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How Does Agricultural Insurance Alter Income Distribution?

by Huang Chen, Kexin Liu, and Lingling Hou

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1. Introduction

As a financial risk-hedging tool, insurance may have impacts on both fluctuations and means of income. The conventional role of insurance is to smooth income flow, called ex-post impact of insurance (Janzen & Carter, 2019; Mas-Colell et al., 1995). In recent year, the effect of insurance on behavior changes, called ex-anti impact, has been widely concerned in both academia and industries (Annan & Schlenker, 2015; H. Cai et al., 2015; Jing Cai, 2016; Karlan et al., 2014). As a result, the change on the mean of income induced by the behavior change has also been also discussed in literature (Donovan, 2020; Farrin & Miranda, 2015).

The behavioral changes can be divided into two categories (Ramaswami, 1993). First, the moral hazard behavior, that is, in order to increase the possibility of getting indemnified, insureds directly reduce the input intensity (Smith & Goodwin, 1996). Second, the adjustment of risk portfolio, that is, because insurance can protect the minimum income level, the insured tends to choose a riskier but more profitable portfolio to obtain a higher expected return (Cole et al., 2017; Hill & Viceisza, 2012).[1] Both of them increase the cost of insurers and jeopardize the long-term sustainable development of insurance markets, hence are widely concerned in marketized insurance industries, such as in automobile insurance and health insurance (Cummins & Tennyson, 1996; Einav et al., 2013).

As a booming field in insurance industry, agricultural insurance is usually highly subsidized by governments for protecting the long-run development of agriculture sector. However, considering the huge financial burden of the subsidy, the extent to which agricultural insurance increases farmers' welfare is a question worth answering by researchers and concerned by policymakers. In addition, although most of agricultural insurance policies have set a relatively high deductible in order to mitigate the moral hazard threat, whether the second type of behavior changes still exists and whether it really brings in long-term expected outcomes increase is a question left up in the air. Finally, beside of the financial burden, does the subsidized insurance have brought other unexpected outcomes should also be noticed.

In this study, we answer the above questions by evaluating the impact of China's policy-oriented livestock insurance (POLI) on the income distribution of pastoralists, corresponding mechanism, and the unexpected ecological cost. The data of this study comes from the author's large-scale field survey in Qinghai Province and Gansu Province in 2017, covering 358 pastoral households over multiple years. The two provinces are major grazing provinces in China. According to 2020 China Statistical Yearbook (National Bureau of Statistics, 2020), the share of grazing industry over provincial GDP is more than 8.5% in Qinghai and 4.5% in Gansu. Especially for the Qinghai, the share of grazing industry in agriculture GDP is 55.2%, ranking first in China.

This study finds that purchasing POLI can increase pastoralists' household net income by about 15800 yuan (count for 25.5% of the sample average).[2] In addition to the net payment from POLI (indemnification received net premium paid by pastoralists) of 2684 yuan, behavior changes are the main mechanism leading to the increase of household net income,

[1] Ramaswami (1993) names the two effects as "moral hazard" effect and "risk reduction" effect.

[2] 100 yuan (RMB) is about $15.56 (based on the exchange rate on January 31, 2021).

including expanding the production scale by enhancing animal rotation rate, saving input costs, and switching to riskier production structure (having more riskier type of animal – sheep, compared with cattle, and increasing infant animal proportion), each of them explain 42.2%, 4.7% and 22.3% of the household net income increase, respectively. These findings confirm two things: first, insurance does promote the absolute level (the first moment) of income; second, the effect is primarily through the second type behavior change -- adjustment of risk portfolio. In order to show the robustness of the conclusion, we also test other variables related to income, such as household gross income, household production cost, pastoral gross income, and pastoral net income. The tests not only confirm the findings but also indirectly support the suggested mechanism, i.e. the impact comes from pastoral income increase rather than cost saving or other income sources.

We also test whether insurance can stabilize income fluctuation (the second moment of income). Due to data limitation, we can only compare the standard deviation and coefficient of variation of household pastoral income during 2008-2010 and 2015-2017 two periods with or without insurance. It is conservatively estimated that purchasing insurance can mitigate 38.7% of the fluctuation of household gross pastoral income.

Furthermore, as the insurance stimulates grazing in general, it creates a burden on the local ecological system, which is an unintended consequence for policymakers' initial purpose of subsidizing POLI. Our study shows that the insurance will reduce the grassland quality, measured by Normalized Difference Vegetation Index (NDVI), by 32% of local long-run standard deviation.

The identification strategy mainly relies on the fixed effect (FE) model and the instrumental variable (IV) method. First, the FE model eliminates all time-invariant endogenous factors. Secondly, we use the gradually expanded village-level insurance policy as an IV for pastoralists' insurance purchases. Since the government may take local weather risks into consideration during expanding POLI, we control the historical climate fluctuation to enhance the exogeneity of the IV. Moreover, the government may also consider other unobserved factors related to grazing activities when implementing POLI. Therefore, we first examine various factors that may affect the expansion of the insurance policy, and find that geographic, demography, economic conditions, and agricultural production conditions cannot predict the implementation of POLI. Secondly, we conduct placebo tests before all impact evaluations, and results show that before the implementation of the policy, there is no significant difference in all independent variables between the villages with and without the insurance policy. The determinant analysis and placebo tests corroborate the exogeneity of the IV to some extent. Nevertheless, this paper further employs the event-study method to verify the parallel trend of the key variables of pastoralists with different future insurance status, and estimation results based on the event-study method (also include the difference-in-difference estimation) are also consistent with the results obtained by using FE with IV.

This study has important practical and theoretical implications. First of all, on the one hand, this study provides quantitative empirical evidence showing that government subsidies on the agricultural insurance market indeed improve farmers' income absolute level and lower the income variation. The income boosting effect is considerably large and worth government to continue financing the market. The mechanism behind the income boost also indicates that overall livestock production would increase. On the other hand, the subsidy not only brings in

fiscal burden on different levels of government administrations but also imposes threats on environmental protection, cause grassland degradation. Secondly, this paper also contributes to the research on insurance. Due to the endogeneity of individuals' insurance purchase behavior, it is difficult to get a true estimate of the effect of insurance on outcome variables from large scale implemented insurance markets.[3] This paper uses an on-going insurance project -- POLI, currently world largest livestock insurance project (in terms of total premium collected), promoted by the government as a quasi-natural experiment to identify the causal effect of insurance purchase in real world. Moreover, this paper also empirically finds the mechanism of insurance, confirms and quantifies the phenomenon of behavior changes induced by being insured. Finally, although it is generally acknowledged that insurance has the effect of income smoothing, there are few empirical evidences we can find in literature, especially in agricultural insurance field. The impact of insurance on smoothing income fluctuation found in this paper filled this gap.

The paper is organized as follows. Section 2 provides the background of policy-oriented livestock insurance in China. Section 3 describes the data. Section 4 and 5 present empirical analyses, and Section 6 concludes.

2. Background of POLI

In order to support agricultural development and increase farmers' income, the Chinese government began to implement policy-oriented agricultural insurance in 2007, offering high subsidies to insurance premiums, with an average subsidy rate of 70-85%. After more than 10 years of rapid growth, China's total agricultural insurance premium increased from 5.18 billion yuan in 2007 to 81.5 billion yuan in 2020, ranking the second in the world (China Securities Journal, 2021; Economic Daily, 2017). Grazing industry plays an important role in agricultural sector. In 2019, the output value of grazing industry in China accounted for 26.7% of the total agricultural output value.[4] Therefore, for strengthening livestock farmers' risk resistance capability and stabilizing grazing industry production, the Chinese government also launched POLI in 2007, which has now extended to all provinces in China and has become the largest livestock insurance market in the world (China News, 2014; Economic Daily, 2017).

In addition to the high premium subsidy, one special feature of POLI is that the policy is promoted by administrative orders of governments at all levels. The insurance police is formulated by the provincial government and passed down to every sub-branches. The detailed insurance operations are performed by county-level insurance companies and assisted by the agricultural bureaus at the same level. Towns and villages are gradually selected into the POLI year by year; for the villages that are covered by the POLI, the insurance purchase is entirely voluntary (Government of Qinghai Province, 2012). The village leaders help insurance company assigned salesmen (called "insurance coordinator", "xie pei yuan" in Chinese) to confirm who decide to purchase the POLI, and finish the whole buying transaction, including collecting premium and verifying the numbers of livestock bred and

[3] Insurance randomized control trails (RCTs) are good at obtaining the true effect of insurance purchases, but the careful designed and monitored insurance programs in RCTs could be very different to a long-run real world operational insurance project, such as POLI.

