidy (derived from the OECD Agricultural Support Data as shown in Figure 3) by the national total farmland. All other variables were county level and derived from the *CSYRE* for 1,878 counties from 2002 to 2008. Agricultural labour and agricultural labour share were used as the dependent variables in the econometric regressions. *Per-capita farmland* was used as a proxy for the intensity of the agricultural subsidies. We also collected data for six control variables that had the potential to affect migration: per-capita agricultural output, non-agricultural wage, population density, local fixed assets, local revenue and *local expenditures*.

4. Econometric strategy

We estimated the effect of agricultural subsidies on agricultural employment through the following fixed effect panel model:

$$\ln y_{it} = \beta PF_{i,t-1} * PS_{t-1} + \gamma PF_{i,t-1} + \delta PS_{t-1} + \eta Z_{it} + \theta year_t + v_i + \varepsilon_{it} \quad (11)$$

where y_{it} is the number of people employed in agriculture for county i in year t. We used the natural log of y_{it}, which is less sensitive to distributional problems, as the dependent variable. As robustness checks, we also used two

Table 1 Definition and summary statistics of the variables

Variables	Definition	Mean	SD
Agricultural labour	Workers in farming, forestry, animal husbandry and fishery (1,000 people)	135	100
Agricultural labour share	Percentage of workers in agriculture (%)	56.6	15.2
Per-capita farmland (PF)	Farmland per agricultural labour (hectare)	0.47	0.66
Per hectare subsidy (PS)	Average agricultural subsidy (1,000 CNY/hectare)	2.63	1.22
Per-capita agricultural output	Yearly per-capita agricultural output (1,000 CNY)	9.3	10.0
Non-agricultural wage	Yearly non-agricultural wage (1,000 CNY)	14.7	8.9
Population density	Population density (person/km^2)	310	278
Local fixed assets	Local fixed assets (million CNY)	2,083	3,119
Local government revenue	Revenue of local governments (million CNY)	229	543
Local government expenditures	Expenditures of local governments (million CNY)	486	472

Note: This table summarises the county-level variables for 1,878 counties from 2002 to 2008. All CNYs are in 2008 constant values. All data except per hectare subsidy were derived from the *CSYRE* (2003–2009). Per hectare subsidy was derived from the OECD Agricultural Support Dataset.

alternative independent variables: the share of agricultural labour and yearly changes in agricultural employment.

For the independent variables, $PF_{i,t-1}$ was the per-capita farmland in county i, lagged by one year; PS_{t-1} was per hectare agricultural subsidies, lagged by one year; and $PF_{i,t-1} * PS_{t-1}$ denoted the interaction term of $PF_{i,t-1}$ and PS_{t-1}. These variables were lagged by one year for two reasons. Firstly, the lagged independent variables enabled us to address the concern of reverse causality: although changes in agricultural employment would affect current and future per-capita farmland, they would not affect past per-capita farmland. Secondly, the seasonality of agricultural production determined that decisions regarding labour reallocation must be made ahead, so the observed migration in the current year would most likely be due to the effect of subsidies in the previous year.

The inclusion of the interaction term $PF_{i,t-1} * PS_{t-1}$ was necessary in order to capture the true effect of agricultural subsidies. As detailed previously, because the subsidies were mainly based on the contracted farmland areas for a given subsidy rate, farmers with higher per-capita farmland received a larger amount of subsidy. In other words, the magnitude of the effect of agricultural subsidies on agricultural employment depended on per-capita farmland. On the other hand, per-capita farmland itself may also have affected agricultural employment. The interaction term provided a way for us to distinguish between the effect of agricultural subsidies through per-capita farmland and the effect purely caused by per-capita farmland. Specifically, since the interaction term was included in model (11), the coefficient γ

reflected the effect purely caused by per-capita farmland, and the coefficient β reflected the effect of agricultural subsidies through per-capita farmland. Finally, for given per-capita farmland (PF_g), the marginal effect of agricultural subsidies on agricultural employment was $\beta PF_g + \delta$.

