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Factors affecting grain loss reduction efforts among Chinese farmers

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Abstract: In this study, we used psychology and organisational behaviour theories to determine the main elements affecting Chinese farmers' grain loss-reduction efforts (LREs). We established social factors (SFs), policy factors (PFs) and buyer's strategies (BSs) as the three central factors and constructed a theoretical framework linking these factors to grain producers' LREs. Using this framework, we designed a survey questionnaire and an interview guide; we subsequently collected 1 536 valid questionnaire responses and 25 interview transcripts. The findings revealed that SFs, PFs and BSs had a significance positive effect on the LREs of grain producers. Critically, grain producers from significant Chinese grain-producing regions did not always minimise the effects of the independent variables (*SF*, *PF* and *BS*) on the dependent variable (*LRE*). This research provides a new viewpoint on grain farmers' LREs activities and may be used to tailor policy and commercial strategies.

Keywords: grain producers; influencing factors; loss-reduction efforts; postharvest losses; structural equation modelling

Food security is a cornerstone of national stability. However, serious postharvest losses pose a major challenge to China's food security. According to 2016 statistics from the Ministry of Agriculture and Rural Affairs of the People's Republic of China, grain postharvest handling losses average between 7% and 11%; notably, the annual grain loss and waste could feed 200 million people (Zhan and Du 2021). From 2022 to 2024, (China's Central Document No. 1, 2022; 2023; 2024) stressed the necessity of reducing grain losses across the supply chain, and several incentive programmes and initiatives have promoted loss-reduction efficiency. Despite these efforts, the actions of grain supply chain members remain insufficient, particularly during the harvest stage, where losses are most severe (Zhao et al. 2022). For example, only approximately 30.59% of grain producers pick up wheat ears after harvesting in China (Liu et al. 2024).

In recent years, scholars primarily have explored the influencing factors and solutions of grain producers' loss-reduction efforts (LREs). They focused on three aspects:

i) the concept of LREs,

ii) the assessment of losses during production stages and their root causes and

iii) the exploration of strategies to mitigate these losses.

The concept of LREs. Despite the absence of a unified definition in academic circles, investigators in various studies have examined a range of strategies to minimise postharvest losses. Li et al. (2021) indicated that investments in loss-reduction technolo-

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gies by fresh produce supply chain members reflected decision-makers' commitment to LREs. In this article, we define LREs as the collective measures implemented by grain supply chain stakeholders to minimise grain losses and waste. We evaluated the level of effort on the basis of the LREs initiatives and inputs of supply chain members.

The assessment of losses during production stages and their root causes. Investigators in existing studies have measured grain losses during the harvesting stage at both macro and micro levels. In their macro-level research, Delgado et al. (2021) have advanced measurement methods to address various stages of grain loss from preharvest to product distribution. Conversely, the micro-level approach delves into detailed analyses, accounting for disasters, crop traits and anthropogenic factors. It precisely evaluates yield losses via techniques like yield decomposition and production loss allocation (Zhao et al. 2022). As for the causes of grain losses, investigators concentrate on diverse factors, including production practices, climatic conditions and the socio-economic backgrounds of the grain producers (Rao et al. 2019; Randell et al. 2022; Zhang and Yang 2023). For example, farming techniques, soil states and temperature directly affect grain quality losses (Nugroho and Lakner 2022; Zhao et al. 2024). In addition, the interplay between soil traits and pests can harm crop development, elevating the loss risk for grain producers (Hudecová and Rajčániová 2023). According to Blakeney (2019), high temperatures can alter crop physiology and damage cellular structure, affecting yields. Maziku (2020) further suggests that grain producers with higher levels of education and extensive experience tend to have lower grain losses.

The exploration of strategies to mitigate losses. Existing research mainly focusses on methods to reduce gain losses, such as enhancing production practices, adapting to climate change (Mustafa et al. 2024) and tackling producers' socio-economic challenges. Specifically, crop protection strategies can prevent or reduce pest-induced losses, and genetic advancements can bolster wheat's resistance to germination, thereby effectively averting yield losses (Chang et al. 2023). Kauppi et al. (2021) highlighted that nutrient depletion in crops can significantly reduce grain output. To mitigate this issue, they advocated for practices such as crop rotation and strategic tillage, which can enhance yields and minimise losses. Furthermore, facing the losses caused by flooding, Zhao et al. (2022) advocated for the advancement of water conservation techniques and the optimisation of planting configurations and locations. Nonetheless, research on training producers to reduce losses remains scant (Ali et al. 2021).

