The reduction of cotton cultivation in Shandong Province of China

Does off-farm employment matter?

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Abstract

Purpose – The purpose of this paper is to explore the potential causes of the reduction of cotton cultivation in Shandong Province of China from the perspective of smallholders and notably examine the role of off-farm employment.

Design/methodology/approach – This paper extends an integrated behavioral model to analyze the relationship between off-farm employment and cotton cultivation by taking into account farmers' risk attitudes. A household survey data of 144 Bt cotton farmers in six villages in Linqing County, Shandong Province conducted in 2012 and 2013 is used. A simultaneous equations model is established and further estimated by using three-stage least squares method.

Findings – Although the introduction of Bt cotton has promoted the increase in cotton acreage in China from 1999 to 2007, the planting area of cotton has been decreasing since 2007. The results show the significant correlations among risk attitude, off-farm employment, and cotton cultivation. The planting area of cotton is positively correlated with farmers' willingness to take risk but negatively associated with off-farm employment of family members. The findings imply that the rapid emergence of off-farm labor markets is a major reason for the reduction of cotton acreage in Shandong Province. In the context of the more opportunities of off-farm employment in China, cotton acreage is expected to decrease further.

Originality/value – The findings provide a reasonable explanation for the reduction of cotton cultivation in Shandong. This analysis contributes to a better understanding of the relationships among individual risk attitude, off-farm employment, and agricultural behavior, thereby adding to the literature about the application of the integrated behavioral model.

Keywords Off-farm employment, Risk attitude, Cotton cultivation, Three-stage least squares

Paper type Research paper

1. Introduction

As one of major global cotton production and consumption countries, China has experienced three phases of cotton cultivation since the 1990s (Figure 1). First, in the 1990s, the planting area of cotton in China decreased from 6,538.47 thousand hectares by 1990 to 3,725.6 thousand hectares by 1999. One major factor to the reduction of cotton cultivation in this period is damage due to insect pests, particularly bollworms. In the early 1990s, China's cotton farmers started to use pyrethroids, which were more effective and safer than organophosphates used in the 1980s, therefore causing a short increase in cotton acreage in 1994. However, as in the case of other pesticides, China's bollworms began to rapidly develop resistance to pyrethroids in the middle of 1990s (Huang, Hu, Fan, Pray and Rozelle, 2002). Cotton farmers had to use more and more pesticides. Accordingly, cotton farmers not only suffered to the increasing risk of pests but also confronted the increase in the cost of

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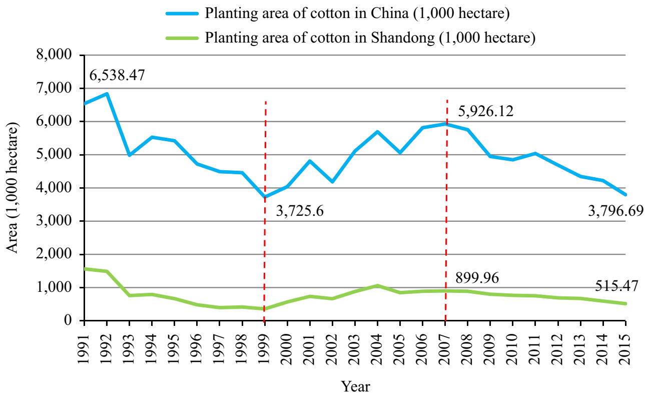


Source: National Bureau of Statistics of China (2016)

Figure 1.
The planting area of cotton in China and Shandong Province

pesticide input. Hence, in the context of the ineffectiveness of cotton varieties produced by conventional breeding methods and the rising use of pesticides by farmers, in 1997 the Ministry of Agriculture approved the commercial use of cotton varieties that were genetically engineered with a Bt gene to produce the toxin that kills bollworms (Huang, Hu, Rozelle, Qiao and Pray, 2002).

