Modeling heterogeneity in preferences for organic rice in China: evidence from a choice experiment

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Abstract

Food certification is widely considered to be a promising approach to sustainable food production as it utilizes market forces, rather than direct intervention, to balance ecological, economic, and social benefits of farming. However, certification schemes have yet to penetrate major food production systems in many non-western countries. For example, certified organic rice is hindered by a lack of consumer trust and the high costs of conversion facing farmers in China. In this paper we explore the potential drivers of supply and demand for environmentally-friendly rice in China using the choice experiment. We find that there are significant differences in demand and supply economics: rice farmers pay more attention to attributes linked to taste and agronomy while urban consumers pay more attention to whether the rice is safe and healthy to eat. Furthermore, certified rice production from nature reserve is problematic as cultivation costs are high due to environmental restrictions and consumers are not especially concerned or aware about nature reserve designation in the context of rice production. We conclude that the best way to strengthen the certification and promotion of environmentally-friendly rice is through joint production with fish and other species such as frogs, as consumers have greater trust in biological indicators and farmers can also receive an additional income. In the long run, an integrated rice certification system based on green production technology and reliable "biological labels", could achieve major biodiversity benefits. However, additional conservation measures may still be required for fish/frog predators of conservation importance such as the endangered Oriental White Stork (*Ciconia boyciana*).

Keywords: Environmentally-friendly rice certification; Agricultural policy; Choice experiment; Biodiversity; Oriental White Stork

1. Introduction

The intensification of agriculture poses a huge challenge to biodiversity conservation because of land use conversion and intensification of agronomic practices (Lucia and Santiago, 2007; Norris, 2008; Hass et al., 2018; Florian et al., 2019). Although the importance of agri-biodiversity is recognised by international commitments and initiatives such as the Aichi Targets (CBD, 2019) and the United Nations Sustainable Development Goals (UN, 2019), implementation of sustainable farming approaches remains a significant challenge.

Traditional government intervention measures to protect agri-biodiversity such as regulation, voluntary codes of practice and environmental subsidy schemes have contributed significantly to the reform of agricultural policy in the EU and USA, but they are expensive to support (Uthes and Matzdorf, 2013; Monica, 2016; Kuhfuss et al., 2016; Gregory et al., 2018; Eoin et al., 2020). Developing countries such as China, whose policy continues to emphasize agricultural production and ambitious green reforms along the western model are not affordable (Li et al., 2015). Food certification is therefore increasingly considered to be a more viable long-term approach to sustainable food production as it is driven by market forces (consumer power), rather than direct financial intervention. Food certification has strong sustainability properties due to the dynamic efficiency of the market compared to government interventions (Wang and Meng, 2015; Aygun and Marcin, 2020).

Certification work by combing a technical strategy that favours ecology and biodiversity (Fischer et al., 2014), with an economic incentive from a market premium (Treves and Jones, 2010; Aaron et al., 2019), that can compensate for additional costs and ideally enhance livelihoods (Waldron et al., 2012). An environmentally-friendly food certification also can balance the ecological, economic, and social benefits of farming and enhances product competitiveness.

Rice is the staple food of China and many other Asian Countries (FAO 2003a, b), and green farming and certification standards for rice have recently been introduced, but it’s difficult for farmers with low incomes because of the high costs of conversion and consumption levels are low due to a lack of consumer trust (McKenzie et al., 2013; Satoshi et al., 2014; Roberta et al., 2020).

Our geographic focus is the Sanjiang Plain in Heilongjiang Province, China, which is the largest freshwater wetland in Asia. It is of international significance for bird conservation (Chen, 2018; Luo et al. 2020), but it is also strategically important for Chinese commercial grain production, with a cultivated land area of 63,470 km^2 (Li et al., 2020), managed by 52 state-owned farms (Wang et al., 2017). From 1954 to 2010, the wetland area in Sanjiang Plain shrank by almost 89%, from 37,713 km^2 to only 4,261 km^2 (see Fig. A.2 in the Appendix) with catastrophic effects on biodiversity (Liu et al., 2017). For example, the population of Oriental White Stork fell to less than 50 individuals by 1990 (Zhang, 2011). Through the establishment of nature reserves, the population has slowly recovered to around 1,000 (Peng, 2020), but the species remains critically endangered on the IUCN Red List (IUCN, 2020). However, in recent years, organic rice in the Sanjiang Plain has developed rapidly (see Fig. A.3 and Fig. A.4 in the Appendix). The breeding ground of this species, around the Honghe and Xingkai nature reserves in the Sanjiang Plain, has been identified as a key area for combining rice production with a rejuvenation of ecological function and wetland biodiversity under the "*National Strategic Plan for High-Quality Development of Agriculture (2018-2022)*".