In summary, prior research primarily focussed on the measurement methods of grain losses, the analysis of causes and measures to reduce losses. However, investigators in a few studies discussed the influencing factors related to producers' LREs. These factors are particularly important when viewed from a supply chain perspective, so addressing this issue solely through the lens of individual behaviour theory is inadequate. Therefore, our goal in this study was exploring the factors affecting the producers' LREs, which is important for building a grain-saving loss-reduction system across the grain supply chain.

To address the issue, we proposed a theoretical framework grounded in individual behaviour theory. With this framework, we identified social factors (SFs), policy factors (PFs) and buyer's strategies (BSs) as the three pivotal factors influencing grain producers' LREs. With this method, we divided influencing factors into independent (*SF*, *PF* and *BS*), dependent (*LRE*) and moderating variables (individual characteristics). We then designed a questionnaire to assess grain producers' LREs, targeting farmers from major grain-producing areas as research subjects. In addition, interviews with grain producers in regions helped to reveal the underlying mechanisms influencing LREs. On these bases, we provide actionable recommendations to enhance grain conservation and reduce losses.

MATERIAL AND METHODS

Theoretical basis and research hypothesis. Complex interactions between internal motives and external environmental factors generate dynamic behaviour changes, according to psychology and organisational behaviour studies. Such information is useful to explain the decision-making processes behind loss-reducing behaviours among grain producer groups, such as grain producers and farmers. Endogenous variables like education and economic position and exogenous elements like organisational incentives and environmental influences affect these behaviours.

Therefore, the questionnaire focussed on assessing the influence of endogenous factors, such as the educational level, income level and grain producer age. In addition, it explored the effects of exogenous factors on producers' LREs behaviours. On the basis of the grain production-supply-marketing continuum, grain

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producers, the government and grain purchasers are connected. At the same time, producers are embedded in a social structure with the family as the nucleus. Their social networks encompass acquaintances and friends. Within these relationships, producers assume various social roles, which significantly influence LREs, either directly or indirectly. In this study, we aimed to explore the determinants of producers' LREs. These factors include *SF*, *PF* and *BS*. On this basis, we propose the following hypotheses.

H_1: *SF* exert a positive influence on producers' *LRE*.

Social relationship theory highlights the complex web of connections and interactions that individuals have within their social structures. In rural China, farmers' core social networks typically consist of relatives and family members (Si et al. 2022). These relationships exert a significant influence on the behavioural decisions of grain producers. Research indicates that these kinship networks play a crucial role in enhancing farmers' willingness to engage in certain practices (Luo et al. 2023). Furthermore, male producers tend to have more robust social networks than their female counterparts have, and these male producers also exhibit a greater willingness to implement loss-reduction strategies (Luo et al. 2020).

H_2: *PF* positively affect producers' *LRE*.

Government subsidy policies are widely recognised as effective instruments for encouraging grain producers to reduce losses (Zhang et al. 2022). Agricultural subsidies promote rational fertilisation practices, indirectly contributing to the reduction of grain losses (Guo et al. 2021). However, Chang et al. (2016) observed that mandatory policies, such as water conservation measures, may elicit negative responses from farmers. These negative responses have the potential to undermine LREs.

H_3: *BS* positively affect the producers' *LRE*.

In the grain procurement process, a common interest conflict between buyers and producers often results in an inverse correlation between yield and price (Soullier and Moustier 2018). This phenomenon can dampen producers' enthusiasm, particularly during periods of high yield (Benfica et al. 2017). Moreover, in green supply chains, retailer-led revenue sharing contracts have been demonstrated to enhance the environmental performance of products. These contracts also increase profits for manufacturers (Song and Gao 2018).

Furthermore, key factors such as grain producers' income level, land size and educational level significantly influence LREs. High-income farmers and those operating on a larger scale (Anriquez et al. 2021) are generally more inclined to implement effective measures to minimise postharvest losses. However, in developing countries, a negative correlation is observed between the education level of farmers and their grain loss rates (Liu et al. 2023). Arah et al. (2016) and Arends-Kuenning et al. (2022) agreed that farmers with lower levels of education lose more grain.