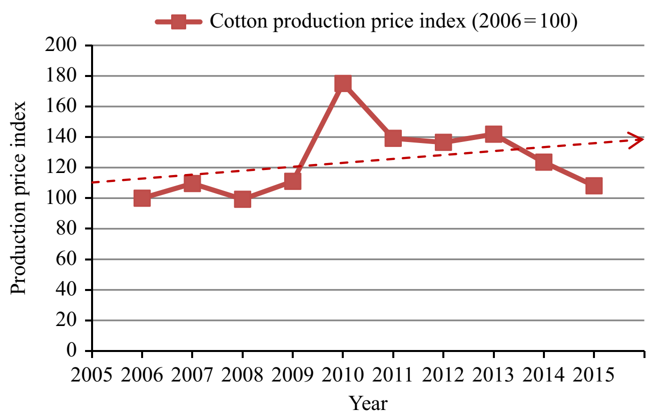
In the second phase (1999-2007), benefit from the application of genetically engineered and biotechnology in the breeding of cotton, China's cotton acreage increased to 5,926.12 thousand hectares by 2007 (Figure 1). During this period, modern agro-biotechnology has been adopted gradually at the global level (Qaim, 2005), while genetically modified crop area has grown rapidly (Wang *et al.*, 2015). With the commercialization of this new technology, one of the first to be introduced was Bt cotton (Marra *et al.*, 2001), which has been a positive example of the application of agro-biotechnology (Huang *et al.*, 2010). Particularly, in China, Bt cotton as the most extensively grown transgenic crop is recognized as a well-documented success story of biotechnology adoption (Huang, Hu, Rozelle, Qiao and Pray, 2002; Wang *et al.*, 2015; Cai *et al.*, 2017). Earlier studies demonstrated that Bt cotton in China has significantly improved production efficiency and had positive health and environmental impacts by reducing pesticide use without affecting yields (Pray *et al.*, 2001, 2002; Huang, Hu, Fan, Pray and Rozelle, 2002; Huang, Hu, Rozelle, Qiao and Pray, 2002; Huang, Rozelle, Pray and Wang, 2002; Huang *et al.*, 2003, 2010; Qiao, 2015), consistent with the study of Bt cotton in other countries such as Argentina (Qaim and De Janvry, 2003). Although insect-resistant Bt cotton has been lauded for its ability to reduce pesticides use, it is a paradox that Chinese Bt cotton farmers continue using excessive amounts of pesticides (Ho *et al.*, 2009; Liu and Huang, 2013). This may be because a lack of quality control of Bt variety undermines the trust of farmers in the effectiveness of pest control inputs (Pemsl and Waibel, 2007), while Liu and Huang (2013) found that farmers who were more risk averse used greater quantities of pesticides. Farmers' knowledge and understanding of the Bt technology may also be an important factor influencing the use of pesticides for Bt cotton (Pemsl *et al.*, 2011).

Despite there exist somewhat controversies over the pesticide use of Bt cotton, China's Bt cotton has been spreading with the increase in cotton acreage in the second phase. The study of Qiao (2015) showed that the rates of Bt cotton adoption in China had been gradually increasing to a very high level, from 27.6 percent by 2003 to 80.73 percent by 2012. In particular, the almost complete adoption of Bt cotton has occurred in Hebei and Shandong Provinces since 2003 (Huang *et al.*, 2010; Liu, 2013; Wang *et al.*, 2015).

Unexpectedly, in the third phase (2007-2015), although the price of cotton in China shows an increasing trend (Figure 2), the planting area of cotton in China has been declining approximately by 36 percent from 2007 to 2015. In particular, cotton acreage in Shandong, the highly efficient production area of cotton in China, has decreased by 42.7 percent, from 899.96 thousand hectares by 2007 to 515.47 thousand hectares by 2015 (Figure 1). The study of Fernandez-Cornejo *et al.* (2002) argued that the future growth of Bt crops in the USA would be slower or negative, depending on the infestation levels of the target pests. However, there is no evidence that China's bollworms have developed resistance to the toxin produced from Bt cotton. The argument of Fernandez-Cornejo *et al.* (2002) seems not enough to give a practical reference for the case in Shandong. To the author's knowledge, existing studies could not provide a sufficient explanation for such reduction of cotton acreage. Hence, it is still unclear what factors have induced cotton farmers in Shandong to quit from cotton cultivation in recent years.

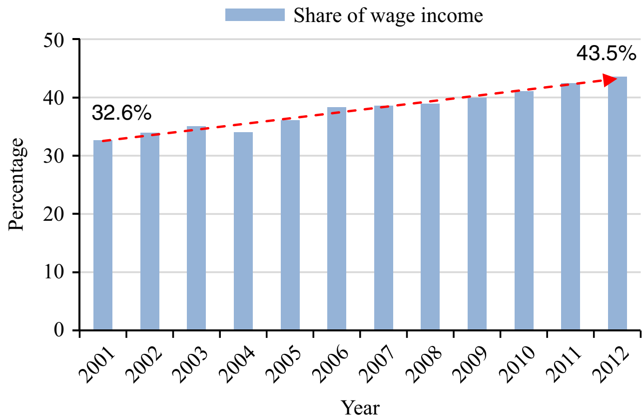
While Bt cotton has reduced the labor input of pesticide use, China's cotton farming remains labor intensive due to the relatively high labor input in the entire production period. Thus, the author considers the rapid emergence of the off-farm labor market in China may play a significant role in the reduction of cotton cultivation in Shandong. In the past decade, China's off-farm labor market has been rapidly developing, which can be characterized by rising non-agricultural wages and booming migration of young farmers (Wang *et al.*, 2011; Wang, Yamauchi, Otsuka and Huang, 2016). As shown in Figure 3, the share of wage income in rural household net income has been increasing since 2001. The rising wage income fostered farmers' participation in off-farm employment (Liu, 2017), while movement off the farm affected farming practices of farmers (Wang, Huang and Rozelle, 2016). Therefore, it is possible that off-farm employment could affect farmers' behaviors of cotton cultivation by facilitating labor force away from the farm. However, off-farm employment is likely to be endogenous for explaining the behavior of cotton cultivation due to the existence of mutual effect between them (Kouser *et al.*, 2017).