The coefficient on PS_{t-1}, δ, represents the effect of PS_{t-1} on $\ln y_{it}$ when $PF_{i,t-1}$ is zero, which is not of our interest. According to Wooldridge (2016, p.201), the coefficient on the level term will be meaningful if we reparameterise model (11) as

$$\ln y_{it} = \beta\left(PF_{i,t-1} - \mu_1\right) * \left(PS_{t-1} - \mu_2\right) + \gamma' PF_{i,t-1} + \delta' PS_{t-1} + \eta Z_{it} + \theta year_t + v_i + \varepsilon_{it} \tag{12}$$

where μ_1 and μ_2 are the sample means of $PF_{i,t-1}$ and PS_{t-1}, respectively. Now the coefficient on PS_{t-1}, δ', represents the partial effect of PS_{t-1} on $\ln y_{it}$ at the mean value of $PF_{i,t-1}$. Comparing models (11) and (12) we have the following:

$$\delta' = \delta + \beta\mu_1. \tag{13}$$

Therefore, a meaningful partial effect of PS_{t-1} can be calculated using estimates of (11) and the sample mean μ_1. The marginal effect of agricultural subsidies calculated from (12) is the same as that calculated from (11) $\beta\left(PF_g - \mu_1\right) + \delta' = \beta PF_g + \delta$. Because our main interest is the marginal effect of agricultural subsidies, we will only estimate model (11); we will use the transformed coefficient according to (13) when we need to interpret the coefficient of the level term.

Our model also addressed the concern of omitted variable bias by including various control variables and fixed effects. Z_{it} was a vector containing six control variables that had the potential to affect agricultural employment: per-capita agricultural output,[11] non-agricultural wage, population density, local fixed assets, revenue of local governments and expenditures of local governments. These variables were included to account for the time-varying determinants of labour reallocation; as robustness checks, we excluded them to test the sensitivity of our key estimates. We also included a year trend,$year_t$, to account for the effect of common time trends on labour reallocation. More importantly, we included a full set of county dummy v_i to account for all time-unvarying county-specific determinants of labour reallocation. Finally, ε_{it} is the error term. When estimating the model, we cluster the error term at the county level to adjust for potential dependence in it. In addition, we will provide a spatial autoregression to check the robustness of our findings to spatial autocorrelation.

[11] Per-capita agricultural output was used as a proxy for agricultural wage, which was unavailable for most of our sample years.

Finally, we would like to clarify the variation used in identifying model (11). As mentioned before, the data on per hectare subsidies are in national level because data at the province or county level were not available. This should not cause a major bias because agricultural subsidies are provided by the central government and the rate of the subsidies is similar across regions. However, this indeed imposes a challenge for our identification because the subsidy rate only varies over the eight sample years. For this reason, we employ another source of variation: inter-county differences in per-capita farmland. This variation is relevant because it measures the intensity of the agricultural subsidies in the sense that farmers with higher per-capita farmland received a larger amount of subsidy. By interacting per hectare subsidies with per-capita farmland and including level terms of them, model (11) uses variation from both sources.

5. Empirical results

For this section, we first estimated the effect of agricultural subsidies on agricultural employment using model (11) and provided various robustness checks. We then calculated the overall effect of China's agricultural subsidies on its labour reallocation.

5.1 The marginal effect of agricultural subsidies

The baseline estimates are reported in column (1) of Table 2. Consistent with our theoretical prediction, we found that agricultural subsidies significantly reduced the outflow of agricultural labour. Specifically, both the coefficients of lagged per hectare subsidies (lagged PS) and the interaction term (lagged PF $\times$ lagged PS) are positive and statistically significant, indicating a positive marginal effect of agricultural subsidies on agricultural employment. For given per-capita farmland, the marginal effect of agricultural subsidy was $0.24PF_g + 0.23$. Detailed calculations for the marginal effects will be presented in the next subsection. As mentioned before, the estimated coefficient of lagged PS is difficult to interpret. We can transform it into the partial effect at the mean value of per-capita farmland according to (13). The transformed partial effect is 0.34 (i.e. 0.24*0.47 + 0.23), which means that a unit (1,000 CNY/hectare) increase in agricultural subsidy will reduce the yearly outflow of agricultural labour by 340 people in a county with the average per-capita farmland.