Accordingly, in this study, we examined the effects of moderating variables on grain producers' LREs. These moderate variables include gender, age and income sources. In addition, we assessed the moderating effects of the independent variables on the dependent variable.

Model building. In this section, we have identified three pivotal factors influencing the *LRE* behaviour of grain producers: social relationships (Si et al. 2022), the policy environment (Zhang et al. 2022) and buyers' strategies (Liu et al. 2020). By leveraging expert consultations, brainstorming sessions and research findings from Luo et al. (2020) and Zhang et al. (2022), we developed a comprehensive measurement questionnaire. On this basis, we constructed a structural equation model to examine the effects of these factors on the LREs of grain producers in China's major grain-producing regions. Furthermore, we delved into the interplay and mechanisms among these factors (Figure 1).

Questionnaire and interview design. To design the questionnaire, we used a five-point Likert scale with response options ranging from 'strongly agree' to 'strongly disagree'. The questionnaire was divided into two sections: 'Basic Information' and 'Variable Investigation'. To ascertain the validity and reliability

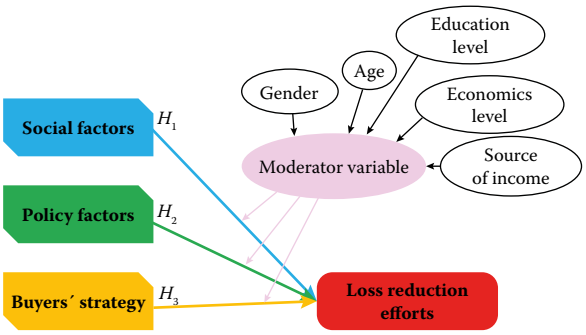

Figure 1. Theoretical model for grain producers' LRE

H_1: *SF* exerts a positive influence on producers' *LRE*; H_2: *PF* positively affects producers' *LRE*; H_3: *BS* positively affects the producers' *LRE*; *SF* – social factors; *PF* – policy factors; *BS* – buyers' strategy; *LRE* – loss reduction efforts

Source: Author's own elaboration

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of the questionnaire, we conducted a preliminary survey in Henan province. In the beginning, we distributed 100 questionnaires, resulting in 76 valid responses. We calculated the reliability coefficient at 0.86, and the content validity index was 0.78. After the presurvey, we refined any ambiguous or incomplete statements within the questionnaire. Subsequently, we conducted a large-scale formal survey across 13 major grain-producing regions in China.

To explore the driving factors behind grain producers' engagement in LREs, we combined expert consultations and brainstorming sessions to formulate interview both open-ended and closed-ended questions. Open-ended questions covered harvest weather and government help, and closed-ended questions assessed self-reported yearly grain loss rates.

Data collection. In 2023, for this study, we established cooperative relationships with 17 university teams across China (Nanchang University etc.) and conducted a comprehensive questionnaire survey. The survey focussed on three majors grain crops: wheat, rice and corn. For the geographical representativeness of the sample, the survey covered 13 major grain-producing areas. The cooperative team in each major producing area strictly inquired and investigated in accordance with the requirement of 'the farmer is currently planting grain crops' and verified by checking planting records or field visits. At the same time, we selected farmers with different planting scales for surveys to ensure the representativeness and diversity of the survey results. The collection was mainly through face-to-face interviews, combined with snowball sampling, to collect a large amount of first-hand data. We performed many pretests on questionnaire design to ensure validity, data accuracy and dependability. Finally, we reviewed the collected data to ensure the quality and validity of the final data, and we obtained 1 536 valid questionnaire responses, with an effective rate of 83% (Table 1).

For the interview phase of the study, we used a stratified sampling method, selecting two or three grain producers from each province, stratified according to the average planting area. We conducted these interviews over a period of 19 days, resulting in a total of 25 online interview sessions (Table 2).