The objective of this study is to explore the potential causes of the reduction of cotton cultivation in Shandong Province and in particular to examine the role of off-farm employment. The data used in this study were collected from 144 cotton farmers in six villages in Linqing County of Shandong Province in 2012 and 2013. The author presents a conceptual framework of the integrated behavioral model to illustrate the relationship between off-farm employment and cotton cultivation by taking into account risk attitude. Based on the analysis framework, the author develops a simultaneous equations model



Source: National Bureau of Statistics of China (2016)

Figure 2. The trend of cotton production price index in China



Source: National Bureau of Statistics of China (2016)

Figure 3.
The share of wage income in rural household net income (2001-2012)

which includes three equations representing risk attitude, off-farm employment, and cotton cultivation, respectively. Due to the endogeneity of risk attitude and off-farm employment in explaining cotton cultivation, the model is estimated by employing three-stage least squares (3SLS). Furthermore, the author uses Probit and Tobit regressions to assess the impacts of risk attitude, off-farm employment, and cotton cultivation on the decision of cotton cultivation in the next year.

The rest of this paper is organized as follows. Section 2 presents a conceptual framework of the integrated behavioral model. In Section 3, the author develops two empirical models and shows the estimation methods for them. Section 4 briefly introduces data source and descriptive statistics. In Section 5, the author reports and discusses the model results. The last section presents our summary and conclusions.

2. Conceptual framework

Due to the constraint of household resource endowment such as labor and capital, the allocation of these resources among different behaviors may also result in correlations among the decision making on these behaviors, e.g. off-farm employment and agricultural behavior (Huang *et al.*, 2009, 2012; Che, 2016; Wang, Huang and Rozelle, 2016). Therefore, farmers' cotton cultivation can be hypothesized to be correlated with their off-farm employment (Kouser *et al.*, 2017).

Previous studies suggested that both farmers' cotton cultivation and off-farm employment were associated with their risk attitudes. For instance, Liu (2013) examined the role of individual risk attitudes in the decision to adopt a new form of agro-biotechnology in China and found that farmers who were more risk averse adopted Bt cotton later. The studies of Dohmen *et al.* (2011) and Hardeweg *et al.* (2013) showed the significant correlations between individual risk attitudes and employment behavior. Normally, rural households engaged in agricultural activities face considerable risks in their income process (Dercon, 1996), and their attitudes toward risk are major determinants of the new technologies' diffusion (Moscardi and De Janvry, 1977) and their off-farm employment (Lamb, 2003). Hence, the farmers with heterogeneous risk attitudes may differ in the behaviors of cotton cultivation and off-farm employment.

To illustrate the relationship between cotton cultivation and off-farm employment, the author intends to develop a framework based on the integrated behavioral model by taking into account individual risk attitude. As stated in previous studies such as

Lynne *et al.* (1988), an integrated behavioral theory is needed by drawing on the best from both psychology and economics. Risk attitude as a kind of psychological state has attracted the attention of economists who assess the correlations between risk attitudes and various behaviors (Kingwell, 1994; Tversky and Wakker, 1995; Xiao *et al.*, 2001; Ekelund *et al.*, 2005; Fellner and Maciejovsky, 2007; Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013). The omission of risk attitudes could bias the coefficient estimates of other variables that could potentially be correlated with risk attitudes (Liu, 2013). Hence, it is necessary to incorporate risk attitude into the analysis on the relationship between cotton cultivation and off-farm employment.

Adapted from a model of risk perception and risk behavior in the study of Brewer *et al.* (2004), a conceptual framework for the relationship among risk attitude, off-farm employment, and cotton cultivation is developed and presented in Figure 4. In the observed year *t*, two dot lines denote the possible impacts of the behaviors of off-farm employment and cotton cultivation on individual risk attitude, two solid lines reflect the likely effects of risk attitude on these two practices in turn, and two dash lines represent the potential correlations between these two behaviors. Finally, three dash-dot lines indicate the potential impacts of risk attitude, off-farm employment, and cotton cultivation in the year *t* on the decision of cotton cultivation in the next year, respectively.

According to findings of previous studies and above conceptual framework, the author proposes three hypotheses in this study:

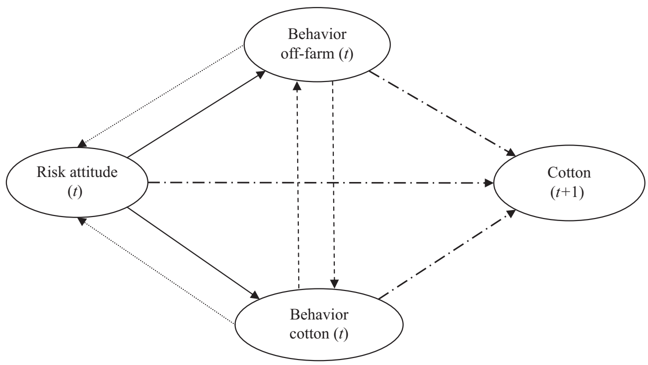
H1. Farmers' behaviors including off-farm employment and cotton cultivation are significantly correlated with their risk attitudes.

H2. Farmers' cotton cultivation and off-farm employment are negatively correlated.

H3. Farmers' risk attitudes, off-farm employment, and cotton cultivation significantly affect their decisions of cotton cultivation in the next year.

