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Impact of farmers' benefits linking stability on cloud farm platform of company to farmer model

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Abstract: China has formed a new C2F (company-to-farmer) model of internet and agriculture. How to build a sustainable linkage of the C2F platform is important for promoting agricultural industrialization. Based on the cognition theory and internet thinking, we characterized the linkage mechanism and stability framework of the C2F regarding default proportion, benefits fairness and benefits gap. Using the logistic regression method, we constructed the impact effect model of benefit links stability based on the farmers' characteristics, platform cognition and social environment. We found that in the C2F, optimizing farmers' age structure (17.93%, impact effect), increasing farmers' income level (16.79%), as well as improving farmers' education level (14.33%), policy support (11.35%), platform service quantity (9.82%), market volatility (9.11%), platform transaction transparency (9.07%), farmers' risk tolerance (7.93%), and platform technical guidance effect (3.67%) had a significant impact on reducing default proportion (28.13%) and benefits gap (36.55%), thus heightening benefits fairness (35.32%). The research suggested, we should promote the sustainability of C2F by improving the farmers' digital ability and platform function, developing innovative linkage mechanisms between companies and farmers, strengthening government guidance, and protecting the policy environment.

Keywords: agricultural consortium; classification logistics; farmers' cognition; internet platform; relative effect function

The benefits consortium of companies and farmers based on internet can share risks and benefits, which is the main mode of agricultural industrialization in China. The decentralized and small-scale farms (Lowder et al. 2016) will continue to exist for a long time and have to have digital capacity to facilitate production and management (Peter et al. 2019). The benefits linking requires the companies to form close cooperative relationships with farmers through unified management and service (Lin et al. 2017) so that they can share risks and benefits of the whole industrial chain (Zahri et al. 2019). Research related to benefits linking shows that the contract model with large instability, imperfect external environment, low quality and cooperation ability of farmers, and a serious breach of contract for risk aversion showed all these factors affected the benefit links (Hao 2004).

With permeating of internet into rural areas, and after the proposal of the Internet^{+} plan in 2016, the new benefits linking model based on internet platform (cloud farm management information system, and e-commerce) called C2F [i.e. company + internet (to) + farmers] has gradually been formed. The C2F is expected to change an unequal position of companies and farmers (Liu et al. 2016). It is aimed at promoting the real-time information integration, data sharing, and guiding the farmers from being production-oriented to the consumption-oriented (Marcelo et al. 2015).

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Research on internet cognition and behaviour is driving new technology adoption, based on the framework of willingness, motivation and behaviour (Taylor and Todd 1995). The differences in farmers' characteristics, farm-scale, policy environment, and network facilities would affect farmers' perception of internet (Espinosa et al. 2010), such as the usefulness of content quality, the ease of use on friendly interactions, the credibility of information, and expected workload (Faham 2019), which acts on farmers' acquisition and use of information (Davis 1989); in particular, the perceived benefits and risks determine the willingness of farmers to adopt the benefit-linking behaviours (Wilson 1999). The new platform services increased the farmers' understanding of benefits and risks, which enhances the self-development of benefit-linked companies (Cristobal et al. 2020).

The C2F allows the farmers' benefits-linking behaviour based on internet cognition. The platform is not only new technology, but important new thinking, e.g. based on shared economics (Botsman 2010). The farmers understanding of the C2F and use of internet were very limited. Developing a new impact mechanism and factors of the platform to find the effectiveness and benefits linking stability of the C2F (Duan 2017) is important to speed up the "Internet^{+} agriculture" in China.

Based on the cloud farm platform in which the companies and their farmers are taken as the research objects, using questionnaire investigation, farmer cognition, and shared theory, we characterized the benefits linkage mechanism and stability framework of the C2F. By the logistic regression method, we constructed the impact effect model of linkage stability and carried out the empirical analysis. We found the main impact factors and their relative effects on benefit links, and made some suggestions for promoting the benefit links in the C2F.

Resaerch and theoretic framework

The C2F model based on the internet shared thinking. In Figure 1, the C2F is the industrial and digital platform with the core of shared economics (Porter and Kramer 2011), matching and integration of products, services and platforms (Henten and Windekilde 2016). Companies and farmers are the equal subject users of the platform, which acts as the intermediary and the information center connecting the benefits. Regarding a resource chain, the platform can promote the integration and optimization of fragmented resources, and reduce the benefits gap between farmers and companies; moreover, regarding a service chain, the production and management are linked and implemented (Marcelo et al. 2015). Regarding an information chain, companies provide accurate market information to farmers and guide them to reconstruct product structure and reduce costs, whereas farmers can appreciate the fairness in the distribution of benefits.