[4] Calculated from *2020 China Statistical Yearbook* (National Bureau of Statistics, 2020).

insured.[5] Pastoralists only pay the unsubsidized part of premium, and the insurance company uses the name list of insured pastoralists to claim the subsidy fund from government fiscal departments.[6] The insurance coordinator will be in charge of claim processing later on.

Although the expansion of POLI is under administrative orders -- sounds exogenous, the grazing activity is obviously restricted by climate conditions, so the government may still consider the local natural disaster history, especially the large-scale storms and severe droughts, when promoting policies. Policy documents and news reports confirm this point (see Appendix Table A1)[7]. For example, in a major document on POLI issued by the Government of Qinghai Province in 2012, it was written, "insurance can improve pastoralists' ability to fight against natural disasters and the comprehensive production capacity of grazing industry, effectively prevent and resolve the risks caused by disasters, ensure that pastoralists can get timely compensation for losses after disasters, and resume production as soon as possible." In addition, from the perspective of the data used in this paper, the promotion of insurance policy and climate fluctuations do have a significant correlation (riskier places tend to have priority in being covered by POLI), so the historical climate fluctuations are listed as the main control variables in this study.

Although we do not observe any other factors that could possibly drive the expansion of POLI based on our research team's filed survey and the government policy documents and media reports we summarized in Appendix Table A2, we still explore various factors that may affect the process. In Table A2 of the Appendix, we examined the local physical and geographical conditions, population and economic conditions, and agricultural production conditions, and found that these factors could not predict the insurance policy expansion. This determinant analysis supports the description of POLI in Table A1, and suggests an valid conditional IV for us to evaluate the impact of insurance purchase.

Anecdotal evidence also supports the view that livestock insurance really helps pastoralists resist natural risks and increase their income. A news report, posted on the official website of China's central government, describes an interview with a pastoralist named Matuo Wan from Qinghai Province: "thanks to livestock insurance, I have recovered a lot of losses for my family." Six cattle and ten sheep of his family were frozen to death in a snow disaster. As they were insured, he received a total of 15000 yuan of compensation, greatly

[5] The number of animals a pastoralist wants to purchase insurance for is also a voluntary decision according to central government agricultural insurance guideline. Given the technology conditions in research period, it is practically hard for insurance companies to differentiate which animal within a pastoralist's herd is insured or not. Therefore, in order to prevent treating, in practice, the insurance company will record the numbers of animals a pastoralist bred and insured, so that an insured ratio can be calculated for each participant. If loss happens, the indemnification will be calculated by (the number of lost animals) * (indemnification standard) * (the insured ratio). The indemnification standard is set at provincial level for each type of animal, for example, 2000 yuan for a cattle and 300 yuan for a sheep.

[6] In Gansu Province, the total premium of cattle and sheep is 120 yuan and 18 yuan respectively, the subsidy proportion of the central, provincial and county governments is 40%, 30% and 20% respectively, and the proportion borne by pastoralists is 10%, and the actual premium is 12 yuan and 1.8 yuan respectively; in Qinghai Province, the total premium of cattle and sheep is 120 yuan and 18 yuan respectively, and the subsidy proportion of the central, provincial and county governments is 40%, 35% and 10%, respectively The actual premium is 18 yuan and 2.7 yuan respectively.

[7] We prepared an appendix file containing:1) a summary of policy documents and media reports, 2) the result of determinant analysis that will be introduced soon, 3) and the full versions of all regression results. But due to the length constraint of ICAE conference paper submission, we didn't upload the appendix with the paper. It can be provided if required.

mitigating the losses caused by the disaster (Xinhua, 2013).[8] This case shows that livestock insurance may indeed play its role in benefiting pastoralists' income flow, but the specific effect depends on further empirical test based on large-scale investigation.

3. Data

The data of this paper comes from a large-scale field survey conducted by the author in two grazing featured provinces in the Northwest of China, Qinghai and Gansu in 2017. The survey randomly selected 10 counties (4 counties in Gansu and 6 counties in Qinghai), 30 towns (3 towns in each county), 60 villages (2 villages in each town) and 358 households (6 households in each village).[9] The survey tracked multiple years of information, specifically: village-level data, such as insurance policy (2007-2017), local geographical and economic characteristics (2008-2010, 2015-2017), and prices of inputs and products (2007-2017); household-level data, such as income (2008-2010, 2015-2017), production (2008-2010, 2015-2017), insurance purchase (2007-2017), and household characteristics (2007-2017). In addition, count-level climate data were obtained from China Meteorological Administration: temperature and precipitation (2003-2017). The data description is shown in Table 1, and the specific variable definition will be explained later.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Main Variables					
Income boosting effect (2015-2017)					
Household gross income (yuan)	1,074	80066.08	93719.01	0	660800
Household net income (yuan)	1,074	61968.7	83300.21	-176650	649500
Pastoral gross income (yuan)	1,074	45712.86	65888.71	0	541300
Pastoral net income (yuan)	1,074	27615.48	58681.95	-247240	530000
Household production cost (yuan)	1,074	18097.38	31768.94	0	365462
Insurance indemnification (yuan)	1,074	955.4004	4563.46	0	98000
Operational grassland size (ha)	1,074	490.7978	1278.641	0	9593.467
Operational livestock size (sheep unit)	1,074	435.6637	403.8794	0	2533
Marketed livestock size (sheep unit)	1,074	51.06976	74.78967	0	725
Supplementary hay (ton)	1,074	2.155597	10.1691	0	200
Supplementary fodder (ton)	1,074	1.686299	3.444933	0	37.5
Operational sheep ratio (ratio)	1013[1)]	0.311461	0.384681	0	1
Marketed sheep ratio (ratio)	820	0.423642	0.43483	0	1
Operational cattle infant ratio (ratio)	1,013	0.096746	0.075969	0	0.421687
Operational sheep infant ratio (ratio)	1,013	0.040811	0.055164	0	0.26465
Income Smoothing Effect (2008-2010, 2015-2017)					

[8] The amount of compensation mentioned in the news report is consistent with the coverage standard specified in the policy document of Qinghai Province, i.e. 2000 yuan for a cattle and 300yuan for a sheep. The news also implies that the interviewed pastoralist purchased insurance for all of his livestock.

[9] Two villages are in exceptions, one of which surveyed seven households and the other surveyed three households.

Pastoral gross income SD (yuan)	422[2)]	15818.63	26197.65	0	262741.9
Pastoral gross income Mean (yuan)	422	36069.14	45010.38	0	260333.3
Pastoral gross income CV	356[3)]	0.577715	0.48144	0	1.732051
Land and Grassland Quality (2011-2017)					
Operational grassland size (ha)	2,506	492.9584	1285.995	0	9593.467
NDVI[4)]	2,506	0.63237	0.167527	0.074	1
Control variables (2008-2017)					
County Level					
Precipitation CV in the past 5 years	100	0.328175	0.302032	0.039212	1.705027
Temperature CV in the past 5 years[5)]	100	0.073689	0.068737	0.013545	0.27583
Village Level					
Hay price (yuan/kg)	600	0.983801	0.496182	0.1	2
Fodder price (yuan/kg)	600	1.068056	0.138579	0.6	1.5
Grassland rental (yuan/ha·year)	600	180.9046	164.3092	3	600
Wage (yuan/month)	600	2193.523	938.6653	500	4650
Cattle price (yuan/capita)	600	4002.827	1651.833	1000	11000
Sheep price (yuan/capita)	600	656.9791	242.6136	175	1500
Household Level					
Labor size (person)	3,580	3.636592	1.705161	1	15
Age (year)	3,580	36.84101	6.738058	17	60
Education (year)	3,580	2.894682	3.133098	0	14
Female labor ratio (ratio)	3,580	0.50003	0.164682	0	1

Notes: 1) 61 household observations do not breed livestock in some years in 2015-2017, therefore, their calculated operational sheep ratio is undefined. Similar reason for the marketed sheep ratio, some pastoralists do not sell animals in specific years.

2) This variable is measured at period level, and only for households having consistent insurance purchase behavior within each of the two periods (2008-2010 and 2015-2017). There are 211 such households.

3) 33 households do not breed livestock during one of the two periods, therefore, their pastoral gross income CV is undefined. CV standards for the coefficient variation.

4) NDVI (Normalized Difference Vegetation Index) measures quality of each pastoralists' grassland, the higher the better.

5) Temperature is measured in Fahrenheit.