3. Empirical models

Based on the analysis framework illustrated above, in this section the author proposes two empirical models: to examine the relationship between off-farm employment and cotton cultivation by incorporating risk attitude; and to assess the possible impacts of risk attitude, off-farm employment, and cotton cultivation on farmers' decisions of cotton cultivation in the next year. Furthermore, the author presents the econometrical methods to estimate these two models.



Source: Author's illustration

Figure 4.
Conceptual framework of the relationships among risk attitude, off-farm employment, and cotton cultivation

3.1 Model specification

Following the conceptual framework of the relationship between risk attitude, off-farm employment, and cotton cultivation in Figure 4, the author establishes three equations:

$$Risk_{it} = \alpha_0 + \alpha_1 Off\_farm_{it} + \alpha_2 Cotton_{it} + \alpha_3 Z_{it} + \varepsilon_i \tag{1}$$

$$Off\_farm_{it} = \beta_0 + \beta_1 Risk_{it} + \beta_2 Cotton_{it} + \beta_3 M_{it} + \mu_i \tag{2}$$

$$Cotton_{it} = \theta_0 + \theta_1 Risk_{it} + \theta_2 Off\_farm_{it} + \theta_3 N_{it} + u_i \tag{3}$$

where i index the ith household and t represents year t. *Risk* is a variable of risk attitude, *Off_farm* denotes the circumstance of off-farm employment of family members in a household, and *Cotton* represents the status of cotton cultivation of a household. Z, M, and N are three vectors of variables that may also affect *Risk*, *Off_farm*, and *Cotton*, respectively. α_0, α_1, α_2, α_3, β_0, β_1, β_2, β_3, θ_0, θ_1, θ_2, and θ_3 are parameters to be estimated, while ε, μ, and u are random error terms.

Furthermore, to capture the potential impacts of risk attitude, off-farm employment, and cotton cultivation in the year t on farmers' decisions of cotton cultivation in the year $t+1$, the author further specifies the following equation:

$$Cotton_{i(t+1)} = \rho_0 + \rho_1 Risk_{it} + \rho_2 Off\_farm_{it} + \rho_3 Cotton_{it} + \rho_4 N_{it} + \omega_i \tag{4}$$

where ρ_0, ρ_1, ρ_2, ρ_3, and ρ_4 are parameters to be estimated and ω is a random error term. In view of the research objective of Equation (4) and in order to simplify the equation, all explanatory variables used here are predetermined variables.

3.2 Model estimation

In Equations (1)-(3), all dependent variables are endogenous explanatory variables of other equations, while the error terms ε , μ, and u are expected to be correlated. Thus, these three equations are supposed to be constructed as a simultaneous equations model and to be estimated via 3SLS. The approach of 3SLS introduced by Zellner and Theil (1962) employs the method of instrumental variable to obtain consistent estimates and further uses generalized least squares (GLS) to account for the correlations between the disturbances across the different equations of the system. In previous studies regarding the relationship between risk and behavior such as Jacques and Nigro (1997), 3SLS has also been employed to control for the possible simultaneity bias and endogeneity bias.

Following the introduction of 3SLS by Zellner and Theil (1962) and Greene (2012), the estimation of the author's model is proposed to be implemented by three steps: each endogenous variable on all exogenous variables will be estimated by ordinary least squares, and then the author can obtain the predicted value of each endogenous variable; based on the residuals of each equation estimated by two-stage least squares, the author can further yield a consistent estimate of the covariance matrix of the equation disturbances; and a GLS estimation should be implemented by using the covariance matrix estimated in the second stage and with the predicted values from the first stage in lieu of endogenous variables.

Furthermore, to validate the use of 3SLS and guarantee a precise result, two identification tests are further implemented. The test of Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix is used to identify the independence of the three equations, while the Hansen-Sargan Over-identification Statistic is employed to test the problem of over-identification in a simultaneous equations model.

Equation (4) is proposed to be estimated by two methods according to two setting forms of the dependent variable. First, $Cotton_{i(t+1)}$ is treated as a dummy variable, wherein $Cotton_{i(t+1)} = 1$

represents the ith farmer plants cotton in the year $t+1$, otherwise $Cotton_{i(t+1)}$ will equal 0. In such case, Equation (4) will be estimated by Probit regression. Second, the author defines $Cotton_{i(t+1)}$ as the planting area of cotton in the year $t+1$ and hence estimates it using Tobit regression due to the consideration of a censored dependent variable.

4. Data and descriptive statistics

4.1 Data collection

Data utilized in this study were collected in a household survey of cotton farmers in Linqing County, which is located in the northwestern part of Shandong Province in the Yellow River region belonging to the highly efficient production areas of cotton in China. The fact that Shandong has been accounting for more than 10 percent of the national cotton production since 2002 and that the experimental station of the provincial cotton research center is situated in Linqing emphasizes the importance of cotton in this area (Dohmeier, 2012).

