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Asymmetric price effects on food demand of rural households: Panel evidence from China

Jiaqi Huang [a,b,*], Gerrit Antonides [b], Fengying Nie [a]

[a] Agricultural Information Institute, Chinese Academy of Agricultural Sciences, Mail: 12 Zhongguancun South Street, Beijing 100081, PR China
[b] Urban Economics Group, Department of Social Sciences, Wageningen University, Mail: Hollandseweg 1, Wageningen 6706 KN, the Netherlands

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ABSTRACT

This study aims at detecting asymmetric price effects on food demand for rural households and compares different specifications for including reference prices in demand models. Different from the standard demand model, asymmetric price effects on food demand imply that households react stronger to price increases than price decreases as compared with the reference price. This study tests for asymmetric price effects on food demand separately for pure consumers and farmers in rural areas for the first time. Using three waves of a rural household panel survey in six poor counties of China, this study shows asymmetric price effects on demand for rice and potatoes for pure consumers, and for pork for farmers. Comparisons of different methods of specifying the reference price in demand models show that the model adding price increase and price decrease terms to the standard demand model has a coherent foundation in demand theory and incorporates both acquisition and transaction utility. Although this model had a slightly better fit to the data than the segmented price model—separating people facing price decreases from people facing price increases—it hardly showed evidence of asymmetric price effects. Asymmetric price effects were mostly found to be significant in the segmented price model. Taking into account asymmetric price effects in food demand analysis uncovers the complexity of the mechanism of price effects on demand under different price change directions and may be helpful in estimating less biased price elasticities. Possible causes of mixed asymmetric price effects for different food items and different types of households are discussed.

1. Introduction

Consumer food demand analysis is often offered as a research tool to provide an empirical basis for designing food policies. Price elasticity, for example, is usually estimated to know how food demand will be influenced by food price (Robles, Torero, & Cues, 2010; Ecker & Qaim, 2011; Rudolf, 2019). Food demand analysis based on standard demand models all assume that the price effect on food demand is symmetric, which means that price elasticity is the same in situations of price increase and price decrease. However, asymmetric effects on demand under different directions of price change has been observed in reality, and particularly consumer demand decreases more to a certain level of price increase than demand increases to an equivalent level of price decrease (Kalwani, Yim, Rinne, & Sugita, 1990; Hardie, Johnson, & Fader, 1993; Neumann & Böckenholt, 2014). General *loss aversion* theory (Kahneman

* Corresponding author at: Agricultural Information Institute, Chinese Academy of Agricultural Sciences, 12 Zhongguancun South Street, Beijing 100081, PR China.

E-mail address: huangjiaqi@caas.cn (J. Huang).

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& Tversky, 1979; Tversky & Kahneman, 1991), proposing that, based on a certain reference point, people are usually more sensitive to changes than to the absolute level of their circumstances, and also more sensitive to negative changes (*losses*) than to positive changes (*gains*), has been offered as an explanation. Ignoring the asymmetric demand pattern of consumers under the symmetric demand assumption in standard demand models may lead to misunderstanding of people's reaction to price changes and to biased estimation of price elasticities (Putler, 1992; Bijmolt, Heerde, & Pieters, 2005; Biondi et al., 2020).

Asymmetric price-effect studies often appear in the marketing literature on consumer choice models (Kalwani et al., 1990; Mayhew & Winer, 1992; Bell & Lattin, 2000), but are very limited in the economics literature. Putler (1992) was the first incorporating loss aversion theory into classical microeconomic demand theory, providing a theoretical basis for empirical demand analysis of modeling reference price effects. We found some studies focusing on asymmetric price effects, particularly on demand for food and drinks (Putler, 1992; Krishnamurthi, Mazumdar, & Raj, 1992; Hardie, Johnson & Fader, 1993; Maynard & Subramaniam, 2015; Talukdar & Lindsey, 2013; Yan, Tian, Heravi, & Morgan, 2016; Biondi et al., 2020). However, the results differed across the studies. Some showed food demand to be more sensitive to price changes when prices go up than when prices go down, while others showed no significant asymmetric price effects, or even reverse effects (a price decrease having a greater impact than a price increase).