3.1 The Expansion of POLI

Figure 1 depicts the expansion of the POLI and the pastoralists' take-up rate in the sample. From 2008 to 2010, only one surveyed village had been selected into the pilot of POLI, but no surveyed pastoralist reported buying insurance. The real effort of promoting POLI started in 2011; the proportion of villages selected into the POLI increased from 10% (6 villages) in 2011 to 66.7% (40 villages) in 2017. Meanwhile, the pastoralists' take-up rate in the insured villages increased from 16.7% in 2011 to 75% in 2017, indicating the POLI was getting popular in the program reached area.[10] In one word, the livestock insurance has not

[10] As long as a pastoralist purchased the insurance for one of her livestock, we define that she took up the insurance.

only experienced the expansion on the scope, but also experienced the increase in purchase intensity.

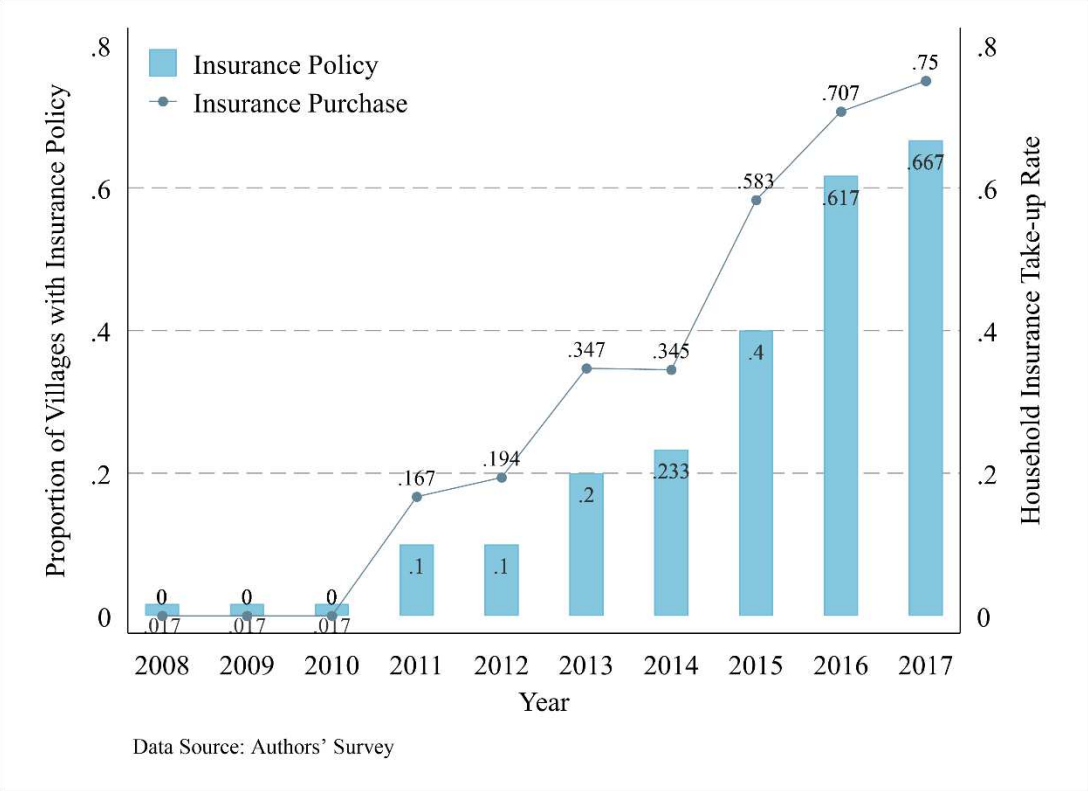

Figure 1 Expansion of Insurance Policy and Take-up Performance

4. Model

The purpose of this paper is to study the impact of insurance purchase on household income absolute level, income fluctuation, and grassland quality. Identification strategy mainly relies on the fixed effect model and instrumental variable method. First, in order to eliminate the endogeneity brought by the factors that do not change over time (for example, the inherent risk preference of households), this study controls the fixed effect at the household level. But even so, the household-level purchase behavior is endogenous, mainly due to the individual specific risk (idiosyncratic) that may change in time. For example, the change of individual financial situation, livestock diseases, and wild animal attacks, to some degree they all affect the motivation of insurance purchase and the outcome variable -- income. Therefore, this paper employs the village-level insurance policy as the IV of household-level insurance purchase. To be more specific, whether there is an insurance policy at the village level (i.e. the village is covered by POLI) directly affects the eligibility of pastoralists' insurance purchase, so the IV must be relevant.[11] Furthermore, since the POLI is implemented from the top to the bottom, after controlling for the climate risk factors that may affect the order of the expansion, the insurance policy may be seen as an exogenous shock to villages (pastoralists have no way to affect the implementation order of the insurance policy), i.e., the conditional exogeneity of IV would be satisfied, IV is valid.

[11] Without village-level insurance policy, pastoralists cannot buy insurance.

To be more conservative, since social economic development may affect the growth of grazing industry and push government to speed up the expansion of insurance market, this paper also controls the prices of inputs and products related to grazing activities. Household characteristics of pastoralists that may be related to insurance purchase are also included.

Based on the above analysis, the following fixed effect model using insurance policy as IV for insurance purchase is specified for the *i*th pastoralist in the *j*th village in county *c* in year *t*:[12]

$$Y_{ijct} = \tau_{ijc} + \alpha \widehat{I_{ijct}} + Risk'_{ct}\gamma + Price'_{jct}\delta + HH'_{ijct}\lambda + Year'_{t}\eta + \varepsilon_{ijct} \quad (1)$$

where Y_{ijct} represents income absolute level, income fluctuation, and grassland quality. I_{ijct} stands for insurance purchase, I_{ijct} = 1 means that the pastoralist purchases the insurance, otherwise equals to 0. $\widehat{I_{ijct}}$ is the fitting value from the first stage of the estimated 2SLS operation using insurance policy as IV, denoted as $Policy_{jct}$. $Policy_{jct} = 1$ means the pastoralists of village *j* are eligible to buy insurance in year *t*, otherwise equals to 0. $Risk_{ct}$ represents weather risks, including CVs of precipitation and temperature in the past five years in year *t*; $Price_{jct}$ is used to control the exogenous market conditions, including the prices of hay, fodder (measured by the price of corn, which is the main component of fodder), grassland, labor, cattle and sheep per capita (in logarithm form). HH_{ijct} represents the household characteristics, including the number of labor force, the average age of labor force, the average education of labor force, and the proportion of females in the labor force. $Year_t$ stands for year fixed effect; τ_{ijc} stands for household fixed effect; ε_{ijct} is the error term.

The equation 1 is also used in the mechanism analysis after adding more variables as controls. Specifically, the mechanism analysis of this paper relies on mediation analyses. We first replace Y_{ijct} with the mediation variables to check whether insurance will affect those factors; if the answer is yes, then the mediation variables will be added to the original estimation (using Y_{ijct} as the dependent) as extra controls to see whether the coefficient of insurance variable changes, so as to find out whether a mediation variable is the mechanism of insurance influencing income (Heckman et al., 2013; Imai et al., 2010; Robins & Greenland, 1992).

In addition, in order to further verify the conditional exogeneity of the insurance policy, before performing each estimation, we conduct placebo tests to verify whether the dependent was already differentiated among pastoralists in the villages with different future insurance states before the policy actually promotes. For example, in the sample without the insurance policy in one year, the next year's insurance policy is used as a placebo variable to regress on the dependent variable in the previous year (the setting of control variables and fixed effect remains unchanged). If the placebo variable from the next year is insignificant, it suggests that the IV is highly possible to be conditional independent to the pre-treatment status of the dependent. If the placebo test ends up with a significant result, it implies that the IV may be draw out based on the initial value of dependent. However, that does not mean the estimation will be biased, since we use fixed effect model, the difference in the initial value of the dependent will be dropped out; the credibility of the result in this case depends on whether there would be different proceeding trends in different levels of the dependent, if not, the result is still unbiased. Placebo tests are performed for all regressions that using the IV.

[12] Only the 2nd stage model setting is shown; the 1st stage model setting is omitted.