Table 1. Distribution of research sample

Surveyed provinces	Sample
Heilongjiang Province	116
Jilin Province	100
Liaoning Province	103
Hebei Province	105
Jiangsu Province	120
Jiangxi Province	125
Hunan Province	126
Sichuan Province	103
Shandong Province	104
Henan Province	184
Inner Mongolia	100
Anhui Province	116
Hubei Province	139
Total	1 536

Source: Own processing based on research data

RESULTS AND DISCUSSION

Table 3 outlines the socio-economic characteristics of the valid survey samples. The data reveal that the surveyed grain producers had a gender ratio of approximately 6:4, with men constituting the majority. Notably, 36.46% of the participants were within the 41- to 50-year-old age bracket. In terms of educational attainment, 41.93% of the grain producers had completed junior high school, but a smaller proportion, 12.37%, held a university degree or higher. In terms of monthly income, a significant number of grain producers were within the range from EUR 260–520. It is also noteworthy that farming was the main source of income for 45.03% of the participants, but manual labour was a secondary source for 25.83% of the respondents.

Reliability and validity analysis. In this study, we evaluated the reliability of the questionnaire by using Cronbach's alpha coefficient. Furthermore, we conducted the Kaiser–Meyer–Olkin and Bart-

Table 2. Information about some interviewed farmers

Province	Interviewed	Date	Time*
Heilongjiang Province	Mr. Han	2024/2/2	3 min
Liaoning Province	Mr. Cao	2024/2/3	4 min
Jilin Province	Ms. Li	2024/2/4	5 min
Hunan Province	Ms. Luo	2024/2/13	13 min
Hebei Province	Mr. Chen	2024/2/14	7 min
Henan Province	Mr. Chen	2024/2/16	15 min

*The interview time is affected by dialect and the understanding and expression ability of grain producers, but it has little effect on the accuracy of the interview results

Source: Own processing based on research data

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Table 3. Socioeconomic characteristics of the effective sample (n = 1 536)

Individual characteristics	Option	Amount	Percentage (%)
Gender	male	977	63.61
	female	559	36.39
Age	20 years old and below	31	2.02
	21–30 years old	145	9.44
	31–40 years old	263	17.12
	41–50 years old	560	36.46
	51–60 years old	404	26.3
	61 years old and above	133	8.66
Education level	primary school and below	436	28.39
	junior high school	644	41.93
	high school	266	17.32
	college and above	190	12.37
Monthly income	130 and below	192	12.5
	130–260	279	18.16
	260–520	526	34.24
	520–780	286	18.26
	780–1 040	127	8.27
	1 040 and above	126	8.2
Source of income	farming	1034	45.03
	manual work	593	25.83
	self-employed	339	14.76
	financial	117	5.1
	others	213	9.28

Source: Own processing based on research data

lett's tests by using SPSS 25 (IBM SPSS Statistics 25). We applied these analyses to questionnaires collected from the 13 major grain-producing regions. The results, detailed in Table 4, indicated that all questionnaires satisfied the established criteria for both reliability and validity.

Analysis of influencing factors of LREs. We used analysis of moment structures (Amos) 25 to create a structural equation model to assess *LRE* variables in the important grain-producing regions. We performed model testing by using a representative sample from these 13 regions, as illustrated in Figure 2. Figures 4 through 6 show hypothesis testing findings from all provinces. The *LRE* of grain producers had an R^2 value of 0.750, proving the model was credible and confirmed.

Table 4. Test results of validity and reliability in main production areas

Province	Reliability	Validity
Jiangxi Province	0.81	0.83
Hunan Province	0.82	0.84
Sichuan Province	0.88	0.87
Hubei Province	0.92	0.91
Jiangsu Province	0.91	0.93
Anhui Province	0.88	0.89
Henan Province	0.86	0.87
Heilongjiang Province	0.90	0.92
Jilin Province	0.92	0.93
Liaoning Province	0.91	0.87
Hebei Province	0.88	0.91
Shandong Province	0.91	0.85
Inner Mongolia	0.92	0.91
Main producing areas	0.89	0.95

Source: Own processing based on research data

The comprehensive analysis results from the major grain-producing regions and provincial inspections are presented in Figures 3 through 5. Using Amos 25 software, we subjected the data to a rigorous analytical process. We used a binary 0–1 encoding system to categorise the effects as significant (coded as 1) or nonsignificant (coded as 0). We then used Microsoft Excel (2016) to construct stacked bar charts showing how different factors affected grain yield in different locations.