Mixed empirical results have stimulated research on explaining heterogeneity in asymmetric price effects. Besides loss aversion, the current literature shows that asymmetric price effects may be caused by product categories (e.g., healthy/unhealthy, durable/non-durable, Talukdar & Lindsey, 2013), stockpiling (Maynard & Subramaniam, 2015), habits and general consumer heterogeneity (Bell & Lattin, 2000), reference price operationalizations (Mazumdar & Papatla, 2000), and analysis methods (Neumann & Böckenholt, 2014). Also, the robustness of the application of loss aversion has been challenged. For example, for small-to-moderate losses, loss aversion does not emerge (Yechiam, 2019; Gal & Rucker, 2018), or is even reversed (Harinck et al., 2007). Loss aversion behavior generally emerges where gains and losses are presented separately but not when presented concurrently (Yechiam & Hochman, 2013). These exceptions are explained by the attentional-allocation model, in which "*losses have a distinct effect on attention but do not lead to an asymmetry in subjective value*" (Yechiam & Hochman, 2013, p. 498).

Based on a meta-analysis of loss aversion in product choice studies (Neumann & Böckenholt, 2014), the analysis method was strongly associated with the magnitude of estimated loss aversion effects, which explained about 57% of effect variation across studies. We notice that, in general, the relevant studies use two ways of specifying reference prices in the model, which may reflect different psychological processes of price impact on purchases. One is called the segmented price model, using the comparison of present price and reference price to segment people into two groups, experiencing either losses or gains, then comparing the price elasticities of the two groups (see methods in Yan et al., 2016; Talukdar & Lindsey, 2013). This model is based on the standard demand model, assuming that people make decisions by evaluating the current price, and just comparing people's demand given the present price effect under loss/gain situations. The other model includes both the present price effect and price difference effects by adding the difference of reference price and present price to the standard model, which implies that present price will have a direct effect on consumption, and price differences (losses or gains) may have an additional effect (see methods in Putler, 1992; Biondi et al., 2020). This model relies on Thaler's distinction between acquisition utility and transaction utility (Thaler, 1985). The magnitude of transaction utility depends on the comparison of the present price and the reference price. This idea stems from and is consistent with prospect theory (Kahneman & Tversky, 1979). Different from the segmented price model, the model incorporates the price difference effect assuming that people pay attention to price differences, and further investigates whether there is any asymmetry in response to deviations of present prices from reference prices. How different ways of modeling reference price effects in demand models have influenced the results is not clear; to the best of our knowledge none of the previous related studies made such comparisons.

The limited previous research on asymmetric price effects of food consumption has focused on pure consumers in urban areas of developed countries. It is not clear whether asymmetric price effects also apply to farmers, who are both food consumers and producers. It is likely that, compared with pure consumers, farmers react even stronger to price increases than to price decreases, because price increase represents a profitable situation for farmers, so they sell more products for higher income and consume less of their own produce. However, it is hard to tell whether they perceive a price increase as a more favorable or a more unfavorable situation for a certain kind of product.

In this study, we incorporate asymmetric price effects in demand models to explore possible asymmetric food demand patterns using a three-wave household panel survey of rural households in poor counties of China, where micronutrient deficiency is prevalent (Luo et al., 2011; Wong et al., 2014). This study differs from previous studies in the following ways: first, we apply different ways of modeling reference prices in demand models and compare the results within our study. Second, unlike previous research focusing on pure consumers in urban areas of developed countries, this study focuses on rural households in poor areas of a developing country. Third, a further comparison of asymmetric food demand patterns of pure consumers and farmers (who are both food producers and consumers) is conducted and discussed. Incorporating possible asymmetric price responses in food demand analysis is helpful to understand the complexity of price-change effects and may yield less-biased estimated price elasticities of different food items, which may be helpful in designing food policy tools to improve diets and nutrition of malnourished people.