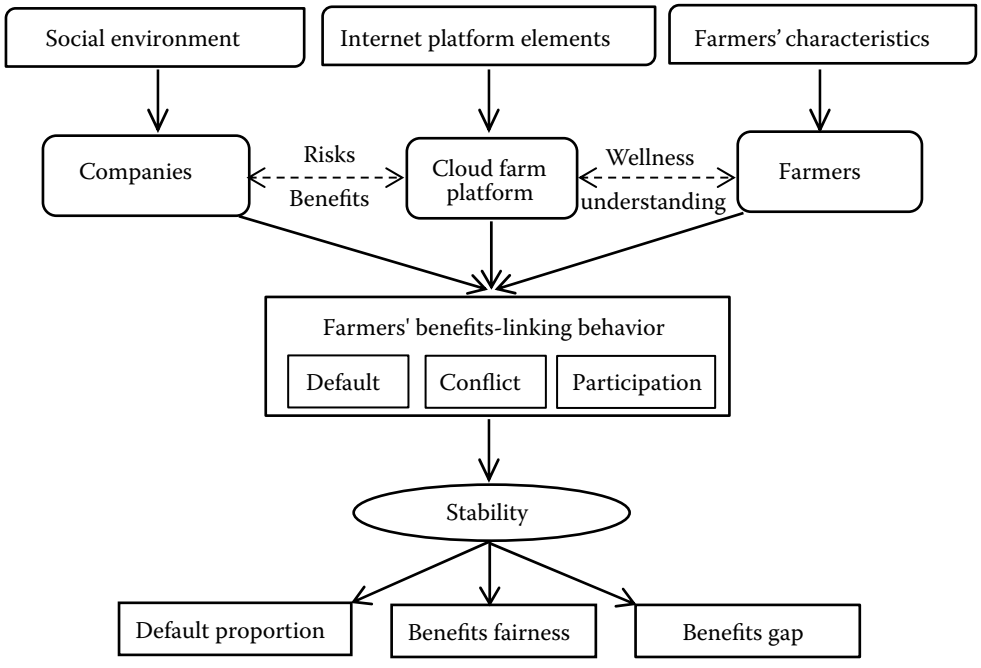

Figure 1. The impact mechanism of the farmers' benefits-linking behaviour based on the cognitive theory in the C2F

Source: Own calculation model

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The C2F is a platform-sharing framework realizing "risk-sharing and benefit-sharing" (Ma and Abdulai 2017). Benefit linking included a mechanism of benefit distribution, protection, adjustments, and constraints. The C2F is driven by the multilateral market, and the balance of benefits among economic entities is pursued, so that the whole economy, as well as individuals, can obtain the maximum benefits.

Research framework based on the cognitive theory with respect to farmers. As a direct business entity in the C2F, the farmers' behavioural choice depends on their cognition and willingness. Given limited rationality and external conditions, the transaction cost depends on personal characteristics and environmental factors (Williamson 1987). The cognition will be affected by the farmers' characteristics, internet factors and social environment, which will affect the choice of the C2F and a degree of farmer participation. In Figure 1, we established a theoretical framework for the impact of benefits linking stability based on the "platform cognition – linking behavior – stability effect". Platform cognition is the willingness of farmers to choose C2F, enabling wide participation; as the core variable, it includes the risk and value perception, is related to farmers' characteristics as the control variable, and is affected by the social environment. Linking behaviour includes farmer default, benefit conflict and degree of participation. The stability effects of the linking behaviours were measured through default proportion, benefits fairness and benefits gaps.

MATERIAL AND METHODS

Research region and data sources. Jiangsu Province has significant advantages regarding use in the C2F model, containing more than 7 700 "leading companies". According to the statistics of Jiangsu Agricultural Leading Enterprise Network, based on the platforms such as WeChat and Taobao, the C2F has driven the development of 6.7 million farmers (40% of total). We selected Jiangsu as research region for its pertinence and representativeness in agriculture development. The research results obtained represent a good reference for internet agriculture in China and other countries.

In order to enunciate the cognition differences among farmers in the C2F, the analytical data were derived from the user questionnaire on the cloud farm platform we developed for production management, technical and market service; we accessed nearly 3 000 farmers with an area of about 4 000 ha in the past 3 years. The questionnaire was designed according to Table 1. The investigated users included one company and its farmers in each of the 3 economic regions, such as Southern, Middle and Northern Jiangsu, chosen by random sampling. We determined the companies in different regions of the platform, randomly selected 5 prefectures (cities or districts) from each region, and randomly selected 20 farmers from each prefecture to be assessed and characterized by the questionnaire starting in summer of 2018.