For the control variables, the negative and significant coefficients of lagged PF suggested that the pure effect of per-capita farmland (with no subsidy) on agricultural employment was negative, which was consistent with the fact that high per-capita farmland is usually observed in regions with low agricultural employment. The estimated coefficients of per-capita agricultural output, local fixed assets and local government revenue were also statistically significant, suggesting the importance of including them as controls.

Table 2 The effect of agricultural subsidies on agricultural employment

Variables	(1) Dependent variable: log agricultural labour	(2) Dependent variable: agricultural labour share	(3) Dependent variable: changes in agricultural labour
Lagged PF × Lagged PS	0.24***	15.16***	28.51***
	(0.07)	(1.83)	(9.39)
Lagged PF	−0.04***	−2.73***	1.91
	(0.01)	(0.22)	(1.29)
Lagged PS	0.23***	7.84***	25.24***
	(0.05)	(2.01)	(8.67)
Non-agricultural wage	−0.00	−0.37***	−0.03
	(0.00)	(0.02)	(0.05)
Per-capita agricultural output	−0.01***	−0.41***	−0.78**
	(0.00)	(0.07)	(0.34)
Population density	0.06	0.28	−2.28
	(0.06)	(1.87)	(6.11)
Local fixed assets	−0.01***	−0.01	0.01
	(0.00)	(0.01)	(0.02)
Local government revenue	−0.01***	−0.09***	0.09**
	(0.00)	(0.02)	(0.04)
Local government expenditure	−0.00	0.06*	0.32***
	(0.00)	(0.04)	(0.10)
Constant	4.64***	61.00***	−10.68***
	(0.03)	(0.95)	(2.95)
County-fixed effects	Yes	Yes	Yes
Time trend	Yes	Yes	Yes
Observations	11,410	11,410	11,410
R^2	0.207	0.426	0.062

*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.
Standard errors clustering at county level are reported in parentheses.

Columns (2) and (3) of Table 2 show the robustness of our main findings regarding labour reallocation. The baseline model used agricultural employment as the dependent variable. This led to a biased estimate of the effect of agricultural subsidy if the natural growth of rural labour correlated with agricultural subsidy. Column (2) used instead the share of labour in agriculture, which was less likely to be affected by natural labour trends, as the dependent variable. We still found that the coefficients of the lagged PS and the interaction term were positive and statistically significant (note that the magnitudes of the estimates were not comparable across models due to the different units). In column (3), the dependent variable was replaced by a more direct measure: yearly changes in agricultural labour. The positive and statistically significant coefficients of lagged PS and the interaction term still indicated that higher agricultural subsidy reduced the outflow of agricultural labour (note that the yearly changes in agricultural labour were negative).

Table 3 checks the robustness of our findings to model settings. Column (1) of Table 3 measured agricultural subsidy by the subsidy rate, which consisted of overall agricultural subsidies as a percentage of the total value of agricultural production (at the farm gate). Consistent with the baseline model, we still found positive and statistically significant estimates of lagged PS and the interaction term. The data in columns (2) and (3) checked the robustness of omitted variables by dropping all control variables and the county-fixed effects, respectively. We still found that agricultural subsidy reduced the outflow of agricultural labour, although the estimated effects were smaller. Finally, Column (4) presents the effect of agricultural subsidy on farmland areas. We found evidence consistent with the assumption of our theoretical model: that agricultural subsidies increased the supply of farmland.