The remaining sections are structured as follows. First we review related studies of asymmetric price effects on food demand, and elaborate the different methods of specifying reference prices. Next, we describe the method used, including data and models selected. This is followed by the estimation results for different food items, for pure consumers and farmers, and for different model specifications. We conclude with a discussion of the implications, limitations, and future research recommendations.

2. Literature

Loss aversion theory is widely applied to study the effects of reference prices on consumer choice (Neumann & Böckenholt, 2014).

The theory has been applied to a wide domain of consumer choices, ranging from consumption of frequently-purchased non-durable goods like food (Hardie, Johnson, & Fader, 1993), tissues (Mazumdar & Papatla, 2000), and less-frequently-purchased durable goods such as computers (Kivetz, Netzer, & Srinivasan, 2004), hardware (Ray, Shum, & Camerer, 2015), and even real estate (Habib & Miller, 2009), to services like energy use (Adeyemi & Hunt, 2007), telephone calls (Bidwell, Wang, & Zona, 1995), transportation (Hess, 2008), traveling (Nicolau, 2011), and healthcare (Neuman & Neuman, 2007).

However, the application of loss aversion in demand analysis is sparse. Putler (1992) was the first to incorporate loss aversion theory into classic microeconomic demand theory, integrating transaction utility derived from a comparison of reference price and actual purchase price into the utility function, thus providing a theoretical basis for empirical demand analysis. He studied how price changes in different directions affect consumers' quantities purchased rather than just consumers' decisions to purchase or not (Maynard & Subramaniam, 2015).

Only a few studies incorporating asymmetric price effects into demand models were found, particularly with respect to food (Putler, 1992; Krishnamurthi et al., 1992; Maynard & Subramaniam, 2015; Talukdar & Lindsey, 2013; and Yan et al., 2016). In this section, we first review the general findings of asymmetric price effect in food demand, then explain and compare different methods of modeling reference price in food demand analysis.

2.1. *General findings of asymmetric price effect in food demand analysis*

Asymmetric price effect in food demand, implying that people's food demand reacts stronger when prices increase than when prices decrease, is not a universal phenomenon. In previous studies, asymmetric price effect, or loss aversion effects as the researchers usually used in the literature, have been found in demand for eggs (Putler, 1992, but only when using the translog demand model), broccoli, grapes, raisins, and whole-grain bread (Talukdar & Lindsey, 2013), which are classified as healthy food, and nutrition-beneficial unhealthy foods (like low-sugar biscuits, and low-fat cream) (Yan et al., 2016). However, reverse loss aversion effects (a price decrease having a greater impact than a price increase) were found for unhealthy foods like beef, soft drinks, and potato chips (Talukdar & Lindsey, 2013). This phenomenon is rooted in the fundamentally different perceptions of palatability for unhealthy and healthy food (Raghunathan, Naylor, & Hoyer, 2006). For healthy food, when price increases, the decreased quantity demand is reinforced by the impulse to underconsume; when price decreases, the increased quantity demand is counteracted by the impulse to underconsume (Wansink & Huckabee, 2005).

Reverse loss aversion effects were also found for coffee when it was out of stock (Krishnamurthi et al., 1992), and for cheese, butter, and margarine, since these are foods that can keep fresh for several weeks which may trigger consumers' stockpiling behavior in situations of price decrease (Maynard & Subramaniam, 2015). The explanation they offered was that sellers provide consumers with more reference price information when lowering their prices, but not when raising prices. So, consumers more easily noticed price decreases, triggering them to store goods. It is natural that people stock up and buy larger quantities when there is a deal and hold down stock when price increases. This behavior will lead to an observed reverse loss aversion effect. However, they did not compare food that can be kept for a longer time with more perishable food.