The overall aim of this study is to provide quantitative data on the drivers of supply and demand for environmentally-friendly rice to understand how to develop the market. Specifically, we use the choice experiment to estimate and compare the preferences of consumers and farmers for specific attributes of environmentally-friendly rice that are of most relevance to rice farming and the environment. In this way, we hope to contribute to the development of a robust and resilient environmentally-friendly rice certification system that better reflects the interests of farmers, consumers and government, which also can drive ecological restoration and conservation through consumer demand. Our study contributes to the emerging literature on environmentally-friendly rice and certification (Yabe et al., 2014; Fiamohe et al., 2015; Carlos et al., 2018), but it is also novel in that we explore both preferences for consumers and farmers to explore supply and demand aspects.

2. Materials and methods

2.1 Research methods

Choice experiment is a survey based on stated preference environmental valuation technique that makes use of hypothetical, using realistic choices based on attributes of the good to infer respondents' preferences for that good. Each respondent is required to choose between 2 (and sometimes more) environmental goods, where all goods can be described by the same attributes. Respondents are assumed to behave as predicted by random utility theory (specifically Lancasterian consumer theory) and choose the good which they prefer most based on the levels of these attributes. Based on their responses, we can statistically infer information about which attributes have the most influence on consumers' choice and the implied ranking of these attributes (Louevere and Timmermans, 1990; Bersisa and Fayisa, 2020). Choice experiments have become firmly established as one of the main methods for estimating the value of environmental benefits of public policies including agri-environmental policies and biodiversity (Francisco et al., 2001; Hanley et al., 2010). The selected attributes and their levels used in this study were described in Table 1 and were guided by the relevant literature and policies context.

The questionnaire was composed of two parts. Part 1 contained questions about the respondents' gender, age, level of education, and annual household income. The level and code of respondents' basic conditions see Table A.1 in the Appendix. The choice experiment itself formed Part 2. To introduce the CE component, respondents were provided with some contextual information gleaned from the literature, together with relevant data on changes in wetlands and the number of storks in the Sanjiang Plain over the years (see Fig. A.2 to Fig. A.4 in the Appendix). Agricultural farming data was collected from the Heilongjiang Province Statistical Yearbook (Heilongjiang Bureau of Statistics, 2012-2019), and policy changes were taken from the official website of the government.

Table 1 Attributes and levels of choice experiment

Attributes	Levels and Code	
Organic	Organic=1 Non-Organic=0	Organic is widely recognized by consumers as indicative of high environmental standards and food safety, which also affects biodiversity (Wang et al., 2012).
Fish Farming	Yes=1 No=0	Fish farming has been practiced for centuries providing protein and supplementary income to rice farmers. Raising fish such as loach requires higher water quality and more intensive, careful management and is therefore associated with high quality rice (Claire et al., 2015; Berg and Tam, 2018; Ahmed and Garnett, 2011).
Nature Reserve	In Nature Reserve=1 Outside Nature Reserve=0	Large areas of land cultivated for rice have been incorporated into the Sanjiang Plain nature reserve. Rice grown in the nature reserve is managed more intensely to protect biodiversity, including storks (Li et al., 2020).

Taste	Good=1 Normal=0	Taste directly affects sales, a common concern of both rice farmers and urban consumers.
Price	5 CNY/500g (0.762 USD/500g) 7.5CNY/500g (1.143 USD/500g) 10 CNY/500g (1.524 USD/500g)	Price affects profits to farmers and purchasing behavior of urban consumers.

We used an orthogonal design to combine the attributes and levels in Table 1. As a Full Factorial Design would have produced large numbers of choices, we reduced the number of combinations by removing meaningless or obviously unreasonable choices to create 10 cards (see Fig. A.1 in the Appendix). Each questionnaire contained 5 choice sets, requiring respondents to make 5 choices between two kinds of environmentally-friendly rice.