Figure 3 demonstrates that SFs positively influenced the LREs of grain producers in the major grain-producing areas and eight provinces, including Heilongjiang, thus supporting hypothesis H_1. However, the

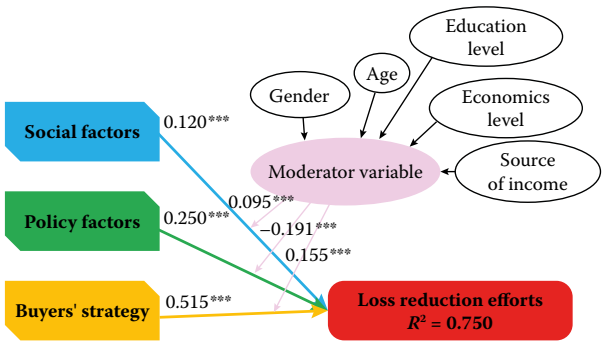

Figure 2. Model validation results for grain production regions; ***significance at 1% level

Source: Own processing based on research data

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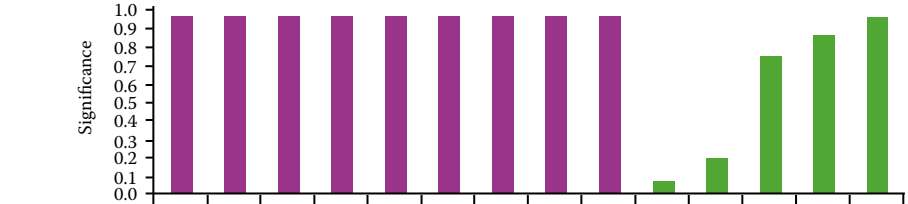


	All areas	Heilongjiang	Hebei	Shandong	Hubei	Inner Mongolia	Anhui	Sichuan	Jiangsu	Liaoming	Hunan	Jilin	Henan	Jianxi
Positive effect	1	1	1	1	1	1	1	1	1	0	0	0	0	0
No effect	0	0	0	0	0	0	0	0	0	0.062	0.189	0.76	0.851	0.987

Figure 3. Results of hypothesis testing for social factors

Source: Own processing based on research data

effect of SFs on grain producers' LREs in five provinces, such as Liaoning, was not significant, which fails to support hypothesis H_1.

Figure 4 shows that *PFs* positively affected the *LREs* of grain producers in the major grain-producing areas and 12 provinces, including Jilin, confirming hypothesis H_2. Nevertheless, in provinces like Hunan, the influence of *PFs* on *LREs* was not statistically significant, which does not support hypothesis H_2.

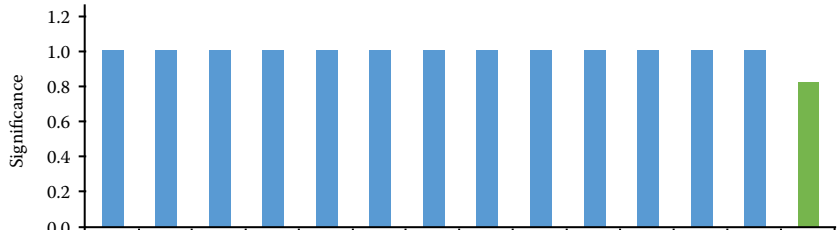
Figure 5 indicates that in important grain-producing areas and 13 provinces, including Heilongjiang, *BSs* boosted grain producers' *LREs*, supporting hypothesis H_3.

Effect of individual characteristics on *LREs*. In this section, we explore the influence of grain producers' personal traits on *LREs* by treating these traits as moderating variables. We processed the data in several stages: first, we standardised variables in SPSS 25 to ensure consistency. Subsequently, we reduced outliers and fluctuations by smoothing variables. We then calculated the interaction between the moderating variable and the independent variable. Amos 25 checks whether this interaction significantly affects the dependent variable. The results revealed four types of moderation: strong negative, strong positive, partial or no effect.

Significant negative moderation. After in-depth analysis, we found that for the main grain-producing areas, such as Inner Mongolia and Sichuan, individual characteristics had a significant negative moderating effect ($\beta = -0.267$, $P < 0.001$, $\beta = -0.251$, $P < 0.001$) on grain producers' LREs. In addition, focusing on the three core elements of grain producers' *LREs*, we found that individual characteristics still had a significant negative moderating effect (Figure 6). However, for Sichuan, individual characteristics had a positive moderating effect between *SFs* and *LREs*.