2.2. *Different methods of modeling reference price in food demand analysis*

Although all studies mentioned above focus on the same question of whether and to what extent the price effect on food demand is asymmetric when price goes up or when price goes down, they use different ways of specifying reference prices in the model. Here, to simplify the comparison of how scholars specify reference prices differently in the model, we do not give the detailed demand model specifications they used, but we present general formulas with "*d*" representing food demand quantity (either in absolute or in log terms) as the dependent variable on the left-hand side of the equations, and different forms of specifying reference price effects on the right-hand side used in different studies.

The standard demand model (Model 1) can be stated as:

$$d_{it} = \alpha + \beta lnp_{it} + \sum_{c=1}^{C} \sigma_c x_{ict} + \varepsilon_{it} \tag{1}$$

where

d_{it} denotes the food consumption quantity of consumer *i* at time *t*;

lnp_{it} denotes the log of price of the food item of consumer *i* at time *t*;

x_{ict} denotes other independent variables *c* associated with consumer *i* at time *t* (*C* being the number of these variables);

ε_{it} denotes the error term;

α, β, σ_c are parameters to be estimated.

Yan et al. (2016) and Talukdar and Lindsey (2013) employ a segmented price model (Model 2) by constructing a dummy variable "D" representing whether a consumer experiences a loss (one segment of the population) or a gain (a different segment of the population) by comparing present price and reference price, and then multiply the dummy variable with logged present price to get the segmented logged prices as follows:

$$d_{it} = \alpha + \beta_1 \mathrm{D}_{it} lnp_{it} + \beta_2 (1 - \mathrm{D}_{it}) lnp_{it} + \sum_{c=1}^{C} \sigma_c x_{ict} + \varepsilon_{it} \tag{2}$$

where

$D_{it} = 1$, if present price > reference price, consumer i experiences a loss at time t;

$D_{it} = 0$, if present price < reference price, consumer i experiences a gain at time t.

The definitions of the other symbols are the same as in (1). In this way, they estimate the own-price elasticity when people experience gains or losses separately and test whether the price elasticity in one case is significantly larger than in the other case (testing if $\beta_1 > \beta_2$).

Different from Model 2, Putler (1992) refers to an underlying theory of demand based on Thaler's distinction between acquisition utility and transaction utility (Thaler, 1985). Putler (1992) derives the Marshallian demand function from a hypothesis of monotonic utility loss and gain functions defined by the difference between actual price and reference prices. He adds price increase and price decrease terms in addition to the standard demand model by calculating the difference between logged reference price and logged present price, and multiplying the dummy variable "D" of experiencing loss or gain with the difference term, as follows (Model 3):

$$d_{it} = \alpha + \beta lnp_{it} + \alpha_1 D_{it}(lnp_{it} - lnp_{it-1}) + \alpha_2(1 - D_{it})(lnp_{it-1} - lnp_{it}) + \sum_{c=1}^{C} \sigma_c x_{ict} + \varepsilon_{it} \tag{3}$$

where lnp_{it-1} denotes the log-price of the food item of consumer i purchased at time $t-1$. The definitions of other symbols are the same as in (1). He assesses asymmetric price effects by testing whether α_1 and α_2 are jointly different from zero, and whether the magnitude of α_1 is significantly larger than α_2. The same type of model was proposed by Vande Kamp and Kaiser (1999) for testing asymmetric effects of advertising on demand of fluid milk in New York City. A more recent study indicates that the model proposed by Vande Kamp and Kaiser (1999) can be readily extended to a model for testing asymmetric price effects (Maynard & Subramaniam, 2015), and the extension is the same as Model 3.

The price increase and price decrease model (Model 3) implies that present price will have a direct effect on consumption, and price differences (losses or gains) may have an additional effect. How different ways of modeling reference price effects on demand models have influenced the results is not clear, to the best of our knowledge, none of the previous related studies made such comparisons.