2.2 Data collection

In June 2018, the rural survey, targeting rice farmers, was carried out in the rural areas of Honghe farm corporation, Xingkai Lake County and Fuyuan County (these sites around the Honghe and Xingkai nature reserve), Sanjiang Plain. In July 2018, the city survey, targeted urban consumers, was carried out in Beijing and Harbin. Face-to-face interviews were used to ensure that respondents could fully understand the questionnaires. Stratified random sampling was used to ensure that respondents with different age characteristics were evenly distributed.

2.3 Data analysis

We analyzed the data using LIMDEP NLOGIT 4.0. We first assessed the aggregate preferences of respondents using Random Parameter Logit (RPL). Although this model type allows for investigating how respondent characteristics impact preferences, it considers all respondents as a single group, which can obscure variations among smaller respondent sub-groups. These differences among sub-groups can be important when investigating issues such as attitudes to wildlife conservation, which can be highly diverse and polarized (Miao et al., 2020). To explore potential sub-group level heterogeneity in preferences, we also used Latent Class Modelling (LCM) (Boxall and Adamowicz, 2002). LCM is a particular form of logistic regression based on the standard random utility model, but which allows partitioning of the sample population into two or more homogeneous classes to allow explore heterogeneity in preferences (Boxall and Adamowicz, 2002; Adams, 2009). In LCM, the optimal number of classes are distinguished by balancing the Akaike Information Volume Criterion (AIC) and Bayes Information Volume Criterion (BIC) (Birol et al., 2006). See the Eq. (A.1) of supplementary material for the specific formula of the model.

3. Results

3.1 Respondents' socio-demographic statistics

In total, we analyzed data from 868 respondents. Out of 800 urban respondents who were given the questionnaires, 462 questionnaires were recovered (recovery rate of 57.8%), of which 450 were valid questionnaires. Of the 450 respondents from rural areas took part and 420 questionnaires were recovered (recovery rate of 93.3%), of which 418 were valid questionnaires. The recovery rate of rural areas is much higher than the urban areas, mainly due to the different pace of life, rural rice farmers have relatively more available time, and of course, the questionnaire was directly linked to their business as rice growers.

The socio-demographic statistics of respondents were fully described in Table A.2 in the Appendix. The proportion of rice farmers aged over 40 years old accounted for 62.1%, indicating an aging population in rural areas, while the age distribution of urban consumers was even. The percentage of farmers with an annual household income of less than 100,000 CNY (15,239 USD) was 80.4%. By contrast, the number of urban consumers with an annual income of less than 100,000 CNY was slightly lower (73.1%). Most urban respondents had attained an average educational level of high school, while most rice farmers were educated to middle school (see Table A.3 in the Appendix).

3.2 Rice farmers' preferences to environmentally-friendly rice

According to the chosen LCM, rural rice farmers were divided into three classes (Table 2). The model was selected based on the values of Bayesian information criterion (BIC) and Modified Akaike's Information Criterion (AIC) with 3 as penalty factor, which was the most conservative standard (Zhou et al., 2020). In this model, the test values of BIC and AIC gradually decreased as the number of categories increased, that is, the model was continuously optimized. The test value was the smallest when the number of categories was 3, and then gradually increased, so the best number of categories was 3 (see Table A.4 in the Appendix).

Based on the LCM, rice farmers in the largest group (LCM1), accounting for 56.6% of the total sample. LCM1 farmers had positive preferences for the organic attribute ($P \leq 0.1$), and this group also showed significant positive preferences for rice with "good taste” (P≤0.1), “high price” (P≤0.01), and “grown in the nature reserve” (P≤0.01). In addition, the preferences of LCM1 farmers had a significant positive correlation with age (P≤0.05).

The second category of respondents (LCM2) accounted for the smallest proportion of farmers (17.6%). This class of respondents had negative preferences for organic attribute (P≤0.05), and significantly positive preferences for the cultivation of rice with fish farming (P≤0.05). The third type of respondents (LCM3) took up 25.8% and showed significant preferences for growing rice with good taste (P≤0.01) in paddy fields in the nature reserve (P≤0.01).