5. Results

5.1 Income Boosting Effect and Mechanism

The subsection 5.1 examines the impact of livestock insurance on household income and the corresponding mechanism, using data from 2015 to 2017, in which we have detailed information on production operations. The major interested dependent variable is the household net income, calculated by subtracting the household production cost from the household gross income.[13]

5.1.1 Basic Results of Income Boosting

Table 2 compares results using different estimation methods.[14] The column (1) presents the result of OLS, showing that the effect of insurance purchase on household net income is negative, but insignificant. The columns (2) and (3) are the results of random effect (RE) and fixed effect (FE), respectively, which are also insignificant at 10% significant level. Although they are insignificant according to the conventional statistical standard, the point estimates increase greatly from OLS/RE to FE, indicating that the FE dose address part of endogeneity brought by time-invariant endogenous factors (such as risk preference).[15] The last two columns are the result of using insurance policy as IV in the FE model estimated by 2SLS. The column (4) is the 2SLS 1st stage result, showing that the weak IV concern is excluded since the F-value of the IV is much larger than 10.[16] The column (5) shows that, at 5% significant level, the purchase of insurance can increase the household net income by 15792 yuan, which is 25.5% of the sample mean. Comparing with the FE result in column (3), the IV result is larger and more significant, meaning that the IV from the village level further solves the endogeneity problem caused by idiosyncratic risks at household level (such as severity of animal attacks, illness, and operational mistakes). Given the validity of IV we have discussed with quantitative supports shown before (by determinant analysis shown in Table A2 in appendix) and after (by placebo tests shown later), we treat the coefficient estimated by the IV-FE in column (5) as our basic result in this study, and the next subsection will analyze the mediating effects based on it.[17]

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[13] The household gross income includes household pastoral income (revenue from selling livestock, revenue from by-products, grassland rental income, and insurance indemnification), wage income, and other incomes (including donation, gambling, subsidies for ecological protection from government, etc.). Household production cost includes livestock purchase cost, costs of hay and fodder, shepherd employment cost, other livestock breeding cost, insurance premium payment (unsubsidized portion), maintenance costs of livestock fence, shed and well, land rental cost, and interest payment of loans.

[14] See Appendix Table A3 for the full versions of the estimation.

[15] Two facts related with risk preference have been empirically tested: 1) farmers with higher risk aversion have higher incentive to purchase insurance (Jing Cai, de Janvry, & Sadoulet, 2020). The higher risk aversion could result in economic loss (McInish, Ramaswami, & Srivastava, 1993; Shaw, 1996). Therefore, omitting risk preference in OLS and RE leads to biased down estimation.

[16] The 1st stage result will not be reported again for 2SLS estimations using the same 1st stage.

[17] Considering that different regions may have different time trends, we also add the cross terms of time dummies and different levels of regional dummies in the IV-FE estimations. The results are robust but not shown in the robustness check section; they can be provided if requested.

Table A3. Results of Different Regression Methods (Full Version of Table 2)

Dependent Variable	Household net income (Mean=61968.7, SD=83300.21)				
	OLS	RE	FE	IV-FE 1st stage	IV-FE 2nd stage
	(1)	(2)	(3)	(4)	(5)
Insurance purchase	-2,835	-60.11	7,048###		15,792**
	(4,649)	(3,838)	(4,304)		(6,430)
Insurance policy				0.655***	
				(0.0447)	
Weather Risks					
Precipitation CV	72,498***	-51,338###	-134,254**	0.299**	-144,220***
	(26,856)	(33,946)	(54,567)	(0.150)	(51,762)
Temperature CV	-502,670***	56,996	572,673##	1.673	591,965###
	(157,949)	(199,484)	(435,971)	(1.739)	(398,698)
Prices of Inputs and Outputs (Log)					
Hay (yuan/kg)	8,619***	4,077	-12,572	0.130	-14,722#
	(3,264)	(4,525)	(12,889)	(0.141)	(12,505)
Fodder (yuan/kg)	102,818***	106,362**	1,471	0.296	-8,867
	(39,672)	(51,329)	(87,023)	(0.438)	(81,417)
Grassland rental (yuan/ha·year)	-4,730##	-11,786**	12,687#	-0.0660	15,805
	(3,372)	(4,917)	(10,185)	(0.0810)	(16,128)
Wage (yuan/month)	-6,752##	-12,440*	-24,418	-0.113	-23,322
	(4,735)	(6,655)	(26,888)	(0.165)	(24,196)
Cattle (yuan/capita)	36,088***	20,032*	5,434	0.00428	5,705
	(8,504)	(10,828)	(14,630)	(0.0363)	(14,574)
Sheep (yuan/capita)	-32,013***	-23,595**	-8,407	0.228***	-13,643
	(8,614)	(11,080)	(16,645)	(0.0750)	(16,357)
Household Characteristics					
Labor size (person)	2,989***	2,580###	5,550##	-0.0209	5,815##
	(1,128)	(1,641)	(4,042)	(0.0349)	(4,380)
Age (year)	871.4***	1,340***	667.5	-0.00365	717.9
	(283.1)	(454.4)	(793.7)	(0.00615)	(777.4)
Education (year)	5,923***	6,794***	867.3	0.0304*	597.9
	(1,156)	(1,610)	(3,533)	(0.0166)	(3,902)
Female labor ratio (ratio)	-726.1	-144.1	7,015	0.321**	2,903
	(11,341)	(16,828)	(37,661)	(0.158)	(36,443)
Observations	1,074	1,074	1,074	1,074	1,074
R-squared	0.288		0.081	0.530	0.077
Number of Household		358	358	358	358
Household FE	NO	NO	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, ### p<0.15, ## p<0.2, # p<0.25

The column (1) in the Table A7 in the appendix is the placebo test result on the IV, showing that the next year's insurance policy is not correlated with previous years' household net income. In other words, there is no significant difference in income between villages with insurance policy and villages without insurance policy before the insurance policy get promoted, which further justifies the exogeneity of IV.

However, no matter what quantitative evidence we have provided for supporting the exogeneity of IV, the validity of IV can never be directly econometrically tested. Therefore, we provide an alternative estimation method that does not rely on the validity of IV to examine the robustness of the basic conclusion -- we limit the estimation sample to the villages with insurance policies, so that whether village-level IV is directly related to the income will no longer affect the analysis in this module. In the villages with insurance, we use the event-study method to exclude the initial differences between pastoralists who buy insurance and who do not and test the income changes of insured pastoralists before and after. The empirical model is as follows:[18]

$$Y_{ijct} = \tau_{ijc} + \sum_{k=-2}^{2} \alpha_k \, Purchase_{ijct,k} + Risk'_{ct}\gamma + Price'_{jct}\delta + HH'_{ijct}\lambda + Year'_t\eta + \varepsilon_{ijct} \quad (2)$$

where, $purchase_{ijct,k}$ is an indicator variable, which measures the time distance from the pastoralist's first insurance purchase year. $k = 0$ represents the year of first purchase; $\text{purchase}_{ijct,-2}$ means two years before the first purchase, while $\text{purchase}_{ijct,2}$ means two years after the first purchase. The omitted group is k = - 1.[19] Since in this subsection, we only have three years of data, the boundaries of k are - 2 and 2. The control variables and fixed effects remain unchanged. The uninsured people in the villages with insurance policy will stay in the estimation sample, in order to eliminate the time trend of income change, solving the under-identification problem (Kirill & Xavier, 2017).

Figure 2 shows the result of the event-study based on equation (2). [20] It can be seen that before the purchase of insurance, there is no statistically significant difference between the incomes of the insured and uninsured, but after the purchase of insurance, there is a significant jump in the household net income for the insured, and the size of the impact (14200-22800 yuan) is generally consistent with the basic result (15792 yuan) based on the IV-FE in Table 2. Appendix Figure A1 and Table A4 report the full version of event-study results and its alternative settings, including using full village sample and using insurance policy instead of insurance purchase as treatment, as well as corresponding the difference in difference (DID) results. Generally speaking, the point estimations are consistent with the main conclusions.

[18] In the following paper, we also study the time of insurance policy, so as to see the overall effect of the policy. In addition to replacing the insurance purchase indicator variable with the insurance policy indicator variable, the other model settings remain unchanged.

[19] For the observations when pastoralists stop buying insurance after their first purchase, we define $purchase_{ijct,k}$ ($k = 1$ or $k = 2$) as 0, and Figure 2 reports the result of this setting. Change the setting, that is, define them as 1, does not change the main result.

[20] Figure 2 corresponds to column (1) in Appendix Table A4.