We completed 300 questionnaires and obtained 282 valid samples, with some missing data and abnormal values, and used SPSS for data processing. The descriptive statistics were shown in Table 1. The overall reliability of the questionnaire is acceptable because Cronbach's alpha value is 0.743.

Impact model based on Ordered Multi-Classification Logistic. According to Figure 1, we selected $Y_1 \sim Y_3$ as indicator types (multi-classified from 1 to 3) for analyzing the stability of the benefit links in the C2F, Y_1 – default proportion, Y_2 – benefits fairness and Y_3 – benefits gap. The impact factors of the benefit links stability were taken as the 16 for control, whereas the core variable X_i as the other indicator type was quantified with the 4 value levels (1 ~ 4, Table 1).

We used Ordered Multi-Classification Logistic regression, called the cumulative odds model, with 20–50% more effective use of the orderly multi classification of data, to establish the impact factor model of the benefit linking in the C2F.

Equation (1) was used to calculate the effect of probability (Muriithi et al. 2012).

$$\mathrm{Logit}(\rho_k) = \mathrm{Ln}\left(\frac{\sum_{i=1}^{k} p_i}{1-\sum_{i=1}^{k} p_i}\right) = \alpha_k + \sum_{i=1}^{m}\beta_i X_i \,,\ \rho_k = \sum_{i=1}^{k} p_i \,,$$
$$p_k = P\left(Y_j \le k \,\middle|\, X\right) \quad (1)$$

where: ρ_k – cumulative probability of event "Y_j takes the top k level"; p_i – probability of event "Y_j takes the k^{th} level"; α_k – constant; β_i – regression coefficient; X_i – independent variables (4 value levels in Table 1), i = 1, 2, …, m, m = 16; Y_j – ordered dependent variables (3 value levels in Table 1), j = 1, 2, 3; k – number of events "Y_j takes the top k level", k = 1, 2, 3.

$$\frac{1}{T}\sum_{i=1}^{T}\mathrm{Logit}(\rho_k) = \alpha_k + \sum_{i=1}^{m}\sum_{j}^{n-1}\beta_{ij}\,\overline{x}_{i,j} \,,$$
$$COR_j = \exp\left(\left|\beta_{ij}\right|\right) \quad (2)$$

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Table 1. Definition of variables and descriptive statistics

Variables	Description	Group definition[#]	Mean	Std. err.
Dependent variable: Stability benefits				
Y_1	default proportion	1: severe, 2: moderate, 3: mild	2.773	0.468
Y_2	benefits fairness	1: bad, 2: average, 3: excellent	2.454	0.711
Y_3	benefits gap	1: higher, 2: average, 3: lower	2.294	0.737
Control variables: Farmers' characteristics				
X_1	age (years old)	1: ≤ 35, 2: 36 ~ 45, 3: 46 ~ 55, 4: ≥ 56	2.538	0.225
X_2	education (years)[a]	1: ≤ 6, 2: 9, 3: 12, 4: ≥ 15	3.087	0.664
X_3	labor quantity (people)	1: ≤ 5, 2: 6 ~ 10, 3: 11 ~ 20, 4: ≥ 21	2.099	0.213
X_4	income (thousand USD)[b]	1: ≤ 15, 2: 16 ~ 35, 3: 36 ~ 45, 4: ≥ 46	2.512	0.249
X_5	farm size (ha)	1: ≤ 1, 2: 1.1 ~ 2.0, 3: 2.1 ~ 3.0, 4: ≥ 3.1	2.391	0.163
X_6	risk tolerance	1: weaker, 2: weak, 3: strong, 4: stronger	3.504	1.443
Core variables: Platform cognition				
X_7	internet infrastructure	1: weaker, 2: weak, 3: good, 4: excellent	3.725	1.513
X_8	information correlation	1: lower, 2: low, 3: high, 4: higher	2.929	0.650
X_9	technical guidance effect	1: weaker, 2: weak, 3: strong, 4: stronger	3.050	0.812
X_{10}	information timeliness	1: weaker, 2: weak, 3: strong, 4: stronger	3.482	0.806
X_{11}	service quantity	1: lesser, 2: less, 3: more, 4: most	3.135	0.677
X_{12}	transaction transparency	1: lower, 2: low, 3: high, 4: higher	3.433	0.840
X_{13}	internet cognitive level	1: lower, 2: low, 3: high, 4: higher	3.050	0.895
Core variables: Social environment				
X_{14}	policy support	1: lower, 2: low, 3: high, 4: higher	2.780	0.955
X_{15}	market volatility	1: lower, 2: low, 3: high, 4: higher	3.007	0.897
X_{16}	agricultural subsidy	1: lower, 2: low, 3: high, 4: higher	2.848	0.865