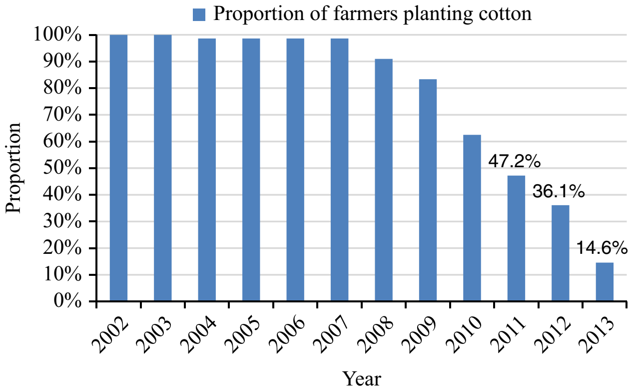
For conducting farm-level interviews of cotton farmers, five villages in Linqing County were first selected in 2002 by taking into account the percentage of cotton in the production system, the access to roads and markets, and the geographical distribution. These five villages are situated in an area of 25 kilometers in diameter, with a distance of 3 kilometers between the two closest villages. In each village, 30 farmers were randomly selected and interviewed. A final sample of 150 cotton farmers in Linqing was compiled in the first survey year in 2002 (Pemsl *et al.*, 2005). The same procedure of data collection was applied to the same set of farmers in 2005 (Wu, 2010). However, six sample farmers have left the villages during the time interval of ten years; accordingly, only 144 traceable sample farmers were interviewed in 2012 and 2013, respectively (Dohmeier, 2012).

Relevant research findings concerning cotton cultivation using the household survey data collected in 2002, 2005, and 2012 have been published in previous studies such as Pemsl *et al.* (2005, 2008, 2011), Pemsl and Waibel (2007), Wu (2010), and Dohmeier (2012). In this study, the author employs the household survey data collected in 2012 and the data of cotton cultivation in 2013. The household questionnaire used in 2012 comprised comprehensive socio-economic information of farmers, e.g. characteristics of family members, well-being, risk attitude, off-farm employment, cropping pattern, information on production input and output of cotton, and so on. The household survey in 2013 was an additional investigation to update the information on well-being, land use, and the production of cotton and other crops.

4.2 Descriptive statistics of key variables

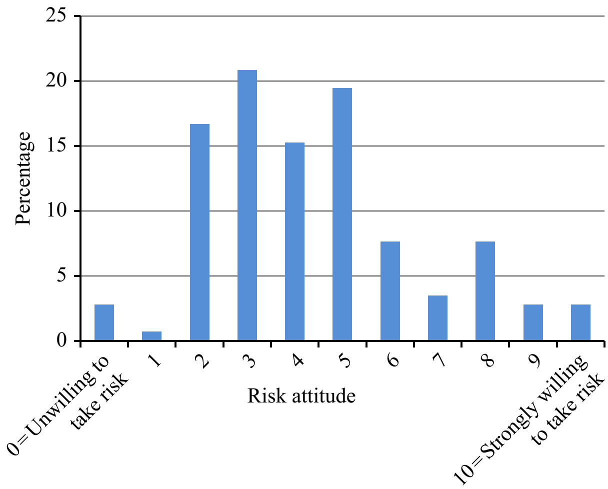
Figure 5 reports the trend of cotton cultivation in the five sample villages in Linqing County of Shandong. In 2002, all farmers were growing insect-resistant Bt cotton varieties (Pemsl *et al.*, 2005). However, more and more farmers quit from cotton cultivation since 2007. By 2012, only 52 farmers (36.1 percent) remained to plant cotton, while the number of cotton farmers continued decreasing to 21 households (14.6 percent) by 2013.

Following the measurement of subjective assessments of risk attitudes in prior studies (Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013), the author applied an 11-point Likert-scale to measure farmers' willingness to take risk in this study. This simple self-assessment of risk attitude is validated by a highly incentivized experiment in Germany and Thailand and thus may provide useful evidence on risk attitude (Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013). Figure 6 shows a histogram of farmers' willingness to take risk in sample, wherein a value of 0 implies "unwilling to take any risk" and a value of 10 means "strongly willing to take risk". Figure 6 shows the bars are slightly higher on the left of the diagram than the right, implying some average risk aversion within the author's sample. Nevertheless, the distribution of farmers' risk attitude in the author's sample is more even than those in



Source: Author's Survey (2012, 2013)

Figure 5.
The trend of cotton cultivation in the five sample villages of Shandong



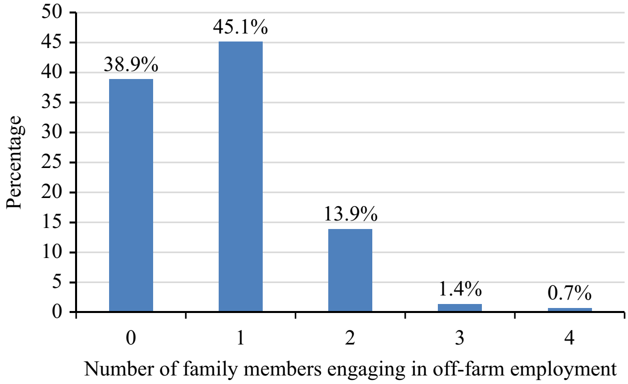
Source: Author's Survey (2012)

Figure 6.
Distribution of farmers' risk attitudes

Germany and Thailand that were intensively distributed in three extreme categories of 0, 5, and 10 (Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013), indicating most farmers' risk attitude are ambiguous and not quite clear.