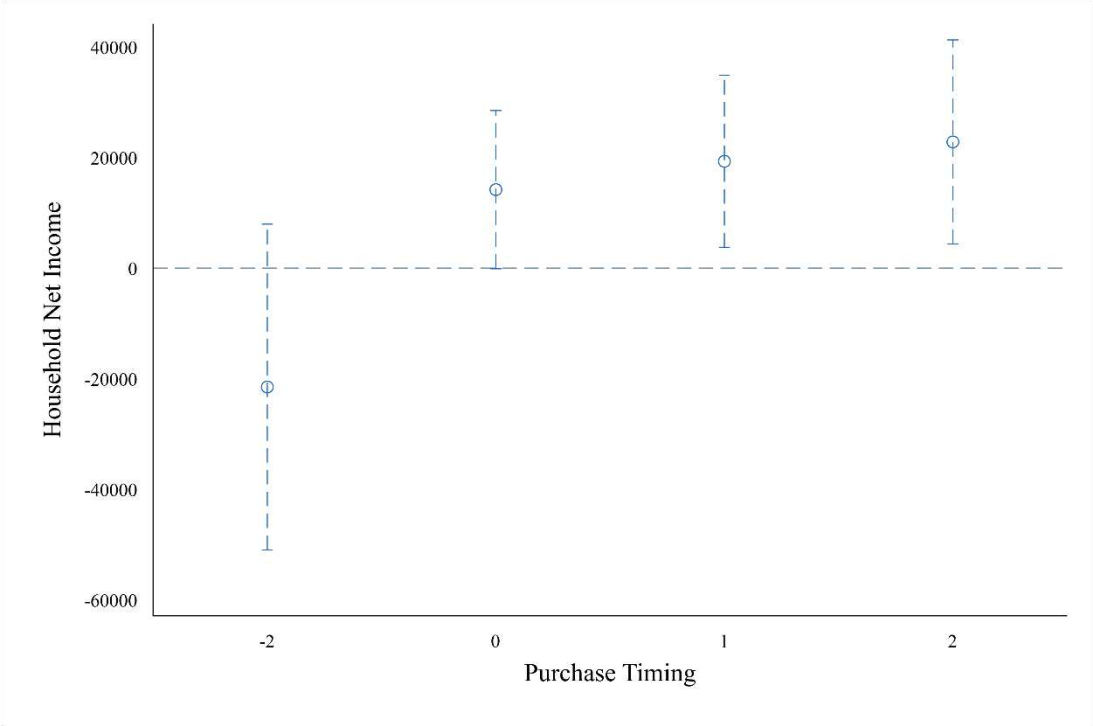


Figure 2 Event-study of Insurance Purchase on Household Net Income (Restricted sample)

Note: this figure depicts the coefficient based on the event-study with the corresponding 90% confidence interval. The year before the first insurance purchase (i.e. k=-1) is set as the comparison group (i.e. the zero level in horizontal axis).

5.1.2 Mechanism – How does Insurance Boost Income?

In order to further explore the mechanism of how insurance boosts the household net income, we use the mediation analysis. First, we explore the impact of insurance on production decisions, and then add the affected terms into the basic IV-FE estimation one by one as mediation channels to examine the changes in the coefficient of insurance purchase, which are their contributions to the net income increase trigged by insurance purchase (Heckman et al., 2013). The investigated mediation factors include the scale of operation: operational grassland size, operational livestock size, and marketed livestock size; the main inputs: the weights of supplementary hay and supplementary fodder; and the breeding structure: operational sheep ratio (over total animal size), marketed sheep ratio, operational cattle infant ratio, and operational sheep infant ratio. Since the insurance premium is highly subsidized by the government, purchasing the insurance is equivalent to receive a risk-conditional income transfer, therefore, in order to excluding the impact of income transfer on the income boosting, we treat the insurance indemnification as one of income boosting factors, and examine it before incorporating others.

Among the mechanism factors investigated, pastoralists face trade-off between riskier but profitable verse less risky but less profitable decisions. Grazing activities have uncertainty, so expanding the production scale means taking higher risks but could possibly generating higher expected return; Hay has lower nutritional value than fodder, but is cheaper than fodder, so choosing more hay is a behavior of chasing higher profit rate but at the cost of risking animals' health; Sheep breeding is more difficult than cattle, since they are more

sensitive to the environment, but the sheep breeding cycle is short with higher profit rate, therefore, inclining to more sheep breeding also belongs to the second type of behavior change -- choose a riskier but more profitable portfolio. Finally, the mortality of young animals is higher than that of adult animals, but the return from the former on is high, so expanding the proportion of young animals is also a high risk but high return decision.[21]

Table 3 shows the impacts of insurance purchases on indemnification and risk-related production decisions.[22] The results show that: 1) the insured pastoralists get an average indemnification payment of 3297 yuan. 2) Insurance can significantly increase the marketed livestock size by 11 sheep units (about 22% of the sample mean); but it has no significant effect on the operational grassland size and operational livestock size. There are several ways for pastoralists to increase the marketed livestock size while maintaining the operational grassland size and the operational livestock size unchanged: first, increase the proportion of fertile female livestock in order to increase birth rate of infant animals; second, directly buy adolescence livestock in the market.[23] The former channel was further verified by regressions in column (9) and (10) in Table 3, while the latter could not be tested in this study since the survey did not collect the number of adolescence livestock in the questionnaire. In general, the mortality rate of juvenile livestock is higher than that of adult livestock; in the case of fixed pasture size, increasing the marketed livestock size means that the rotation intensity of livestock is enhanced, and pastoralists will bear a higher risk of livestock death. It should be pointed out that the insurance company could not distinguish which livestock of the insured households were insured and which were not, thus providing the pastoralists with the motivation to enhance the rotation of livestock, because the dead livestock would be indemnified.[24]

It is also found that by Table 3 that 3) Insurance changes the input scale. Insurance significantly reduces supplementary fodder input by 23% and increases supplementary hay input by 33%; total supplemental feeding increases by 0.32 tons.[25] The former confirms that the insured households chose a more aggressive way of supplementary feeding, while the latter echoes the general conclusion from findings – the production intensity is increased due to having insurance.

[21] We indeed examined other production decisions, including grazing time, non-agricultural activities, loan behavior, etc., and find no statistically significant results with considerable economic scales. The possible reason is that the variation of these data across years is insufficient.

[22] The regression method is consistent with IV-FE in Table 2, only changing the dependent to the indemnification income and mediation factors. The results of the 1st stage are omitted. The full version of results can be found in the Table A6 in the appendix.

[23] Local people call them "skeleton cattle" and "skeleton sheep", that is, the skeleton is mature, but with few muscle on it. After a few months of fattening, they can be sold at good prices on the market.

[24] How the insurance companies dealt with cheating problem has been explained in the footnote 10; Livestock from different pastoralists were marked with different colors in different places on animals' bodies, therefore, it is hard to cheat insurance companies with an uninsured animal from other pastoralists' herds.

[25] The proportion is the estimated coefficient divided by the mean of corresponding variable.

Table 3. Fixed Effect Estimation on Mediation Variables (IV= Insurance Policy)

	Risk-conditional income transfer	Production scale			Input scale		Production structure			
		Area	Animal rotation		Supplementary feeding		Risky animals		Infant animals	
Dependent Variable	Insurance indemnification (Mean=955, SD=4563)	Operational grassland size (Mean=491, SD=1279)	Operational livestock size (Mean=436, SD=404)	Marketed livestock size (Mean=51, SD=75)	Supplementary hay (Mean=1.69, SD=3.44)	Supplementary fodder (Mean=2.16, SD=10.17)	Operational sheep ratio (Mean=.31, SD=0.38)	Marketed sheep ratio (Mean=.42, SD=.43)	Operational cattle infant ratio (Mean=.097, SD=.076)	Operational sheep infant ratio (Mean=.041, SD=.055)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Insurance purchase	3,297***	-1.894	-2.010	11.33*	0.709##	-0.385*	0.00902###	0.0367##	-0.00797##	0.00422###
	(905.3)	(4.283)	(17.46)	(6.745)	(0.522)	(0.233)	(0.00551)	(0.0273)	(0.00561)	(0.00276)
Operational livestock size							-3.14e-05	-9.89e-05#	-4.05e-06	-2.81e-05**
							(3.87e-05)	(8.08e-05)	(1.44e-05)	(1.40e-05)
Marketed livestock size							4.58e-05	-0.00058**	1.94e-05	4.26e-05*
							(5.60e-05)	(0.00026)	(2.57e-05)	(2.28e-05)
Weather Risks	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH Char.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,074	1,074	1,074	1,074	1,074	1,074	1,007	793	1,007	1,007
R-squared	0.081	0.055	0.025	0.036	0.029	0.033	0.048	0.080	0.043	0.065
Number of Household	358	358	358	358	358	358	340	294	340	340
Household FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, ### p<0.15, ## p<0.2, # p<0.25

In order to further investigate the impact on production structure, we control livestock size in column (7) to (10). The results show that: 4) insurance increases operational sheep ratio by 0.9% and marketed sheep ratio by 3.6% at a relaxed significant level of 20%; 5) in addition, insurance reduces operational cattle infant ratio (about 0.8%) and increases operational sheep infant ratio (about 0.42%). According to the internal statistics of local insurance companies, the mortality rate of sheep is higher than that of cattle, and that of young animals is higher than that of adult animals. Therefore, findings 4) and 5) support the conclusion that insurance will encourage pastoralists to choose more aggressive risky strategies. Appendix Table A5 provides all placebo tests of the Table 3.