[a]years of schooling; [b]1.5 USD = 10 yuan in 2019; [#]the reference level on Group 4
Source: Own calculations based on a survey by the authors

$$W(X_i)=\frac{REF(X_i)}{\sum_{i=1}^{m} REF(X_i)},\ REF(X_i)=\sum_{j=1}^{n-1}\left(COR_j\right)^{\delta_{ij}},$$
$$\delta_{ij}=\sqrt{x_{i,j}\times\left(1-x_{i,j}\right)} \quad (3)$$

where: $\overline{x}_{i,j}$ – mean of $\overline{x}_{i,j}$ (i.e. the proportion of the j^{th} level of X_i); COR_j – positive correction value of OR; β_{ij} – regression coefficient of virtual variable $x_{i,j}$ in Equation (1); $W(X_i)$ – relative impact importance of X_i to Y_j; $REF(X_i)$ – relative effect function of X_i to Y_j; δ_{ij} – standard error of $x_{i,j}$; T – total number of samples; n – number of value levels of X_i, n = 4.

RESULTS AND DISCUSSION

In Table 1, means of Y_1, Y_2 and Y_3 were 2.773, 2.454 and 2.294, indicating that the phenomenon of default occurred frequently; however, the C2F could protect the benefits and rights of each business entity and the restriction benefit balance still existed. We calculated the correlation coefficients of $Y_1 \sim Y_3$: $r(Y_1) = -0.051$ ($t = -1.532$), $r(Y_2) = 0.008$ ($t = 1.218$), $r(Y_3) = 0.019$ ($t = 1.320$), $P < 0.01$ ($t = 2.334$). The overall correlation was not significant [$r(Y_i) < 0.3$], so it was necessary to establish 3 regression models to study the impact of the stability of benefit links.

The validity of samples was tested using the Bartlett's spherical test statistic, which was significant at $P < 0.01$, showing there was a significant correlation among variables $X_7 \sim X_{16}$. We eliminated internet cognition (X_{13}) and agricultural subsidy (X_{16}) because of lower correlation for public factors F_1 (platform cognition factors) and F_2 (social environment factors) based on KMO (0.846) using Principal Component Analysis (PCA). Because only 8 core vari-

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ables were selected, we used them directly in the regression model.

Using SPSS software, regression analysis was carried out for Y_i and X_j according to the Equation (1), testing for the significance of β_i. For the $Y_1 \sim Y_3$, the likelihood ratio χ^2 values were 50.525, 43.765 and 83.828, and the collinear test *P*-values were 0.077, 0.120 and 0.341, respectively, indicating that X_j (Table 1) did not have multiple collinearities. The results are shown in Figures 2–4.

Impact of platform cognition and social environment on the benefit links stability

Figures 2–4 showed that increasing technical guidance, service quantity, transaction transparency, and policy support, as well as reducing market volatility could significantly improve farmers' benefit links stability:

Technical guidance effect. It is the perceived farmers' benefit factor. The weaker group of technical guidance effect (X_9, mean = 3.050) had a significantly negative impact on both benefits fairness (Y_2) and benefits gap (Y_3) ($P < 5\%$ or 1%, $OR < 1$). The impact was not clear on Y_1 because the 95% confidence interval (CI) of the weaker group ($P < 1\%$) in default proportion (Y_1) crossed the invalid line ($OR = 1$). We found that improving the technical guidance effect of platform should reduce the probability of Y_2 and Y_3 values belonging to the lower group. It is the function of the C2F and the reason for farmers to connect to company that provided technology guidance for solving the agricultural problems.

Service quantity. It is the perceived farmers' benefit factor. The lesser group of service quantity (X_{11}, mean = 3.135) had significantly negative effects on Y_1 and Y_3 ($P < 1\%$ or 5%, $OR < 1$), and the less group had significantly negative effects on Y_1 and Y_2 ($P < 1\%$, $OR < 1$). Because the 95% CI of the lesser group ($P < 10\%$) of Y_2, and the less group ($P < 5\%$) of Y_3 crossed the invalid line ($OR = 1$), their impacts were not clear. We found that improving the service supply capacity of the platform could reduce the probability of Y_1, Y_2 or Y_3 having values in the lower group. The platform service includes experts, achievements, guidance, and agricultural materials; hence, the quantity and quality of service is the basis for the behaviour choice influencing the benefit links. The platform should strengthen the service sharing according to the diversity and specificity of the farmers' own characteristics and demands.