Figure 7 presents the circumstances of off-farm employment of family members in sample households. Of the total sample households, only 38.9 percent do not have family members engaging in off-farm employment, while over half of households have minimum one family member who is working off the farm. For 13.9 percent households, the number of off-farm employment in a household even reaches 2. These results indicate a high movement of cotton farmers' labor from agriculture to the off-farm sector. Such circumstances are to some extent consistent with the findings of previous employment studies (Su *et al.*, 2015; Wang, Huang and Rozelle, 2016) and the overall developing trend of the national off-farm labor market.

Table I provides detailed definitions and statistics for all the variables used in this study. On average, per capita planting area of cotton in 2012 was 0.49 mu (1 mu = 1/15 hectare),



Source: Author's Survey (2012)

Figure 7. Off-farm employment of family members of sample households

Variables	Description and definition	Mean	SD	Min.	Max.
Sample size			144		
Cotton1	Planting area of cotton in 2012 (mu/person)	0.49	0.84	0	4
Cotton2	Planting area of cotton in 2013 (mu/person)	0.16	0.46	0	2.5
Risk attitude	Willingness to take risk	4.39	2.23	0	10
Off-farm	Proportion of family members engaging in off-farm employment	0.29	0.27	0	1
Age	Age of respondent (years)	53.08	8.96	24	78
Edu	Education of respondent (1 = middle school and above; 0 = otherwise)	0.22	0.42	0	1
Height[a]	Height of respondent (cm)	169.06	4.94	150	180
Head	Whether the respondent is a household head (1 = yes; 0 = no)	0.89	0.32	0	1
Hhsize	Number of family members	2.69	1.03	1	6
Elder	Proportion of elderly (age > 60) in household	0.18	0.35	0	1
Shocks	Shocks experienced in the past three years (1 = yes; 0 = no)	0.16	0.37	0	1
House	Imputed value of owned house (1,000 yuan)	82.69	58.95	0	300
Remoteness	Distance from village to the nearest city (km)	19.97	5.44	15	30
V_cotton	Average planting area of cotton of other farmers in the village (mu/person)	0.49	0.32	0.01	1.03
V_risk	Average scores of risk attitude of other farmers in the village	4.39	0.30	3.81	5
V_off	Average proportion of family members engaging in off-farm employment in the village	0.29	0.07	0.21	0.42

Note: [a]Only 143 observations due to one missing observation
Source: Author's survey

Table I. Socio-economic characteristics of respondent and household in 2012

while it decreased to 0.16 mu by 2013. The mean value of willingness to take risk is just 4.39 in the author's sample, which is even slightly smaller than the results in Thailand (4.56) and a middle value of 5.0 (Hardeweg *et al.*, 2013). The overall attitude risk of the author's sample appears to be risk averse. Also, averagely the proportion of family members engaging in off-farm employment is 29 percent.

Following previous studies (Hardeweg *et al.*, 2013; Su *et al.*, 2015; Kouser *et al.*, 2017; Wang, Huang and Rozelle, 2016), the author includes different control variables in Equations (1)-(3). The characteristics of respondents such as age, education level, height, household head, the shocks experienced in the past three years, and average scores of risk attitude of other farmers in the village are used to identify risk attitude (Equation (1)). As for off-farm employment (Equation (2)), the author proposes to control for two variables at household level including number of family members and proportion of elderly (age > 60) in a household, and two variables at village level consisting of the remoteness, i.e. distance from the village to the nearest city and average proportion of family members engaging in off-farm employment in the village. The control variables used in Equations (3) and (4) are similar to the setting of variables in Equation (2), apart from adding a new variable regarding the value of owned house at household level and using the average planting area of cotton of other households in the village in place of average off-farm employment level. The differences in the setting of exogenous control variables among Equations (1)-(3) are due to take into account the identification of a simultaneous equations model.

5. Results

5.1 Estimation results

Table II reports the estimation results of a simultaneous equations model including Equations (1)-(3) by 3SLS. In the bottom of Table II, *F*-statistics of all these three equations are significant at 1 percent level, confirming the joint explanatory power of all independent variables for the three equations, respectively. The test of Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix rejects the null hypothesis that the three equations are independent at 1 percent significance level, confirming the statistical validity of the author's established simultaneous equations model. Thus, the separate estimation for Equations (1)-(3) will lead to a simultaneity bias. Furthermore, the test of Hansen-Sargan Over-identification Statistic demonstrates that there is not a problem of over-identification, validating the estimation results of 3SLS for the model. In summary, both the specification and estimation of the author's established model are appropriate.