Table 2 Estimation results of model parameter in rural areas

Attribute levels	MNL	LCM 1 Segment 1 (56.6%)	LCM 2 Segment 2 (17.6%)	LCM 3 Segment 3 (25.8%)
Alternative Specific Constant	0.14057	0.43910	-0.07049	-0.24044
	(0.12556)	(0.27763)	(0.64696)	(0.30999)
Organic	0.16655	0.59615*	-1.60422**	0.31957
	(0.15776)	(0.30590)	(0.72568)	(0.58155)
Fish Farming	-0.19865	-0.53798*	1.48661**	-0.63832
	(0.16022)	(0.31417)	(0.73097)	(0.52429)
Nature Reserve	0.49885**	1.85170***	-1.29785	1.59161***
	(0.20444)	(0.68689)	(1.68197)	(0.55232)
Taste	1.15533***	1.23576*	-0.25212	2.85203***
	(0.18428)	(0.64744)	(1.25016)	(0.49090)
Price	0.23241***	0.50249***	0.38089*	0.14086
	(0.03419)	(0.07046)	(0.19591)	(0.10187)
Gender		0.01652	-0.20051	
		(0.37004)	(0.48738)	
Age		0.45417**	0.36628	
		(0.19871)	(0.27582)	

Household	0.20980	0.32581
	(0.28538)	(0.43139)

Note: Multinomial Logit (MNL) and Latent Class Models (LCMs) were used to estimate the utility function of each attribute, with standard errors in brackets (confidence interval of 95%). $^{*}P≤0.1$, $^{**}P≤0.05$, $^{***}P≤0.01$

3.3 Urban consumers' preferences to environmentally-friendly rice

For urban consumers, the RPL estimates suggested that the "organic", "fish farming" and "price" attributes all had a very significant impact on their potential purchasing behaviors. Foremost, urban consumers had a significant inclination to consume organic rice (Beijing: *P*≤0.01; Harbin: *P*≤0.01) (Table 3). As expected, the parameter estimates of the price variables in Beijing and Harbin were both negative, indicating that the higher rice price, the lower the consumers' desire to buy (Beijing: *P*≤ 0.01; Harbin: *P*≤0.01). Taste and nature reserve were not significant attributes to consumers' choices.

Table 3 Estimation results of RPL model parameter in Beijing and Harbin

	Beijing		Harbin	
Choice	Coefficient	Standard Error	Coefficient	Standard Error
Alternative Specific Constant	-1.25275	0.14832	-2.86286**	1.28386
Organic	1.70078***	0.21341	0.88171***	0.21841
Fish Farming	0.60102***	0.20668	0.38825*	0.21767
Nature Reserve	0.241	0.14822	-0.857	1.28363
Taste	1.01175	0.12054	-0.1587	1.26933
Price	-0.45083***	0.09981	-0.38750***	0.1214
Gender	0.01402	0.03301	0.0128	0.05401
Age	-0.03417	0.05104	0.03505	0.32014
Household	0.02205	0.05904	0.05002	0.08471

Note: $^{*}P≤0.1$, $^{**}P≤0.05$, $^{***}P≤0.01$. McFadden Pseudo R-squared = 0.231. Attribute reference level: "non-organic", "no fish farming", "not in nature reserve", "taste normal", "female".

4. Discussion

4.1 Comparing preferences of urban consumers and rural farmers for environmentally-friendly rice

Coordinating the preferences of consumers and farmers is the key to successful environmentally-friendly rice certification. Results from the MNL model for the entire sample indicate that good taste, high prices, and farming in the nature reserve were all positively preferred by farmers. However, the analysis using the LCM model suggested preferences among farmers were diverse with contrasting preferences for some attributes of rice cultivation. Farmers in LCMs 1 and 3, comprising 82.4% of the total sample, shared highly significant and positive preferences for rice grown in the nature reserve and negative preferences for growing rice with fish farming. Cultivation inside the nature reserve was preferred because the majority of farmers noted "this kind of farmland has higher fertility, higher nutrient levels and organic matter". In addition, farming inside the nature reserve was eligible for financial compensation if they retired the land from cultivation - an attractive option for many aging farmers (Wang et al., 2012). Farmers in LCM3 had very strong preferences to grow rice with good taste, whereas LCM1 farmers were more positive with organic production.

Conversely, farmers in LCM2 had strong preferences for rice with fish farming and negative preferences for organic production. As rice with fish farming can use low-toxicity pesticides and additional fertilizer at specific stages, it is easy to contravene the organic standards (Simon et al., 2009), this is understandable. Moreover, LCM2 farmers had negative preferences for farming in the nature reserve and this is probably linked to conflict with other species of conservation interest such as the Oriental White Stork which predates fishes (Claire et al., 2015).