Table 4 shows the second step of mediation analysis: examining the change of insurance impact on household net income after gradually introducing mediation factors.[26] The results are that 1) After adding indemnification income, the impact of insurance on income decreases to 13108 yuan, meaning the indemnification payment explained the increase of income of 2684 yuan (the average premium paid by insured pastoralists was 695 yuan; about 17% of income boosting is explained). 2) The increase of production size explained the net income increase of 6666 yuan (explaining 42.2% of the income boosting). 3) The change in inputs explained the increase in net income of 744 yuan (explaining 4.7% of total effect). 4) 3527 yuan (22.3%) of the net income increase was explained by the change of production structure. Among them, the operational sheep ratio and marketed sheep ratio explained 2436 yuan (about 15.4%), while operational cattle infant ratio and operational sheep infant ratio explained 1091 yuan (about 6.9%). The sum of above channels accounted for 86% of the total income increase, leaving 14% (2171 yuan) unexplained.[27]

It is worth noting that the coefficient of the insurance purchase itself becomes insignificant after adding the operational livestock size and marketed livestock size. This is because the mediation variables dilute most of the income increase. As more mechanisms are found, the left impact of the insurance on income decreases.

5.1.3 Robustness Tests on Income Boosting Effect

We perform robustness tests by gradually changing control variables, testing the impact of insurance on other dependent variables related to household net income, changing climate variables, and adding extra controls.

Firstly, we gradually change the control variables. It can be seen from the Table A9 in the appendix that adding or deleting prices and family characteristics do not fundamentally change the estimation results. Omitting weather risk as controls does change the result, which is easy to understand: weather risk is negatively correlated with income but positively correlated with insurance purchase (actually it could also be positively correlated with IV, as we have discussed in the Introduction), omitting it would cause a biased down estimation.

[26] See Appendix Table A8 for the full version of Table 4 results.

[27] This may be due to the changes in other production decisions that didn't pass the test in the first step of mediation analysis.

Table 4. Fixed Effect Estimation on Mediation Effect of Household Net Income (IV= Insurance Policy)

Dependent Variable	Household net income (Mean=61968.7, SD=83300.21)					
Explained Proportion	Total effect (100%)	Risk-conditional income transfer (17%)	Production scale (42.2%)	Input scale (4.7%)	Production structure (22.3%) Risky animals (15.4%)	Production structure (22.3%) Infant animals (6.9%)
	(1)	(2)	(3)	(4)	(5)	(6)
Insurance purchase	15,792**	13,108**	6,442#	5,698	3,262	2,171
	(6,430)	(6,677)	(5,179)	(5,162)	(5,911)	(5,915)
Mediation Variables						
Insurance indemnification		0.814***	0.889***	0.920***	1.009***	1.016***
		(0.243)	(0.187)	(0.183)	(0.234)	(0.238)
Operational grassland size			-74.41###	-74.66###	-77.44*	-344.1#
			(45.47)	(45.62)	(46.31)	(272.0)
Operational livestock size			23.88#	23.78#	1.178	-2,985***
			(20.21)	(20.17)	(33.10)	(968.9)
Marketed livestock size			558.6***	556.3***	493.1***	-74.98*
			(81.26)	(81.37)	(84.90)	(44.06)
Supplementary hay				-251.4	-284.9	7.133
				(254.8)	(260.2)	(33.65)
Supplementary fodder				-2,191***	-2,793***	481.7***
				(780.5)	(955.4)	(84.93)
Operational sheep ratio					65,114#	48,855
					(50,939)	(50,297)
Marketed sheep ratio					-18,547	-23,017#
					(18,766)	(18,804)
Operational cattle infant ratio						224,325**
						(103,567)
Operational sheep infant ratio						-38,017
						(87,998)
Weather Risks	Yes	Yes	Yes	Yes	Yes	Yes
Prices	Yes	Yes	Yes	Yes	Yes	Yes
HH Char.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,074	1,074	1,074	1,074	790	790
R-squared	0.077	0.085	0.483	0.488	0.462	0.469
Number of Household	358	358	358	358	294	294
Household FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, ### p<0.15, ## p<0.2, # p<0.25

Secondly, we test the impact of insurance purchase on other dependent variables related with household net income to check if the boosted income does come from the expected income sources. According the tested mediation factors, the economic mechanism behind the income boosting can be generally described as enhancing production intensity with adjusting behavior to be riskier but more profitable. Therefore, we shall see the income boost mainly comes from revenue increasing but not cost saving, i.e. second type of behavior change. Appendix Table A10 examines whether the income boost effect comes from the revenue increasing or the cost saving. The result shows that: 1) insurance can overall increase household gross income by 17524 yuan; 2) The impact of each mediation factor on income boosting is similar to that of household net income; 3) Insurance purchase does not significantly increase household production costs. 4) It is worth noting that each additional ton of fodder will increase the production cost of about 2400-2800 yuan (column 10-12), while each ton of hay can only bring up about 800-900 yuan of production cost. Recall the estimation result in the first step of mediation analysis, the size of the increase of hay is twice as much as the size of the decrease of fodder (Table 3, column 5-6), implying that pastoralists do use cheap hay to replace expensive fodder to ensure that the production cost do not raise dramatically while enhancing breeding intensity, which supports the conclusion of finding the second type of behavior change – switch to riskier but profitable decisions.

Furthermore, in order to justify the income boost does come from the production field rather than other fields, the Table A11 in the appendix presents results of regressions on the pastoral gross income and pastoral net income. The result shows that: 1) insurance can overall significantly increase pastoral gross income by 15275 yuan and pastoral net income by 13543 yuan, which are very close to the effect of insurance on the household gross income and household net income, indicating that the increase of net income indeed comes from the field of grazing production rather than other fields.[28] 2) The impacts of mediation factors on the pastoral gross income and pastoral net income are similar to the household gross income and net income.

Thirdly, considering that climate variables have played important roles in finding the results of this paper, Table A12 in the appendix replaces the CVs of precipitation and temperature with the Means and SDs for robustness tests. The results are broadly consistent with the main findings.

Lastly, one suspect on the credibility of the findings is that, during the research period, China was also strengthening ecological protection polices in the western provinces by forcibly banning or restricting grazing activities with heavy income subsidy. If the ecological protection polices accidentally co-moved with insurance policy expansion, the found result could be compromised.[29] In order to examine this concern, we further add dummy variables to represent whether a pastoralist was exposed to any of the two major ecological protection policies to the basic IV-FE estimation for robustness test. The results show that the significance level of insurance purchase remains unchanged, and the size of insurance impact

[28] Other incomes include: wage income, capital income, health insurance, pensions, donations, government transfers (including ecological protection subsidies), etc.

[29] The ecological protection policy and insurance policy are implemented by different government departments. Therefore, there is no evidence from government documents and information resources showing the two policies are related in terms of project expansion. However, consider the size of income subsidy of the ecological protection policy could be large, we still perform this robustness check.

slightly decreases (by 1500 yuan, i.e. around 2.5% of the sample mean), therefore the main finding of this study is not fundamentally changed. See Appendix Table A13, column 1-4.[30]

5.2 Income Smoothing Effect

5.2.1 Basic Results of Income Soothing Effect

This subsection examines whether the insurance indeed smooth income flow. Although theoretically, insurance can reduce income fluctuation, which is also the original intention of the government to support the agricultural insurance market, we find that there is limited empirical evidence on it, especially in the field of agricultural insurance.[31] In order to further verify whether insurance improves the overall income distribution, boosting means and depressing standard deviations, after studying the impact of insurance on the income absolute level, and we further explores the impact of insurance on income fluctuation.

As mentioned above, this survey covers the detailed production, income and insurance data from 2015 to 2017, however, due to the lack of production and income data in 2011-2014 (not surveyed), we can only use the data from 2008-2010 and 2015-2017 to analyze the income fluctuation. In addition, for 2008-2010, only the grazing-related income is available, we change focus of analysis from household net income to its major component -- pastoral gross income, including income from livestock sale and insurance indemnification.[32] In this part, income fluctuation is measured by SD and CV of pastoral gross income. Because we have the data of 2008-2010 and 2015-2017, for the same pastoralist, we calculate the SD and CV of the 2 periods respectively. In addition, we limited the sample to the pastoralists whose insurance purchase statues are consistent within each of the 3-years period, ignoring the complexity of measuring insured or uninsured SD and CV for pastoralists who only bought insurance in specific years.