Significant positive moderation. Because of the influence of individual characteristics, Anhui and Shandong grain producers showed positive regulation ($\beta = 0.340$, $P < 0.05$, $\beta = 0.388$, $P < 0.001$), unlike the key grain-producing regions and Inner Mongolia. It is worth noting that individual characteristics were still negatively regulated in all three key factors affecting LREs (Figure 7).

Partially significant moderation. The data from Hebei and Jiangsu showed that the influence of individual characteristics on BSs was not significant



	All areas	Hubei	Hebei	Liaoming	Jilin	Inner Mongolia	Shandong	Jiangsu	Henan	Sichuan	Anhui	Heilongjiang	Jianxi	Hunan
Positive effect	1	1	1	1	1	1	1	1	1	1	1	1	1	0
No effect	0	0	0	0	0	0	0	0	0	0	0	0	0	0.822

Figure 4. Results of hypothesis testing for policy factors

Source: Own processing based on research data

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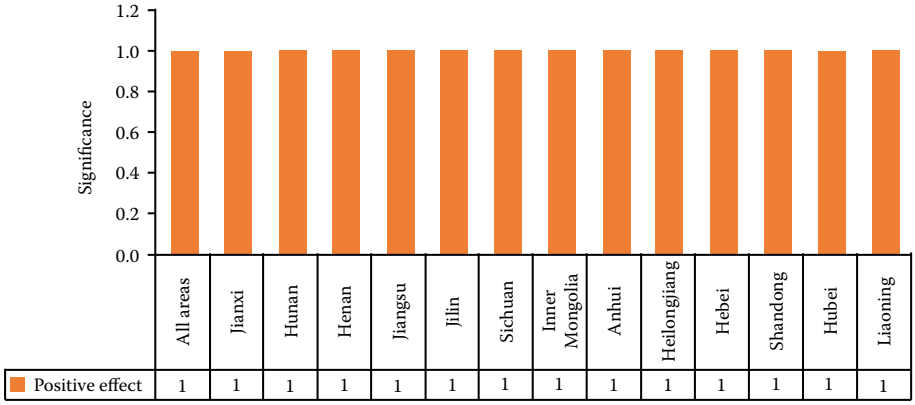