3. Method

3.1. Data

The study used a three-wave set of household panel data (August of 2012, 2015, 2018) from the "Rural China Poverty and Food Security Household Longitudinal Survey" collected by the Agricultural Information Institute of Chinese Academy of Agricultural Sciences. This dataset was gathered from face-to-face interviews in six poor rural counties of three provinces (Shaanxi, Yunnan, Guizhou) in China. The six counties were first selected from the poorest group of 572 National Poor Counties based on viability. In each county, 19 villages were selected using the probability-proportional-to-size (PPS) method, and in each village, 12 households were randomly selected. The total sample size for each wave was 1368 households in 114 villages. A total number of 4107 observations in all three waves were collected from 2127 households. The dataset included household information on food consumption (consumption amount, purchase price, expenditure on staple foods, animal-sourced foods, and other foods), production, market access, and demographics.

3.1.1. Food consumption and price

Regarding the questions on food consumption, a self-reporting recall method was used, using a recall period of 30 days. All specific food items the household consumed in the past 30 days were recorded by asking "How many kilograms of X (a specific food item) has your household consumed in the past 30 days?" Also, the question of "From the total consumption of X (a specific food item), how many kilograms were from purchasing from the market and how many kilograms were from self-production?" was asked for recording consumption quantity from different sources: market purchases and self-production. Following this question, we continued to gather the actual purchase price by asking "For the purchased X (a specific food item), how much did you pay for a kilogram?" For "farmers" who did not purchase a certain food item from the market, we first asked for the market purchase price. If the household could not answer it, we then replaced missing values of purchase prices with the mean of valid reported purchase prices within the same village.

3.1.2. Pure consumers and farmers

From the information on consumption quantities from market purchases and from self-production, we identified "pure consumers" of a certain food item as households whose consumption of this food item was only from market purchases. "Farmers" were identified as households whose consumption of this food item was partly or entirely from self-production.

In order to have substantial numbers of pure consumers and farmers, we chose food items that were commonly consumed and also commonly produced in the survey areas. Those food items were rice, potatoes, and pork. Households who did not consume rice, potatoes, and pork were excluded in the estimation of demand for each food item. Our study included a total of 3418 observations for pure consumers (80.0%), and 856 observations for farmers (20.0%) in three waves for the estimation of rice demand, 1417 and 2342 observations for pure consumers (37.7%) and farmers (62.3%) of potatoes, and 1,619 (47.3%) and 1801 (52.7%) observations for pure consumers and farmers of pork, respectively.

3.1.3. Reference price operationalization

The surveys were conducted with a time lapse of three years. Rice and potatoes are both crops harvested once a year in the survey area. Due to seasonal farm work and selling activities, rural households were well aware and very knowledgeable of seasonal price differences, and most likely to compare the present market prices of commonly produced and consumed food with those in the same period in the previous year. This comparison takes into account the price differences caused by seasonality. Therefore, we used the purchase price of the survey month of one year ago as the reference price, in line with the idea of using past prices as reference prices in most previous studies. However, pork is not a seasonal product, but due to the price data constraint, and in order to be consistent with the analysis of the other two food products, the reference price operationalization of pork is the same as for rice and potatoes.

To obtain reference prices of one year ago, we used the Rural Consumer Price Indices by Food Category and Region in China to deflate these prices to get the purchase prices of rice, potatoes, and pork in 2011, 2014, and 2017 as the reference price.

The descriptive statistics of household consumption, purchase price, and reference prices of rice, potatoes, and pork as well as other independent variables are shown in Tables A1–A3 in Appendix 2.

3.2. Analysis

We applied fixed effect regressions in double-log demand form with three different model specifications for each of the pure consumer sample, and the farmer sample separately. Demand for rice, potatoes, and pork was estimated separately (18 regressions in total). The reasons for method choice and definition of different model specifications are explained below.