Transaction transparency. It is the perceived farmers' risk factor. The lower group of the trading transparency (X_{12}, mean = 3.433) had significantly negative effects on Y_1, Y_2 and Y_3. The low group had significantly negative effects on Y_1 and Y_2 ($P < 1\%$, $OR < 1$). Because the 95% CI of the low group ($P < 10\%$) of Y_1 crossed the invalid line ($OR = 1$), the influence was not clear. The results showed that increasing the fairness of operation of the platform, such as transaction transparency, helped reduce the probability of Y_1, Y_2 or Y_3 having the values in the lower group. The subjective risk caused by poor information transparency also affected the behaviour of the benefit linking. When farmers have little ability and insufficient options to face the risk, they can only choose low risk.

Policy support. The lower group of policy support (X_{14}, mean = 2.780) had a significantly negative impact on default proportion (Y_1), benefits fairness (Y_2) and benefits gap (Y_3) ($P < 1\%$, $OR < 1$). The low group of X_{14} had a significantly negative impact on Y_1 ($P < 5\%$, $OR < 1$), whereas the 95% CI of the low group ($P < 5\%$) of Y_3 crossed the invalid line ($OR = 1$), so the impact was unclear. We found that the improvement of internet and the agricultural policy support should reduce the probability of Y_1, Y_2 or Y_3 belonging to the lower group. Policy support had a positive effect on farmers by building a benefit mechanism of price protection and restrictions.

Market volatility. The lower group of market volatility (X_{15}, mean = 3.007) had a significantly negative impact, and there were positive correlations (most groups had $OR < 1$) with Y_1, Y_2 and Y_3 ($P < 1\%$ or 5%, $OR < 1$). Research showed that the market volatility of agricultural products or materials should be larger, thus increasing the probability of Y_1, Y_2 or Y_3 belonging to the lower group. Less fluctuation in the market price in the C2F was associated with the more stable benefit linking. Farmers pursue their own maximum benefit at the minimum cost as the ultimate goal. When the market price affects their own benefits, they choose to default.

Figures 2–4 showed that internet infrastructure, information correlation and information timeliness of the platform cognition had no significant impact, but there were positive correlations (most groups had $OR < 1$) in the C2F. The reason may be that the income and cost of information acquisition affect the stability of benefit linking. The internet infrastructure was excellent (X_7, mean = 3.725), with most farmers basically having access to market and technology information by computer or mobile in a timely manner (X_{10}, mean = 3.482). The farmers' benefit linking decisions did not depend completely on the usefulness of information (X_8, mean = 2.929).

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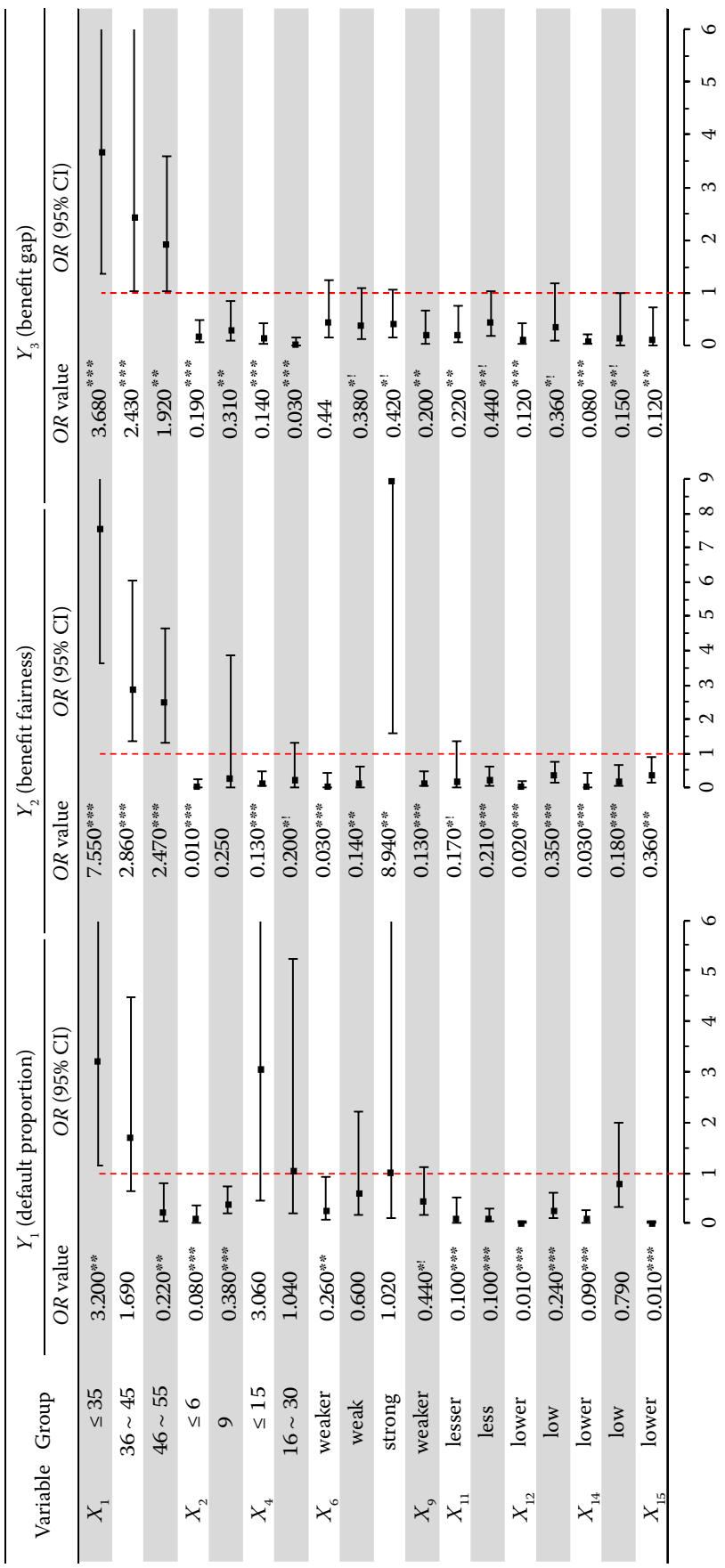