Identification strategy still relies on the use of IV and FE model. Pastoralists' insurance purchase behavior is "self-selected", for example, pastoralists with greater income fluctuations may be more willing to buy insurance, resulting in reverse causality and biased down results. Hence, insurance policy is still used as the IV, and the equation (1) still employed to estimate the income smoothing effect, with the mean of pastoral income within each period is added as the control variable in SD estimation. Moreover, although the measured income fluctuation is the same value in each period, considering that the cross-year variation of the control variables may play roles in explaining the degree of income fluctuation, the regression is still at the year level for improving estimation efficiency. We will shorten the number of years, i.e. regress at the period level, and report them in the robustness test.

[30] The conclusion from mediation analysis with adding the ecological protection police remain the same, while we do not show them. They can be provided if required.

[31] Janzen and Carter (2019) shows that when faced with adverse shocks, insurance can reduce 96% of the possibility of selling assets for rich families and 49% of the possibility of reducing food consumption for poor families. Other related studies rarely provide empirical evidence that insurance can reduce income fluctuation.

[32] In 2008-2010, no pastoralists bought insurance, and the indemnification income was 0.

Table 5 shows the impact of insurance on income fluctuation.[33] The study finds that 1) purchasing insurance can significantly reduce the SD of pastoral gross income by approximate 6000 yuan, accounting for 16.7% of the mean of pastoral gross income in the 2 periods. 2) Buying insurance can reduce income CV up to 0.19 (column 8), which accounts for 33% of its sample mean. The size of income smoothing effect is considerable.

Furthermore, since there is no pastoral who purchased insurance in 2008-2010 (Figure 1), which can be seen as a clear "before intervention" group, so the event-study method can still be performed and the results are shown in Figure 3.[34] It can be seen that after the purchase of insurance, the fluctuation of pastoral income is significantly reduced, and the result of point estimation is consistent with that of IV-FE estimator in the Table 5. Detailed regression results and DID estimations are shown in Appendix Table A15

Table 5. Fixed Effect Estimation on Fluctuation of Pastoral Gross Income (IV= Insurance Policy)

Dependent Variable	Pastoral gross income SD (Mean=15818.63, SD=26197.65)				Pastoral gross income CV (Mean=0.578, SD=0.481)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Insurance purchase	-6,739***	-5,942***	-6,046***	-6,122***	-0.0954*	-0.126**	-0.171**	-0.191**
	(2,017)	(2,077)	(2,302)	(2,374)	(0.0518)	(0.0573)	(0.0727)	(0.0769)
Income Mean	0.604***	0.601***	0.603***	0.606***				
	(0.0416)	(0.0422)	(0.0437)	(0.0436)				
Weather Risks		Yes	Yes	Yes		Yes	Yes	Yes
Prices			Yes	Yes			Yes	Yes
HH Char.				Yes				Yes
Observations	1,266	1,266	1,266	1,266	1,068	1,068	1,068	1,068
R-squared	0.620	0.623	0.639	0.642	0.079	0.095	0.136	0.155
Number of Household	211	211	211	211	198	198	198	198
Household FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, ### p<0.15, ## p<0.2, # p<0.25

[33] See Appendix Table A14 for the full version of results.

[34] 2010 is set as the compared year. Since we use sample that pastoralists' insurance purchase statues are consistent with in each period, the k is replaced with the real year in the Figure 3.

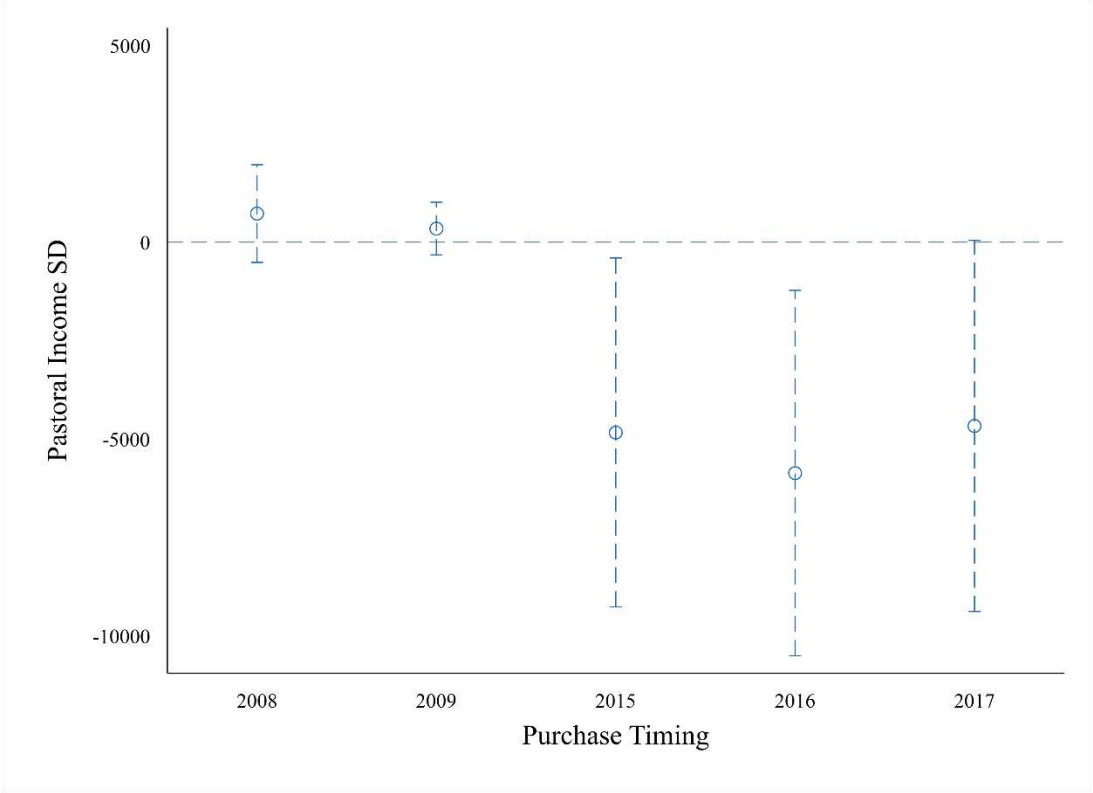


Figure 3 Average Treatment Effect (ATE) of Insurance Purchase on Pastoral Income SD

Note: this figure depicts the estimation coefficient of event-study method and the corresponding 90% confidence interval, in which the dependent variable is income fluctuation. All the effects are compared with the year 2010.

5.2.2 Robustness Tests on Income Smoothing Effect

In this part, we test the robustness by shortening the time dimension of regression sample, changing the climate variables, and altering the ways of measuring the income fluctuation.

First, in the Appendix Table A16, we shorten the 6-year data structure to 2 periods and replace the year level control variables with the averaged corresponding terms. The regression results show that insurance can reduce the fluctuation of pastoral income of about 6000 yuan, although the coefficient becomes insignificant, which may be due to the reduction of sample size, the point estimation does not change. The size of the results on CV becomes larger, implying that the result in the Table 5 is conservative, and the true income smooth effect could be larger.

Secondly, similar to the robustness checks in the last subsection, here we replace the CV of precipitation and temperature with their Mean and SD. The results were consistent. See Appendix table A17.

Lastly, if the insurance does smooth income fluctuation, conditioning on other factors all the same (including the mean of incomes), it should also reduce the spatial income variation among pastoralists within an insurance policy covered village. In the Appendix Table A18, we use alternative way to measure income fluctuation: calculating the income SD between pastoralists in the same village. Column (1) to (4) calculate the SD for all pastoralists within a

village, while column (5) to (8) calculate the SD for insured and uninsured pastoralists separately.[35] The results show that purchasing insurance can significantly reduce the spatial SD of pastoral income by 2870 to 3562 yuan. Compared with the result in the column (5) and (8), the latter one is larger, since the former is the average result of pastoralists with and without insurance, therefore the difference is in line with economic expectations.

5.3 A Tradeoff? -- An Unanticipated Impact of the POLI on Grassland Quality

5.3.1 Basic Results of Grassland Quality

In the previous subsections, we studied the impact of insurance on income distribution, showing that insurance can improve income absolute level and reduce income fluctuation. the mechanism hinges on that the POLI project increases the intensity of production. However, since grassland is the main natural resource input of grazing industry, we suspect that POLI may have an adverse impact on the local ecology which many not be anticipated by China's POLI policymakers. In this subsection, we examine the impact of insurance on grassland quality - using NDVI to measure grassland quality. NDVI is widely used in the study of vegetation and environmental problems (Peng et al., 2013). As we have both insurance purchase and NDVI data at the household level from 2011 to 2017, and the insurance policy data at the village level for the same period, the estimation will be using 8 years of data. Other econometric settings remain unchanged compared with the model in the Table 4.