Preferences among urban consumers were quite consistent between Harbin and Beijing, with pisciculture, low price, and organic all positively preferred. A preference for organic production reflects global trend and recent online sales data of organic rice brands in China's domestic e-commerce platforms, such as Taobao, T-mall, and JD, where (in 2020 prices) suggest that the average price of organic rice is between 5-9 CNY/kg higher than ordinary rice.

Rice with fish farming was also positively preferred by both Harbin and Beijing residents. In the mind of the consumer at least, biological labels such as fish are maybe more directly linked to higher environmental quality than chemical standards or regulations. As many consumers noted during the survey "since fish can be farmed in rice fields, it means that the environment in which they live must be pollution-free". This may reflect concerns about labels and the sale of fake organic rice products (Roberta et al., 2020).

4.2 Challenges and opportunities for environmentally-friendly rice certification for the conservation of biodiversity

Our results explored the potential for developing an environmentally-friendly rice certification scheme to benefit the environmental recovery of the Sanjiang wetlands and the conservation of rare species such as the Oriental White Stork. While preferences among consumers were relatively consistent, farmers were diverse groups, with different preferences. Hence, any certification systems need to solve this heterogeneity by a variety of means, such as education, subsidies, and technologies, will have to be deployed to encourage most farmers to join (Norzanalia et al., 2018).

Organic rice is the most strongly preferred option by consumers, but support among farmers was weaker and ambiguous with farmers in LCM2 (Table 2). Organic rice cultivation requires adherence to strict requirements of organic rice cultivation, but the “immature organic cultivation technology, increased costs, and unstable prices and sales" (Wang et al., 2012; CNCA, 2014) also contribute to significant resistance among farmers in LCM2. Undoubtedly, the loss of income in the early years during conversion and the greater bureaucracy involved are important barriers to adoption (Xu et al., 2021), and considerable investment will be required by the government to support conversion in the short term. Most of the land in the Sanjiang Plain is not suitable for immediate organic production due to the intense use of pesticides and herbicides historically and it is likely that the soil would take a minimum of 3 years to restore before organic standards could be achieved (Qin, 2015).

Organic conversion is currently supported in China as part of China’s long running supply side reforms. In addition, “*Organic Food Certification Standards”* and an organic traceability mechanism have existed since 2004 (Fig. A.5 in the Appendix). Financial support includes a minimum purchase price guarantee system and many technical regulations, but more support is necessary. For example, the establishment of ecological farmer associations can conduct outreach activities to improve their ecological and business awareness (Thu et al., 2020). There are more innovative collaborations between commercial outlets (Aditya et al., 2018), and the government will also help to reduce costs and bureaucracy with regard to sale and cultivation (Wang et al., 2012). In Japan, facing a similar situation, a staged certification process was introduced. In the first stage, farmers were required to reduce chemical fertilizers and pesticides by 20% to achieve intermediate certification and more stringent conditions were applied thereafter (Qin, 2015).

Our study and other research have revealed that consumers lacked trust in the certification system, with a number of consumers expressing some concern about fake organic rice products and general lacked confidence in existing organic certifications and labels (Jin, 2016; Zhou et al., 2017). The concern is widespread in Asia. For example, Nguyen (2018) found that Vietnamese consumers were reluctant to purchase organic products due to insufficient certification information displayed. Until sufficient confidence in certifications including production standards, quality assurance, and origin traceability exists, organic demand is likely to be suppressed. Additional measures taken in the EU's agricultural product certification system to bolster consumers' confidence (Meike and Ulrich, 2012; Albuquerque et al., 2018), such as a third-party certification system and legal protection may also be required (Zhao et al., 2019).

A joint production system of fish (or other species such as frogs or crabs) and rice would appeal to the majority of farmers and consumers, because one of the main advantages of the rice with fish farming model has the high level of trust among consumers for "biological labels" compared to organic labels (Zhou et al., 2017). In Heilongjiang Province (where the Sanjiang wetlands are centred), the area of pisciculture has increased from 80 km^2 in 2013 to 592 km^2 in 2019 (Huang, 2019), and it has been estimated that participating farmers have increased their income by more than 8,000 CNY per hectares as a result (Kong et al., 2018). Other measures adopted by major rice producing organizations, such as the Honghe Farm Corporation (around the Honghe nature reserve), which signed long term contracts with cereal companies and actively introduced equipment and technology to farmers to reduce the costs. Another innovation is the introduction of the Taiwan eel loach (*Chaudhuria caudata*) rather than ordinary loach, referred to as “ginseng in water”, which requires higher water quality, but delivers a higher yield per hectare (Du, 2018).