Figure 2. The significant impact factors influencing the stability of benefit links in C2F (company to farmer)

*, **, and *** indicate significance at 10, 5, and 1% level, respectively; ! – impact is not clear; $OR = e^{\beta}$; *OR* – odds ratio; CI – confidence interval of *OR*; X_1 – age (years old); X_2 – education (years); X_4 – income (thousand USD); X_6 – risk tolerance; X_9 – technical guidance effect; X_{11} – service quantity; X_{14} – policy support; X_{15} – market volatility

Source: Own calculations based on a survey by the authors

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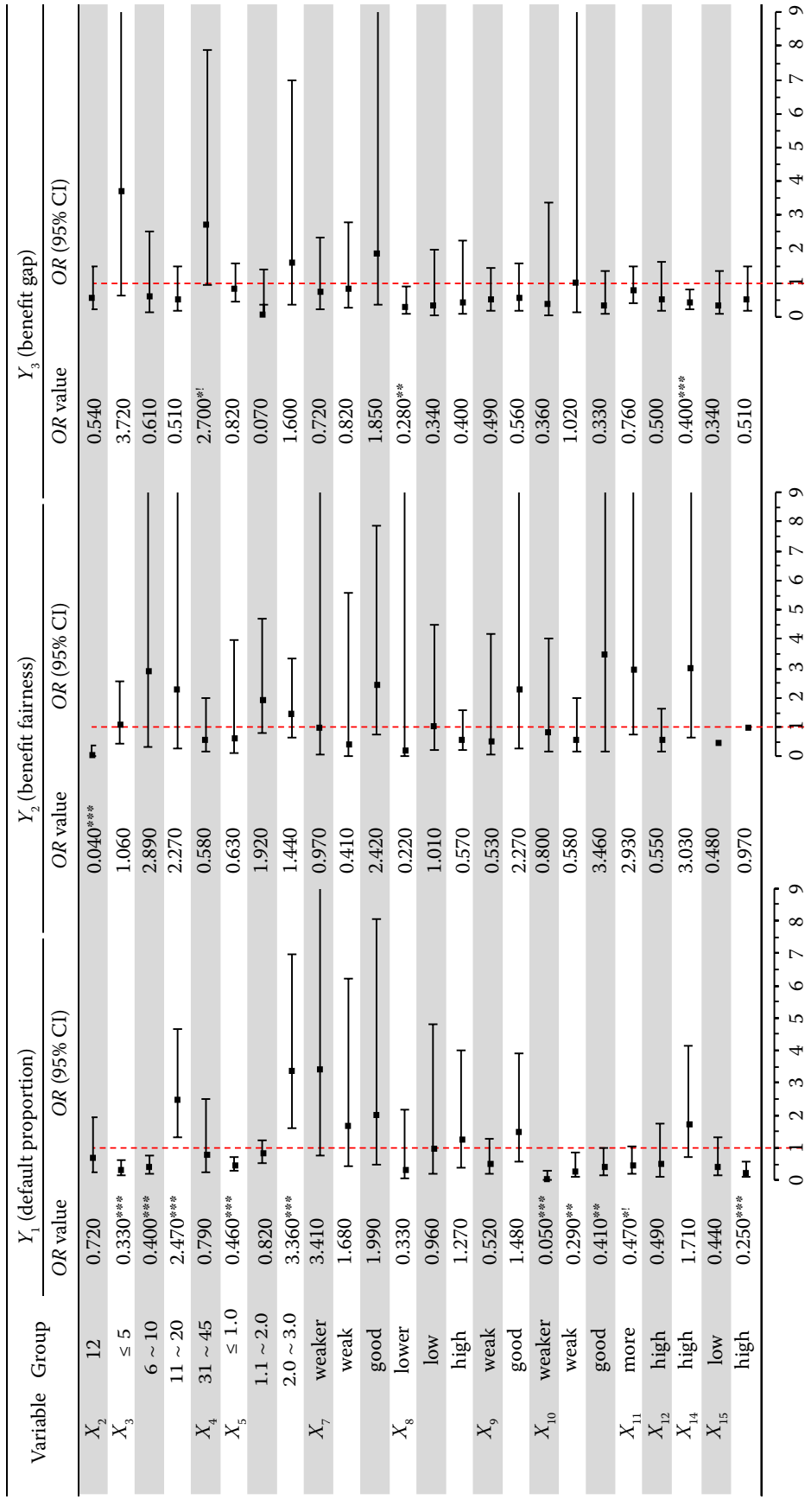