Figure 5. Results of hypothesis testing for Buyers' strategy

Source: Own processing based on research data

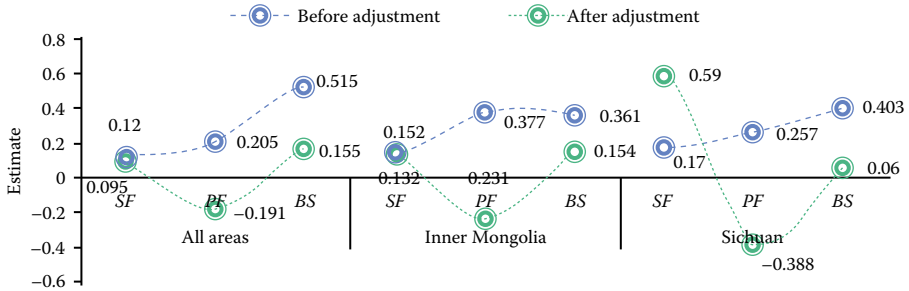

Figure 6. Negative moderating effect of individual characteristics

SF – social factors; *PF* – policy factors; *BS* – buyers' strategy

Source: Own processing based on research data

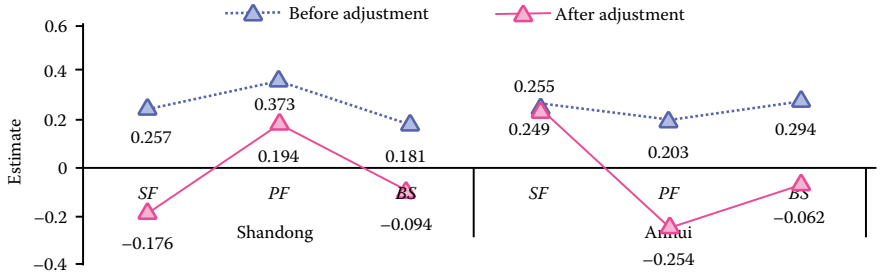

Figure 7. Positive moderating effect of individual characteristics

SF – social factors; *PF* – policy factors; *BS* – buyers' strategy

Source: Own processing based on research data

($P > 0.05$). However, for Jilin, Jiangxi, Hunan and Liaoning, *SFs* had the most significant effect on *LREs* after moderation by individual characteristics. Among them, Jilin and Jiangxi showed a negative moderating effect ($\beta = -0.066$, $P < 0.001$, $\beta = -0.528$, $P < 0.001$), whereas Hunan and Liaoning showed a positive moderating effect ($\beta = 0.247$, $P < 0.001$, $\beta = 0.460$, $P < 0.001$).

Nevertheless, the LREs in Jilin ($\beta = -0.686$, $P < 0.001$), Liaoning ($\beta = -1.090$, $P < 0.001$) and Hebei ($\beta = -0.314$, $P < 0.001$) still followed the trend of major grain-producing regions, showing a consistent negative moderating effect under the influence of individual characteristics. This finding indicates that producers' LREs in these regions were consistently inhibited by individual differences. However, Jiangxi ($\beta = 0.366$, $P < 0.01$), Hunan ($\beta = 0.571$, $P < 0.001$) and Jiangsu ($\beta = 0.282$, $P < 0.001$) provinces had positive moderating patterns like Anhui, showing that individual qualities encourage LREs (Figure 8).

Nonsignificant effect. Unlike the significant moderating effect observed in the former three categories, the moderating effect of farmers' individual characteristics on LREs in Henan, Heilongjiang and Hubei was not apparent. It is worth noting that, in the context of individual characteristic adjustments, the BSs in Henan, Heilongjiang and Hubei had a negative moderating effect on LREs. Especially in Hubei, SFs also showed negative moderating effects, whereas in Henan and Heilongjiang, PFs exhibited a notable negative moderating influence (Figure 9).

Discussion. Results of studies conducted by Luo et al. (2023), Zhang et al. (2022) and Liu et al. (2020) demonstrated positive correlation between *SFs*,

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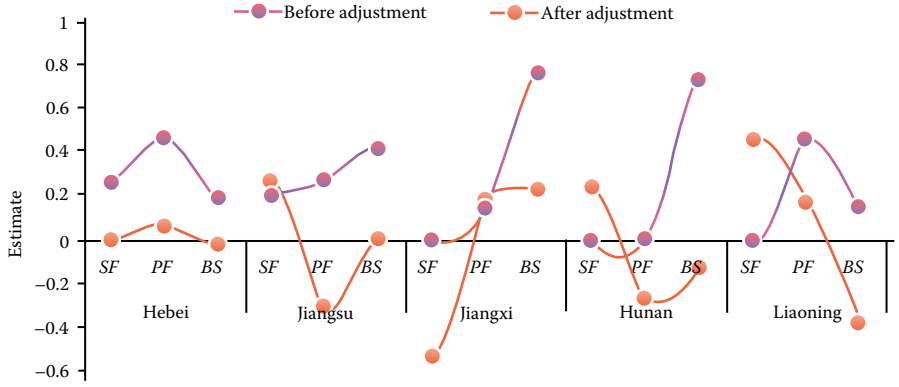

Figure 8. Differential regulation of individual characteristics

SF – social factors; *PF* – policy factors; *BS* – buyers' strategy
Source: Own processing based on research data

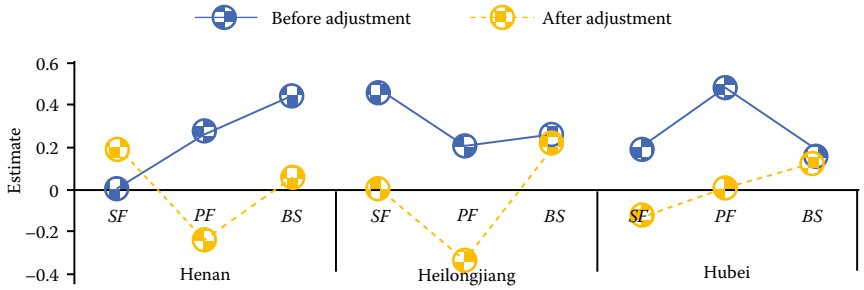

Figure 9. The moderating effect of individual characteristics is not significant

SF – social factors; *PF* – policy factors; *BS* – buyers' strategy
Source: Own processing based on research data

PFs and *BSs* with the enthusiasm of grain producers in major producing regions towards *LREs*. These investigators found that, in these regions, the effect of individual characteristics on grain producers' *LREs* was not always significant. Further analysis of grain producers' LREs actions across provinces showed considerable regional disparities in how many factors affect them. Therefore, in this section, we aim to reveal the precise reasons behind the varying effects on *LREs*. We achieved this by conducting interviews with grain producers in the major grain-producing regions.