We chose to use fixed effect models (FE) after conducting a heteroskedastic-robust and cluster-robust version of Hausman's test (Arellano, 1993; Wooldridge, 2002, pp. 290-91), which was implemented by code "xtoverid" in STATA 15.0 (Schaffer & Stillman, 2016). From the robust Hausman tests of the 18 estimates, all rejected the null hypothesis that no correlation existed between the independent variables and unobserved individual household effects at the 0.05 significance level (see the row of "Sargan-Hansen statistic" in Tables 1–3), indicating that it was appropriate to apply FE in our case.

We chose a simple double-log demand form for our estimations for the following reasons: first, the coefficients of log-price have an economic meaning of price elasticity, which makes it very easy to compare the price elasticities in situations of price increase and price decrease. Second, one purpose of our study was to discuss how different ways of specifying reference prices in the model would influence the judgment of asymmetric price effects. The feature of not having to put restrictions on parameters of the double-log model served this purpose well.

As discussed in Section 2.2, previous studies basically used two ways to incorporate reference price information: segmented price (see (2)), and price difference terms (gains and losses) in addition to the price effect (see (3)). We estimated double-log demand models in both ways of incorporating reference price information, and we also estimated standard double-log demand models (see (1)) as the baseline model for comparative purposes. The three empirical models were specified as in Appendix A.

In Model 2 (segmented price model), we tested asymmetric price effects on demand by testing whether β_1 was significantly different from β_2. Since β_1 and β_2 both indicated own-price elasticity, they were expected to be negative. If β_1 and β_2 were both negative and the absolute value of β_1 was significantly larger than the absolute value of β_2, it meant that households had larger own-price elasticity when experiencing losses than when experiencing gains, indicating loss aversion with respect to price changes.

In Model 3 (price increase and price decrease model), we tested asymmetric price effects on demand by comparing α_1 and α_2— the coefficients of difference of logged price and logged reference price when household experienced a loss or a gain, respectively. α_1 was expected to be negative and α_2 was expected to be positive. If α_1 and α_2 both were in the expected direction and the absolute value of α_1 was significantly larger than the absolute value of α_2, it meant that in addition to a present price effect, households reacted stronger to proportional price changes when experiencing losses than when experiencing gains.

4. Results

Tables 1–3 show the estimated coefficients, goodness of fit, robust Hausman's test results, and statistical tests for asymmetric price effects for the fixed effect models of the demand for rice, potatoes, and pork, respectively. We begin by reporting our findings on asymmetric price effects for different food products by pure consumers and farmers, followed by the comparisons of different model specifications.

4.1. Asymmetric price effects for different food items for pure consumers and farmers

The standard model (Model 1) does not allow different coefficients for price increases and price decreases. The coefficient of the log of present purchase price in Model 1 estimated the base-level own-price elasticity, which was negative and significant for both pure consumers and farmers for all three products, consistent with the law of demand. Pure consumers and farmers showed different price effects on food demand. Generally, farmers were more sensitive to price. Without considering asymmetric price effects (estimated by Model 1), farmers showed higher price elasticity than pure consumers for rice (farmers: -0.644, $p = 0.000$; pure consumers: -0.601, $p = 0.000$), potatoes (farmers: -0.254, $p = 0.000$; pure consumers: -0.214, $p = 0.027$), and pork (farmers: -0.658, $p = 0.000$; pure consumers: -0.504, $p = 0.000$).