Table 6. Fixed Effect Estimation on NDVI (IV= Insurance Policy)

Dependent Variable	NDVI (Mean=0.632, SD=0.168)			
	(1)	(2)	(3)	(4)
Insurance purchase	-0.0230***	-0.0112**	-0.0118**	-0.0120**
	(0.00481)	(0.00499)	(0.00500)	(0.00501)
Weather Risks		Yes	Yes	Yes
Prices			Yes	Yes
HH Char.				Yes
Observations	2,506	2,506	2,506	2,506
R-squared	0.166	0.192	0.210	0.212
Number of Household	358	358	358	358
Household FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, ### p<0.15, ## p<0.2, # p<0.25

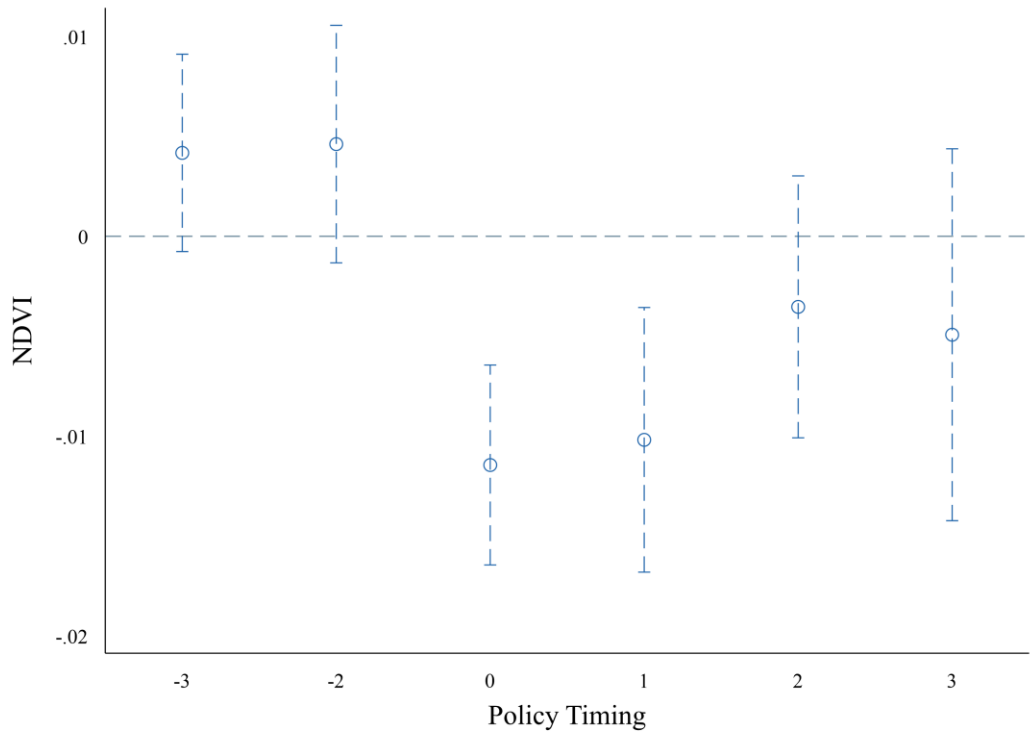
[35] If a household is the only observation who purchases or not purchases the insurance within a village, this household will be dropped out in the estimation from column (5) to (8), as the corresponding SD cannot be calculated.

The Table 6 shows that the expansion of POLI could be really challenging local ecological protection.[36] After adding all the control variables, the insurance reduces the NDVI by 0.012, which accounts for 1.9% of the sample mean. The size of coefficient seems no big, however, considering the fact that the grassland quality is factor that many have large special difference but small-time variation (i.e. hard to change over years given a grassland location), if we compare the estimated coefficient with the sample mean of the vertical year SD of the NDVI (0.037), the size of the impact becomes 32%. Therefore, the benefits of insurance on income is actually at the cost of grassland quality degradation, which is a policy trade-off between the income increase and local ecological protection. The placebo test is still passed, see Appendix Table A20.

Figure 4 shows the results of corresponding event-study method using a 3-years window around the first insurance purchase. It can be seen that after the purchase of insurance, NDVI decreased significantly. Similarly, the result of point estimation is consistent with that of IV-FE estimator. The detailed event-study and DID results are shown in Appendix Table A21.

5.3.2 Robustness Tests on the Impact of Grassland Quality

We test the robustness by changing climate variables and adding policy variables related to ecology. Similar to the test of income, after changing the CV of weather variables to their Mean and SD, the impact of insurance on NDVI remains consistent, as shown in Appendix Table A22. After adding the ecological protection policies, the estimated result is still unchanged (See Appendix Table A13, Column 5-8 for details).



[36] See Appendix Table A19 for details.

Figure 4 Intention-to-Treat (ITT) of Insurance Policy on NDVI

Note: this figure depicts the coefficients based on the event-study with the corresponding 90% confidence interval. The year before the first insurance purchase (i.e. k=-1) is set as the comparison group (i.e. the zero level in horizontal axis).

6. Conclusion and Discussion

This paper examines the impact of agricultural insurance on farmers' income distribution, including income absolute level and income fluctuation, as well as the associated ecological cost of developing this insurance market. By exploiting village-level variation in the implementation of police-oriented livestock insurance in Western China ——Qinghai and Gansu provinces, we are able to evaluate the income boosting effect of insurance and quantify corresponding mechanisms. Result shows that insured pastoralists enjoyed a 26% household net profit boost and was mainly due to adopting riskier but profitable production strategies, rather than conducting moral hazard behavior, i.e., reducing input intensity.

Production scale expansion explains 42% of income raising, primarily driven by enhancing animal rotation; around 5% of income boost is caused by farmers' switch of input portfolio——using cheaper but less nutritionally valuable hay to replace costly but nutritive fodder; adjustment of animal structure towards risky type —— breeding more profitable but more vulnerable animals result in the other 22% of income increase. We also provide empirical evidence that livestock insurance in China could reduce income fluctuation degree by at least 30%. Last but not least, the insured farms tended to over use grassland, resulting in grass quality decreased by 32% if compared with its historical variation level.

Major policy implication from our study is that we provide an angle for policymakers of agricultural insurance in developing countries, perhaps also in developed countries, to broaden the evaluation list when conducting cost-benefit analysis of supporting a policy-oriented insurance market. In China's case, the cost of supporting POLI is not only tremendous fiscal budget, but also possible degeneration of ecosystem, while the benefit is also not just smoothing farmers' income but boosting income absolute level at a considerably large degree. Furthermore, the associated changes after subsidizing POLI could possibly include expansion of mutton supply at the cost of shrinking beef supply, since farmers are replacing cattle with sheep, which is evidenced in this paper.

Furthermore, a highly subsidized agricultural insurance program, such as 85% subsidy rate of POLI in Qinghai province in this study, essentially is a conditional income transfer policy, conditioning on farmers suffering from livestock death. A challenging argument on maintaining POLI is that instead of financing insurance companies on performing insurance service, while farmers only receive 40%-60% of subsidized collected premium, why the government makes the subsidy as direct unconditional income transfer to farmers, which can save a great number of transaction cost of running insurance market, not to mention reallocating insurance companies' profits to farmers. Our paper answers this question by providing quantified evidence that risk-conditional income transfer could bring in risk related behavior changes, leading to a large income increase. Although it is unknown if government changed the POLI as a pure unconditional income transfer program, given the fiscal budget unchanged, what is the outcome would be for farmers, our paper seems provide a slight evidence, based on the result of insurance indemnification in the mediation analysis, that

relaxing budget constraint does not have great income impact on farmers, at least does not have multiplier effect of receiving money payments.

Developing agricultural insurance market in developing countries, aiming to alleviating poverty issue and protecting farming enthusiasm, has been long troubled by high transaction cost problem (Barnett & Mahul, 2007). Livestock insurance can be a break through point in developing agricultural insurance, since the value of each livestock is usually larger than the value from each unit land of crops in small farm dominated countries. This study, to our best knowledge, is the first one that quantifies the livestock insurance impact on income distribution with detailed evidence on mechanisms, however, some questions still are left unanswered: whether our results can be generated to a larger discussion scale, for instance, to larger research area with larger sample size, to livestock industry in other developing or developed countries, or to crop insurance markets.

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