Table 4 checks the robustness of our findings to estimation methods. All control variables are included, but we only report the estimates for the key variables for simplicity. Columns (1) to (3) provide quantile regressions at 25th, 50th and 75th percentiles of the dependent variable, respectively. We estimate the quantile model with fixed effects by the Stata module xtqreg, which uses the method of Machado and Santos Silva (2019). The quantile regressions enable us to check whether the relationship holds across the entire distribution of the dependent variable. The quantile estimates support our finding that agricultural subsidies significantly reduced the outflow of agricultural labour: both the coefficients of lagged PS and lagged PF × lagged PS are positive and statistically significant. Naturally, the size

Table 3 Robust to model settings

Variables	(1) Using subsidy rate instead of subsidy value	(2) Excluding all control variables	(3) Excluding county dummies	(4) Estimating the effect of subsidy on land area
Lagged PF × Lagged subsidy rate	0.01***			
	(0.00)			
Lagged PF	−0.07***			
	(0.02)			
Lagged subsidy rate	0.02***			
	(0.00)			
Lagged PF × Lagged PS		0.24***	0.21***	0.33***
		(0.07)	(0.07)	(0.05)
Lagged PF		−0.05***	−0.05***	−0.05***
		(0.01)	(0.01)	(0.01)
Lagged PS		0.12**	0.19***	0.37***
		(0.05)	(0.05)	(0.06)
Control variables	Yes	No	Yes	Yes
County-fixed effects	Yes	Yes	No	Yes
Time trend	Yes	Yes	Yes	Yes
Observations	11,410	11,410	11,410	11,410
R^2	0.207	0.426	0.062	0.092

*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.
Compared with the baseline model, column (1) replaces the independent variable *per-capita subsidy* with *subsidy rate*, column (2) excludes all control variables, and column (3) excludes county dummies. Column (4) estimates the effect of agricultural subsidy on farmland areas. Standard errors clustering at the county level are reported in parentheses.

Table 4 Robust to estimation methods

Variables	Dependent variable: log agricultural labour				
	(1) Quantile = 0.25	(2) Quantile = 0.5	(3) Quantile = 0.75	(4) Spatial autoregression: *distance-based spatial weights*	(5) Spatial autoregression: *nearest neighbour spatial weights*
Lagged PF × Lagged PS	0.38***	0.23***	0.07***	0.28***	0.26***
	(0.07)	(0.09)	(0.02)	(0.08)	(0.06)
Lagged PF	−0.05***	−0.04***	−0.03***	−0.07***	−0.06***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
Lagged PS	0.07**	0.22***	0.40***	0.25***	0.24***
	(0.03)	(0.09)	(0.08)	(0.06)	(0.06)
County-fixed effects	Yes	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes	Yes
Observations	11,410	11,410	11,410	9,492	9,492
R^2	0.207	0.426	0.207	0.062	0.058

*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.
We only report the estimates for the key variables for simplicity. Standard errors are reported in parentheses.