***SF* effect on grain *LREs*.** Producers care deeply about their grain and feel the effect of losses, but strong networks aid in LREs management. This pattern was not universal; in Liaoning and four other provinces, social resources varied, and information sharing was confined to personal circles. Henan's producers, however, leaned more on professional networks. To enhance these networks and problem-solving, the government should organise meetings and training sessions.

***PF* effect on grain production LREs.** The minimum purchase price policy for damaged wheat in Henan is designed to support farmers' income by setting a minimum purchase price. However, in Anhui province, there was no clear link between *PFs* and *LREs*. Farmers' response to policies was passive due to inadequate information leads to significant losses, especially during disasters. Although farmland insurance exists, the claim process is cumbersome, deterring farmers from participating. To promote active *LREs*, local governments need to improve the insurance claim process and expand coverage.

***BS* effect on grain producers' LREs.** Data collected from 13 major grain-producing regions revealed a positive effect ($\beta = 0.515$, $P < 0.001$) of purchasing strategies on grain producers' LREs. The findings confirmed those of Liu et al. (2020), filling a gap in our knowledge of purchasers' *LRE* effects on producers and showing macro-level mutual incentive connections across upstream and downstream supply chain components.

Effect of individual characteristics on LREs. Differences in gender and income source did not significantly change the positive effects of the three main factors on food producers' derogation behaviour, but age, education level and income did. Notably, economic income exerted a particularly prominent influence in this regard.

CONCLUSION

In this study, we examined the factors influencing LREs among grain producers in major grain-producing regions, and we drew the following conclusions:

i) *SFs*, *PFs* and *BSs* all exerted significant positive effects on grain producers' *LREs*, and

ii) the effects of individual characteristics on grain producers' *LREs* in grain-producing regions were not always significant.

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Policy recommendations. According to the questionnaire results of this study, we offer the following targeted recommendations aimed at promoting grain saving and loss reduction:

i) Regularly share successful loss-reduction case studies to inspire producers to loss reduction. Consistently highlight the success stories of leading grain producers to raise awareness about loss reduction. Engage experts and successful, accomplished farmers to assist others in overcoming challenges, while recognising and rewarding those with exceptional *LRE* performance. Promote the participation of female farmers in loss-reduction initiatives, empowering them with skills and contributing to the sustainability of industry.

ii) Prioritise grain-saving and loss-reduction strategies in grain production. Support farmers in addressing production challenges like pests, diseases and machinery issues. Guarantee the availability of high-quality seeds, and combat the circulation of counterfeit seeds. Key provinces should standardise seed markets and actively combat fraudulent practices. Develop advanced harvesting equipment, train operators and reduce harvest losses. Authorities must carefully select seeds, enhance disaster resilience and encourage farmers to engage in LREs.

iii) Enrich rural personnel and technical strength. Provinces should hire top agriculture technology experts and apply advanced grain loss-reduction methods. To create a technology adoption loop, encourage Anhui province to develop technology professionals to help farmers with less education. Encourage sharing knowledge among leading farmers from Anhui and Shandong to learn diverse loss-reduction strategies and improve techniques.

iv) Improve the relative legal system for ensuring grain security. China's policy departments should tailor policies to provinces and encourage loss-reduction incentives, notably in Hunan. Improved communication with farmers will help shape effective, practical policies.

Limitations of the study. The study has the following two limitations.

i) We did not consider classifying farmers according to their cultivation scale and then analysing loss-reduction behaviours within each category.

ii) In our review and filtering of the collected data, subjective biases may have unconsciously led to the exclusion of some valid data. Despite these limitations, our research findings are still enlightening and lay the foundation for further exploration in this field.

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