However, several issues need to be resolved if pisciculture is to play a major role in biodiversity conservation through certification. The main problem arises from the use of nets to protect the fish from predation by endangered species such as the Oriental White Stock. A subsidy from the government may therefore be required in the early stages of certification to incent net removal for conservation. Alternatively, other measures could be implemented such as scaring to reduce predation levels, although the impacts on fish populations and storks would have to be monitored carefully. In the long run, subsidies could be phased out if the environmentally-friendly pisciculture rice certification scheme generates additional income to the farmers.

We found that consumers were not significantly affected by location inside or outside the nature reserve. This could be because the stork is not as high profile as species such as the Giant Panda, and also because the link between biodiversity and food production is a relatively new concept for Chinese consumers (Christoph and Christian, 2020). In other words, consumers think that wildlife conservation and rice farming are two different concepts. An ambitious educational program directly focusing on the food-biodiversity nexus is therefore necessary if an environmentally-friendly rice certification system is to be successful in China. Ultimately, it would be desirable to add an ecological or conservation element to certification, such as the density of aquatic species, the Oriental White Stork (Hardman et al., 2016). These indicators must be easy to measure and operate by suppliers (Irene et al., 2019; Lukas et al., 2020), and they must be rigorous to bolster consumer confidence in a country like China where consumers' confidence is very low. Expansion of such a system could bring substantial conservation benefits and could be promoted among farmers through activities like seminars and payments to remove the netting.

Another way to increase consumers' awareness about storks and biodiversity conservation generally would be to develop farm tourism whereby urban consumers are attracted to visit the nature reserve to view the storks and obtain first-hand experience of growing environmentally-friendly certified rice. Eco-tourism ventures are operating around the world with some success and within the Chinese nature reserve system there is a considerable opportunity for nature reserves to combine conservation with innovative agricultural products, agronomy and eco-tourism (Adenekan, 2017; Ziphozakhe et al., 2020).

In the future, environmentally-friendly rice certification schemes could also enhance conservation by contributing a small percentage of the price to conservation, such as building artificial nests for storks (Duan et al., 2010). In 2018, the output of organic rice in Heilongjiang Province was 628,700 tons (data from Heilongjiang Statistical Yearbook 2019), and assuming that whenever a consumer buys a 10kg bag of rice at a cost of 150 CNY, and if only 0.1 CNY was donated to stork conservation, this would raise approximately 6.3 million CNY/year. This approach would probably target consumers with high income, who already demonstrate a preference for high-quality products with high prices (Huynh and Mitsuyasu, 2015; Su, 2016). Such a differentiation based on income would restrict the market potential but help enhance the premium achieved by stork-friendly rice (Fredrik et al., 2010).

In summary, our research suggests that an environmentally-friendly rice certification system has considerable potential to reshape the biodiversity-livelihoods-agriculture nexus in China (Jackson, 2007; Groeneveld et al., 2018). Although environmentally-friendly rice certification systems may not accommodate full heterogeneity among farmers and consumers, it would strengthen the links between them for the benefits of the economy and environment if appropriately designed. By investigating both farmers' and consumers' preferences for environmentally-friendly rice products, we have demonstrated that large scale expansion could be achieved by investment in the robust and verifiable certification of both organic rice and fish farming. An integrated rice certification system based on green production technology and reliable "biological labels", will effectively complement government regulatory approaches in terms of meeting biodiversity conservation, further measures such as the removal of bird netting, the education of farmers, and impacts on agri-biodiversity will also be desirable (Moon et al., 2002; Veronika, 2013). Despite the current issues concerning consumers' and farmers' confidence, the chance of success in China may be higher than elsewhere due to the Chinese agricultural system as it still offers significant price support to rice farmers (e.g. minimum price guarantees) and hence is suited to mitigate the large financial risks that farmers convert to more environmentally-friendly farming systems.

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