The estimation results in the second column of Table II indicate that farmers' risk attitudes are significantly affected by the off-farm employment of family members and

	Risk attitude		Off-farm		Cotton1	
Variables	Coef.	SE	Coef.	SE	Coef.	SE
Risk attitude			0.01	0.02	0.09	0.05**
Off-farm	−19.07	5.76***			−2.71	0.74***
Cotton1	1.89	1.13*	−0.21	0.09**		
Age	−0.15	0.06**				
Edu	0.21	0.41				
Height	0.10	0.06*				
Head	−0.62	0.87				
Hhsize			−0.02	0.02	−0.14	0.07*
Elder			−0.12	0.06**	−0.28	0.23
Shocks	−0.20	1.13	0.03	0.07	0.10	0.21
House					0.0004	0.001
Remoteness			0.02	0.01***	0.04	0.02**
V_risk	1.41	0.51**				
V_off			0.14	0.05**		
V_cotton					0.55	0.27*
_cons	−5.04	13.68	0.09	0.16	0.10	0.53
Obs.		143		143		143
F-statistics		3.17***		2.90***		5.76***
Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix Test					118.48***	
Hansen-Sargan Over-identification Statistic Test					16.27	

Notes: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$
Source: Author's calculation

Table II.
Regression results of 3SLS for risk attitude, off-farm employment, and cotton cultivation

cotton acreage. Column 3 reports the estimation results of off-farm employment, showing only cotton acreage is a significant influence factor while the coefficient of risk attitude is statistically insignificant. As shown in Column 4, the planting area of cotton is significantly impacted by both risk attitude and off-farm employment. Hence, *H1* can be confirmed partially, while *H2* is fully approved.

According to above estimation results, it can be concluded that off-farm employment lowers farmers' willingness to take risk, while cotton cultivation can increase their willingness to take risk. Due to labor allocation within a household, cotton cultivation negatively affects the proportion of family members engaging in off-farm employment and conversely a higher level of off-farm employment in a household can also result in fewer cotton acreage. Hence, the fact that China's off-farm labor market is rapidly emerging is an important reason for the reduced planting area of cotton in Shandong Province.

Table III reports the results of Probit and Tobit regressions for cotton cultivation in the next year (Equation (4)).The tests of Wald χ^2 or F-statistics of all regressions are significant at 1 percent level, confirming the joint explanatory power of these predetermined variables for cotton cultivation in the next year and the validity of the specification of Equation (4).

The estimation results in Table III indicate that the decision of cotton cultivation in the next year is significantly affected by off-farm employment and cotton cultivation in the last year. A household with a higher level of off-farm employment and fewer area of cotton will plant fewer cotton in the next year. It seems that the reduction of cotton cultivation will be persistent in Shandong Province in next few years. Furthermore, inconsistent with the estimation results of Equation (3), risk attitude has an insignificant impact on cotton cultivation in the next year, regardless of Probit regression (1) and Tobit regression (1). Even when the variables of off-farm employment and cotton cultivation are not controlled (Probit (2) and Tobit (2)), the coefficient of risk attitude is still insignificant. Hence, *H3* is also just partially confirmed.

5.2 Simulation and discussion

Based on the estimation results in Tables II and III and the correspondingly calculated marginal effects, the author reconstructs the conceptual framework from Figures 4 to 7.

	Whether plant cotton				Planting area of cotton			
	Probit (1)		Probit (2)		Tobit (1)		Tobit (2)	
Variables	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
Risk attitude	−0.06	0.08	−0.06	0.07	−0.01	0.08	−0.05	0.11
Off-farm	−1.41	0.67**			1.07	0.29***		
Cotton1	1.04	0.27***			−1.56	0.64**		
Hhsize	−0.06	0.20	−0.29	0.19	−0.14	0.19	−0.57	0.29**
Elder	0.52	0.53	0.35	0.41	0.44	0.44	0.39	0.57
Shocks	0.30	0.38	0.01	0.38	0.20	0.36	−0.14	0.55
House	0.005	0.003	0.004	0.002	0.004	0.003	0.006	0.004
Remoteness	−0.30	0.18*	−0.08	0.04**	−0.30	0.22	−0.09	0.06
V_cotton	8.99	5.20*	3.39	0.57***	9.60	6.19	5.00	0.97***
_cons	−1.08	0.81	−0.88	0.74	−1.52	0.82*	−1.59	1.10
Obs.		144		144		144		144
Wald χ^2 /F-statistics	25.14***		54.30***		5.26***		7.86***	
Pseudo R^2		0.43		0.19		0.36		0.16

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
Source: Author's calculation

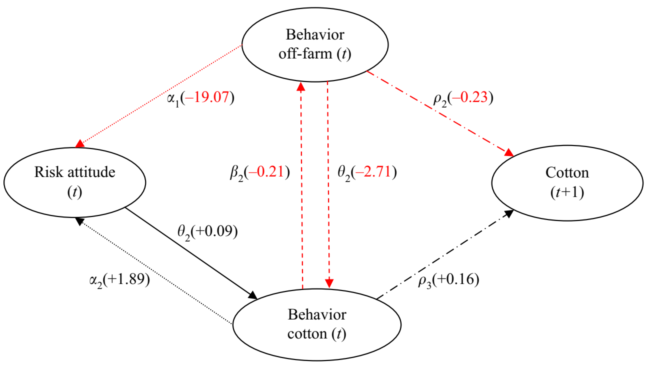
Table III. Estimation results of cotton cultivation in the next year

The red line denotes negative effect, while the black line represents positive effect. The numbers in parentheses are the corresponding marginal effects between the two variables, wherein the marginal effects for cotton acreage in the next year are the unconditional expected values from Tobit regression (2). Overall, Figure 8 can more clearly show the relationship between risk attitude, off-farm employment, and cotton cultivation.