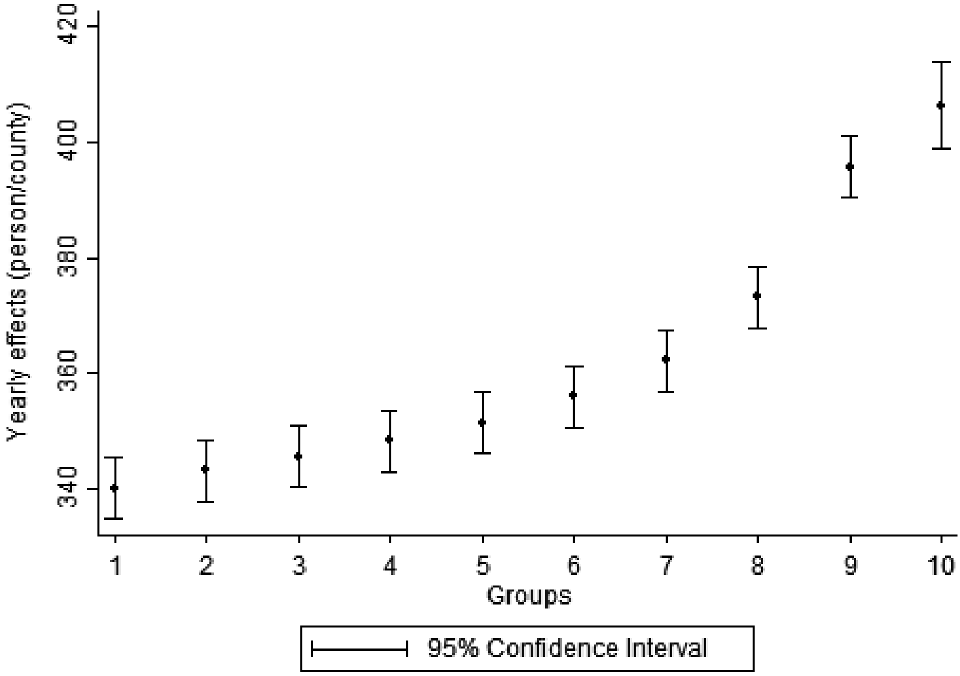

Figure 5 The effect of the agricultural subsidies on county-level agricultural employment across county groups.
Note: We divided all counties into 10 equal-sized groups according to their per-capita farmland and then calculated the effect for each group, based on the regression coefficients of the baseline model.

of the estimate differs across quantiles and only that at the 50th quantile similar to our baseline estimate.[12]

Column (4) of Table 4 addresses the potential concern of spatial correlation. Urbanisation of a county may depend on what is happening in neighbouring counties. Our baseline model follows the literate to address this concern by clustering the error term at the county level (e.g. Deschênes and Greenstone 2007; Fisher *et al*. 2012). In this robustness check, we address this concern by spatial autoregression (Anselin 1988; Elhorst 2010) that directly includes spatial lags in the model. Specifically, following Lee and Yu (2010), we include an additional control variable $\sum_{j \in N} w_{ij} \ln y_{jt}$ in model (11), where w_{ij} is a spatial weight defined as the inverse of the distance between counties i and j, calculated as the distance between the county centroids.[13] The inter-county distance is calculated from China county shapefiles using ArcGIS. A

[12] We will not calculate the overall effect by summing up the marginal effect at different quantiles of the dependent variable. Instead, we will do it by summing up the effect across the quantiles of per-capita farmland, which is our independent variable that measures the intensity of agricultural subsidies. See Section 5.2 for details.

[13] By using w_{ij} as weights, the relationship between the dependent variables of counties i and j would be weaker the further apart these counties are. We estimate the spatial panel-data models by the Stata module *xsmle*.

drawback of this approach is that about 2000 observations have to be dropped in order to form a balanced panel, which is required when calculating the spatial weight. Despite of this, we find the estimates of the key variables are comparable to that in our baseline model, and the marginal effect calculated from them is only slightly larger.

Another concern of the spatial regression approach is the use of the distance-based spatial weights matrix: Given the big variation in the size of China counties (much larger in the west than the east, and somewhat larger in the north than the south), a given distance weight will cover far more neighbours in the south/east than in the north/west. To address this concern, we also provide the spatial regression estimates that use the 'nearest neighbour' spatial weights instead. Specifically, we follow Olivia *et al.* (2018) to use the 5-nearest neighbour weights (i.e. the element of w_{ij} is the dummy that equals 1 if the centroid of county j is one of the 5-nearest neighbour centroids of county i); we have also tried 4- and 6-nearest neighbour weights and found similar results. As presented in Column (5) of Table 4, the estimates are quite similar to that in Column (4).

5.2 The overall effects

We calculated the overall effect of agricultural subsidies on the outflow of agricultural labour over the sample period according to the baseline estimates. We did this through the following four steps. Firstly, we sorted all sample counties according to their per-capita farmland and then divided them into 10 equally sized groups to obtain the mean per-capita farmland for each group. Secondly, we calculated the marginal effect in each group as $\beta PF_g + \delta$, where β and δ are the estimated coefficients of the interaction term and lagged PS, respectively, as reported in column (1) of Table 2, and PF_g is the mean per-capita farmland for group g. Thirdly, we transformed the logarithm marginal effect back into the level marginal effect and multiplied it by average yearly agricultural subsidy to obtain the county average yearly effect for each group. Finally, we summed up the yearly effects across all counties to obtain the overall effect.