Figure 3. The impact factors non-significantly influencing the stability benefit links in C2F (company to farmer)

*, **, and *** indicate significant at 10, 5, and 1% level, respectively; ! – impact is not clear; $OR = e^{\beta_i}$; ; *OR* – odds ratio; CI – Confidence Interval of *OR*. X_2 – education (years); X_3 – labor quantity (people); X_4 – income (thousand USD); X_5 – farm size (ha); X_7 – internet infrastructure; X_8 – information correlation; X_9 – technical guidance effect; X_{10} – information timeliness ; X_{11} – service quantity; X_{12} – transaction transparency; X_{14} – policy support; X_{15} – market volatility

Source: Own calculations based on a survey by the authors

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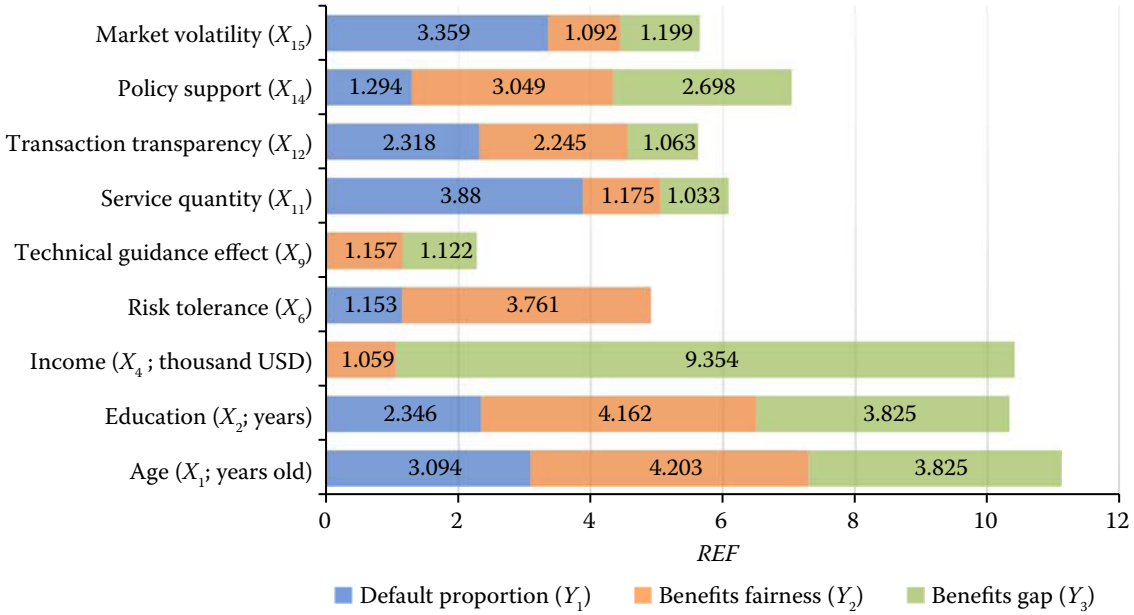

Figure 4. The Relative Effect Function (ERF) influencing the farms' benefit linking behavior stability in the C2F