Given the relatively constant risk attitude in a short term, the positive impact of risk attitude on cotton cultivation in the year, and the insignificant impact of risk attitude on cotton cultivation in the next year, the author can conclude that risk aversion leads to some farmers planting fewer cotton in the observed year, but risk aversion cannot be treated as a reason resulting in the reduction of cotton cultivation of farmers in Shandong over the last decade.

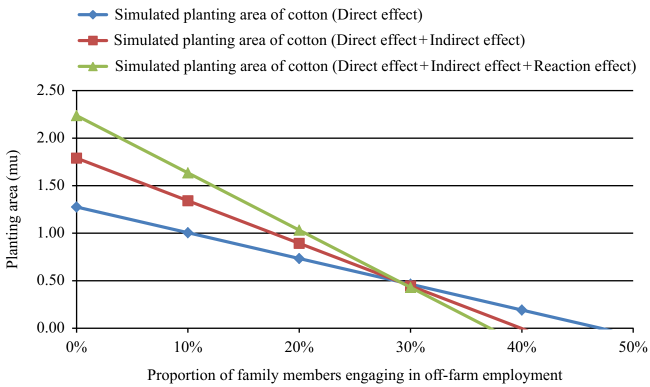
Off-farm employment negatively affects the planting area of cotton, while cotton acreage, in turn, has a significant and negative impact on off-farm employment. Hence, to accurately capture the impact of off-farm employment on cotton cultivation, it is essential to control for the former's endogeneity. The study of Zhan *et al.* (2012) believed that receiving more off-farm income could increase the odds that a farm may quit from producing grains. However, the estimated coefficients of off-farm income share were not statistically significant. This may be because that their study did not control for the endogeneity of off-farm employment. Through controlling for the endogeneity by using 3SLS, the author's results confirm that the rising off-farm employment is a reason for farmers quitting from cotton cultivation.

According to Figure 8, the author furthers project the planting area of cotton with the changes in the proportion of family members engaging in off-farm employment. The direct marginal effect of off-farm employment on cotton cultivation and the predicted planting area of cotton at the mean values of all explanatory variables are used to simulate the trend of cotton acreage with the changes in off-farm employment. As shown in Figure 9, the solid line represents the relationship between cotton cultivation and off-farm employment by only taking into account the direct effect from Equation (3), the dashed line denotes their relationship by additionally considering the indirect effect via risk attitude, while the dotted line is drawn by further adding one-time reaction effect of cotton cultivation on off-farm employment. The results visually show a decreasing trend of cotton cultivation with the increase in the proportion of family members engaging off-farm employment. If the off-farm labor markets in China could further develop, the planting area of cotton would continue decreasing in Shandong Province. Also, the practical impact of off-farm employment on cotton cultivation is higher than the direct effect in Equation (3). According to the simulation



Source: Author's calculation

Figure 8.
Estimated relationships among risk attitude, off-farm employment, and cotton cultivation



Source: Author's calculation

Figure 9. Simulated planting area of cotton in the case that off-farm employment changes

results, the author can further anticipate that a cotton farmer in Shandong will stop planting cotton, once the proportion of family members engaging in off-farm employment in the household is near 40 percent.

6. Conclusions

Cotton is an important cash crop in China and many countries. Cotton often suffers from various diseases and pests such as bollworms, so that in the early 1990s China's cotton acreage has been decreasing. The application and promotion of Bt cotton have promoted the increase in cotton acreage in China since 1999; however, from 2007 the planting area of cotton has been declining again in China, especially in Shandong Province. This paper is the first study to explore the potential causes of the reduction of cotton cultivation in Shandong and notably to examine the role of off-farm employment. Based on the household survey data of 144 farmers in Linqing County of Shandong Province, the results suggest that cotton cultivation is positively correlated with farmers' willingness to take risk, but negatively correlated with off-farm employment of family members. In other words, farmers with a higher willingness to take risk are more likely to continue to planting cotton while those who experience good off-farm employment may reduce the cotton area in Shandong. Hence, farmers with heterogeneous risk attitudes differ in cotton acreage, while the rapid emergence of the off-farm labor market in China is the primary reason for the reduction of cotton cultivation.

The findings of this study have important implications for a better understanding of the future development of cotton cultivation in China and the transformation of the rural economy in the context of the rapid development of off-farm labor markets in China. The negative correlation between off-farm employment and cotton cultivation shows they are substitutable so that policies designed to raise the one must come at the expense of the other (Lamb, 2003). Provided the off-farm labor markets in China can further develop, the future of cotton cultivation will confront a great challenge, that is, more and more cotton farmers would quit from cotton cultivation. This study to some extent also provides a reference for understanding the reduced acreage of other field crops such as grains in China. With the rising wage in China, an increasing number of farmers might quit from agriculture and engage in off-farm employment, while the left behind farmers would specialize in farming (Wang, Huang and Rozelle, 2016). Hence, the results also imply that the development of off-farm labor markets has facilitated the rural economic transformation in China.

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