Figure 5 presents the county-level average yearly effect of agricultural subsidies on agricultural employment for each county group. We found that the average yearly effect increased with per-capita farmland, and the effect ranged from 340 to 406. The average county-level yearly effect was 362, with a 95 per cent confidence interval of 357–368. In other words, the agricultural subsidies from 2002 to 2008 reduced the average yearly outflow of agricultural labour by 362 people for an average county. Adding up the county-level effects as shown in Figure 5, across all sample counties, we found that agricultural subsidies reduced the average yearly outflow of agricultural labour in China by 0.68 million people, with a 95 per cent confidence interval of 0.67–0.69. Combining this with the observed average annual rural–urban migration during this period, which was 12.0 million people according to National Bureau of Statistics of China (2017), we roughly calculated that agricultural subsidies reduced the national yearly outflow of agricultural labour by 5.67 per cent.

6. Concluding remarks

The current study investigated the effect of agricultural subsidies on urbanisation in China by examining their effect on agricultural employment. Using a panel of county-level data, we found that agricultural subsidies reduced China's yearly labour reallocation from agricultural to non-agricultural sectors by 0.68 million people – about 5.7 per cent of the observed annual rural–urban migration. We saw this as evidence that abnormal agricultural subsidies have retarded urbanisation in China.

Several caveats should be considered when interpreting our estimates. Firstly, we excluded data from prefectural-level cities and county-level urban districts where agricultural employment is negligible; therefore, our numbers may have slightly underestimated the actual overall reducing effect of agricultural subsidies. Secondly, because of data limitations, we estimated only the effect of agricultural subsidies from 2002 to 2008. Considering that agricultural subsidies were increased substantially after 2008, the effect could be stronger after our sample period. Finally, our study used changes in agricultural employment to infer the effect of agricultural subsidies on labour reallocation. Further studies using real labour reallocation data might lead to better estimates.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Acemoglu, D., Johnson, S. and Robinson, J.A. (2001). The colonial origins of comparative development: An empirical investigation, *American Economic Review* 91, 1,369–1,401.

Anderson, K. (2009). *Distortions to Agricultural Incentives: A Global Perspective, 1955–2007*. Washington DC: The World Bank.

Anderson, K. (2010). *The Political Economy of Agricultural Price Distortions*. Cambridge University Press, Cambridge and New York.

Anselin, L. (1988). *Spatial Econometrics: Methods and Models*.Vol. 4. Dordrecht, Netherlands: Springer Science & Business Media.

Carrington, W.J., Detragiache, E. and Vishwanath, T. (1996). Migration with endogenous moving costs, *The American Economic Review*, 86, 909–930.

Chang, G.H. and Brada, J.C. (2006). The paradox of China's growing under-urbanization, *Economic Systems* 30, 24–40.

Chen, Y., Jun-Yi, W.A.N. and Chan, W. (2015). Agricultural subsidy with capacity constraints and demand elasticity, *Agricultural Economics / Zemedelska Ekonomika* 61, 39–49.