Source: Own calculations based on a survey by the authors

Impact of farmers' characteristics on the benefit linking stability in the C2F

Figures 2–4 showed that the control variables such as the farmers' age, education, income, and risk tolerance, had a significant impact on the benefit linking stability, whereas the farm size and labor quantity had no significant impact on it. The groups (≤ 35 years old) and (46 ~ 55 years old) of age (X_1, mean = 2.538) had a significantly positive impact on default proportion (Y_1), benefits fairness (Y_2) and benefits gap (Y_3) (P < 1% or 5%, OR > 1), and the group (36 ~ 45 years old) had a significantly positive impact on Y_2 and Y_3 (P < 1%, OR>1). The group (≤ 6 years) of education (X_2, mean = 3.087) had a significantly negative impact on Y_1, Y_2 and Y_3 (P < 1%, OR < 1), and the group (9 years) had a significantly negative impact on Y_2 and Y_3 (P < 1% or 5%, OR < 1). The group (≤ 15 thousand USD) of income (X_4, mean = 2.512) had a significantly negative impact on Y_2 and Y_3 (P < 1%, OR < 1). The weak group of risk tolerance (X_6, mean = 3.504) had a negative impact on Y_1 and Y_2 (P < 5% or 5%, OR < 1).

The results indicated that farmers' characteristics of middle-aged, secondary education, middle income, and certain risk tolerance had the significant to benefit linking stability. With the improvement of income level, the overall age of farmers would be likely to decrease; the younger farmers have a broader mind, strong ability to learn and accept the new technologies related to the platform, and are more inclined to choose a stable way of benefit linking. The farmers' high education level was helpful in recognizing the cooperation and benefits linking with companies, which might have avoided market risks and enhanced understanding of how to increase benefits.

Relative impact effects on the farms' benefit linking stability in the C2F

Figure 4 showed the relative importance of the factors influencing the benefit linking in the C2F. The factors we considered were age (X_1, 17.93% – importance W), income level (X_4, 16.79%), education level (X_2, 14.33%), policy support degree (X_{14}, 11.35%), platform service quantity (X_{11}, 9.82%), market volatility (X_{15}, 9.11%), platform transaction transparency (X_{12}, 9.07%), risk tolerance (X_6, 7.93%), and the technical guidance effect of the platform (X_9, 3.67%).

For all the X_1, the total effect (REF = 17.446; REF is the Relative Effect Function of X_i to Y_j) of default ratio accounted for 28.13%. The relatively highly influential factors were age (X_1, REF = 3.094;), services quantity (X_{11}, REF = 3.880), and market volatility (X_{15}, REF = 3.359). The overall effect of benefit equity (Y_2) (REF = 21.904) accounted for 35.32%. For all the X_2, the relatively highly influential factors were age (X_1, REF = 4.203), education level (X_2, REF = 4.162), and risk-bearing capacity (X_6, REF = 3.762). The overall effect of benefit gap (Y_3, REF = 22.667) accounted for 36.55%. The relatively highly influential factors

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were income level (X_4, *REF* = 9.354), farmer age (X_1, *REF* = 3.824) and policy support (X_{14}, *REF* = 2.698).

CONCLUSION

We found that in the C2F, optimizing age structure of farmers, increasing farmers' income level, as well as improving farmers' education level, policy support, platform service quantity, market volatility, platform transaction transparency, farmers' risk tolerance, and platform technical guidance effect, had a significant influence on reducing default ratio, benefits gap, and heightening distribution equity, but the labour force, business scale of farmers, internet infrastructure, information relevance, and information timeliness had no significant impact on the benefit linking. The offer of the following suggestions.

Improve the digital ability of farmers in the C2F. The high-quality education training resources should be integrated into the C2F. According to the farmers' characteristics and the diversity and specificity of their needs, the special and systematic training should be carried out. Efforts should be made to create a good "situation", form a close "cooperation", launch a timely "dialogue" and cultivate new vocational farmers. Let farmers improve digital production and operation capacity in the future.

Optimize the mechanism of benefit linking in the C2F. Benefit distribution is the direct embodiment of the stable degree of benefit linking between farmers and companies, and should not be limited to the distribution of direct profits, the purchase of protection prices, and the provision of technical services and professional training for farmers, but also should take advantage of the platform's convenient, fast and efficient features and the powerful information collection functions to integrate resources and share values.

Increase the sharing service platform in the C2F. To form a sharing mechanism of integrating technological resources, we need to increase support for rural internet infrastructure, promote broadband access by villages and groups, narrow the digital divide between urban and rural areas, strengthen the construction of information chain, and build a big data service platform to link farmers and companies. The organization and the information-trading platform should be constantly improved. We should integrate the relevant agro-experts resources and create a "platform + to share technological resources".

Strengthen policy guidance in the C2F. The establishment of the benefits linking mechanism cannot be separated from the guarantee and support offered by the relevant policies. We need to improve the rights and obligations of each business entity in the development of agricultural industrialization, improve the legal norms of the agricultural product market on the internet platform, as well as effectively protect the benefits of farmers, companies and consumers regarding benefit distribution and benefit realization.

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