Christensen, P. and McCord, G.C. (2016). Geographic determinants of China's urbanization, *Regional Science and Urban Economics* 59, 90–102.
Deschênes, O. and Greenstone, M. (2007). The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather, *American Economic Review* 97, 354–385.
Ebanks, G.E. and Cheng, C. (1990). China: a unique urbanization model, *Asia-Pacific Population Journal* 5, 29–50.
Elhorst, J.P. (2010). Spatial panel data models, in Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis*. Springer, Berlin Heidelberg, pp. 377–407.
Fang, S. (1990). Urbanization in mainland China, *Issues and Studies* 26, 118–33.
Fisher, A.C., Michael Hanemann, W., Roberts, M.J. and Schlenker, W. (2012). The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather: comment, *The American Economic Review* 102, 3749–60.
Friedmann, J. (2005). *China's Urban Transition*. University of Minnesota Press, Minneapolis.
Harberger, A.C. (1971). Three basic postulates for applied welfare economics: an interpretive essay, *Journal of Economic literature* 9, 785–797.
Hayami, Y. and Anderson, K. (1986). *The Political Economy of Agricultural Protection: East Asia in International Perspective*. Allen and Unwin, London and Sydney.
Huang, J. and Yang, G. (2017). Understanding recent challenges and new food policy in China, *Global Food Security* 12, 119–126.
Huang, J., Wang, X., Zhi, H., Huang, Z. and Rozelle, S. (2011a). Subsidies and distortions in China's agriculture: evidence from producer-level data, *Australian Journal of Agricultural and Resource Economics* 55, 53–71.
Huang, J., Wang, X., Zhi, H., Huang, Z. and Rozelle, S. (2011b). Subsidies and distortions in China's agriculture: evidence from producer-level data, *Australian Journal of Agricultural and Resource Economics* 55, 53–71.
Huang, J., Wang, X. and Rozelle, S. (2013). The subsidization of farming households in China's agriculture, *Food Policy* 41, 124–132.
Li, S. and Li, X. (2017). Global understanding of farmland abandonment: a review and prospects, *Journal of Geographical Sciences* 27, 1123–1150.
Long, H. and Liu, Y. (2016). Rural restructuring in China, *Journal of Rural Studies* 47, 387–391.
Machado, J.A.F., Santos Silva, J.M.C. (2019). Quantiles via moments, *Journal of Econometrics* 213, 145–173.
Meng, L. (2012). Can grain subsidies impede rural–urban migration in hinterland China? Evidence from field surveys, *China Economic Review* 23, 729–741.
Milanovic, B. (2005). *Worlds Apart: Measuring International and Global Inequality*. Princeton University Press, Princeton.
Murray, P. and Szelenyi, I. (1984). The city in the transition to socialism, *International Journal of Urban and Regional Research* 8, 90–107.
National Bureau of Statistics of China (2017). Number of Employed persons at Year-end in Urban and Rural Areas. Available from URL: http://data.stats.gov.cn/english/easyquery.htm?cn=C01
OECD (2019). Producer and consumer support estimates database. Available from URL: http://www.oecd.org/tad/agricultural-policies/producerandconsumersupportestimatesdatabase.htm
Olivia, S., Boe-Gibson, G., Stitchbury, G., Brabyn, L. and Gibson, J. (2018). Urban land expansion in Indonesia 1992–2012: evidence from satellite-detected luminosity, *Australian Journal of Agricultural and Resource Economics* 62, 438–456.
Putterman, L. and Dong, X.-Y. (2000). Pre-reform industry and the state monopsony in China, *Journal of comparative economics* 28, 32–60.
Scharping, T. (2001). Hide-and-seek: China's elusive population data, *China Economic Review* 12, 323–332.

Song, F. and Timberlake, M. (1996). Chinese urbanization, state policy, and the world economy, *Journal of Urban Affairs* 18, 285–306.

Tan, Y., Hui, X. and Zhang, X. (2016). Sustainable urbanization in China: a comprehensive literature review, *Cities* 55, 82–93.

The World Bank (2018). World development indicators. Available from URL: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

Whyte, M.K. (1983). Town and country in contemporary China, *Comparative Urban Research* 10, 9–20.

Woodruff, C. and Zenteno, R. (2007). Migration networks and microenterprises in Mexico, *Journal of Development Economics* 82, 509–528.

Wooldridge, J.M. (2016). *Introductory Econometrics: A Modern Approach*. Nelson Education, Boston, MA.

Xu, C., Holly Wang, H. and Shi, Q. (2012). Farmers' income and production responses to rural taxation reform in three regions in China, *Journal of Agricultural Economics* 63, 291–309.

Yi, F., Sun, D. and Zhou, Y. (2015). Grain subsidy, liquidity constraints and food security—Impact of the grain subsidy program on the grain-sown areas in China, *Food Policy* 50, 114–124.

Yu, W. and Jensen, H.G. (2010). China's agricultural policy transition: impacts of recent reforms and future scenarios, *Journal of Agricultural Economics* 61, 343–368.

Zhang, K.H. and Song, S. (2003). Rural–urban migration and urbanization in China: evidence from time-series and cross-section analyses, *China Economic Review* 14, 386–400.

Zhang, L. and Zhao, S.X. (2003). Reinterpretation of China's under-urbanization: a systemic perspective, *Habitat International* 27, 459–483.