As for asymmetric price effects, the results of Model 2 show that the coefficient of the log of present purchase price for households who experienced a loss was higher than that for households who experienced a gain for pure consumers of all three food items (see the rows of β_1 and β_2 in Tables 1–3), and for farmers of rice and pork, indicating that households were generally more sensitive to price if they were in a loss situation than if they were in a gain situation, as expected from loss aversion theory. However, the significance of asymmetric price effects in situation of losses and gains differed by food item and by type of household. For rice and potatoes, pure consumers showed statistically significant asymmetric price effects. The price elasticity in the case of a price increase for pure consumers was − 0.578 ($p = 0.000$) for rice and − 0.237 ($p = 0.012$) for potatoes, whereas in the case of a price decrease it was − 0.540 ($p = 0.000$) for rice and − 0.082 for potatoes, the difference being significant at $p < 0.01$ and $p < 0.05$ (see results of row "Test $\beta_1 = \beta_2$" in Tables 1–3) respectively, consistent with the loss aversion hypothesis. These significant asymmetric price effects were only found for pure consumers of rice and potatoes, not for farmers. However, farmers showed significant asymmetric price effects in their demand for pork, with a price elasticity of − 0.608 ($p = 0.000$) in case of a price increase and − 0.582 ($p = 0.000$) in case of a price decrease ($p < 0.01$). The price effects of pure consumers of pork were not significant.

To sum up, for the pure consumers, significant asymmetric price effects on demand were found for rice and potatoes. For the farmers, significant asymmetric price effects were only found for pork.

Table 1
Estimated coefficients, goodness-of-fit, and statistical tests for the fixed effect models of the demand for rice of pure consumer sample, and farmer sample by different model specifications.

	Rice pure consumers (80.0% of total)			Rice farmers (20.0% of total)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Log of rice price	−0.601***		−0.560***	−0.644***		−0.466**
(β)	(0.05)		(0.07)	(0.15)		(0.17)
D*Log of rice price[a.]		−0.578***			−0.617***	
(β_1)		(0.05)			(0.15)	
(1 − D)*Log of rice price		−0.540***			−0.575***	
(β_2)		(0.06)			(0.16)	
D*(Logged price − logged reference price)			0.202			−0.196
(α_1)			(0.11)			(0.23)
(1 − D)* (Logged reference price − logged price)			0.245*			0.420**
(α_2)			(0.10)			(0.13)
Log of flour price	−0.100***	−0.102***	−0.103***	0.021	0.036	0.032
(γ_1)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Log of potato price	−0.126***	−0.140***	−0.142***	−0.192*	−0.198*	−0.186*
(γ_2)	(0.03)	(0.03)	(0.03)	(0.10)	(0.10)	(0.09)
Log of staple food expenditure	0.875***	0.880***	0.880***	0.950***	0.951***	0.956***
(ρ)	(0.03)	(0.03)	(0.03)	(0.07)	(0.07)	(0.07)
Log of adult equivalents	−0.018	−0.019	−0.015	0.034	0.044	0.039
(φ)	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)
Gender of household head	−0.029	−0.027	−0.027	−0.112	−0.116	−0.109
(δ)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.08)
Distance to market	0.003	0.003*	0.003*	−0.002	−0.002	−0.002
(ϑ)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	−0.425***	−0.495***	−0.533**	−0.411	−0.491	−0.740***
	(0.14)	(0.14)	(0.18)	(0.27)	(0.26)	(0.22)
Observations	3,148	3,148	3,148	856	856	856
R-squared (within)	0.571	0.574	0.576	0.806	0.808	0.814
Number of households	1,789	1,789	1,789	652	652	652
F-value	177.34	157.76	142.33	98.85	88.13	79.69
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan-Hansen statistic	369.513	399.149	452.651	25.651	27.375	33.119
P-value	0.0000	0.0000	0.0000	0.0006	0.0006	0.0001
Test $\beta_1 = \beta_2$		7.11			2.44	
P-value		0.0077			0.1187	
Test $\alpha_1 + \alpha_2 = 0$			12.23			0.81
P-value			0.0005			0.3690

Robust standard errors in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$
a. "D" indicates whether the household experienced a loss (D = 1), or a gain (D = 0).

Table 2
Estimated coefficients, goodness-of-fit, and statistical tests for the fixed effect models of the demand for potatoes of pure consumer sample, and farmer sample by different model specifications.

	Potato pure consumers (37.7% of total)			Potato farmers (62.3% of total)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Log of potato price	−0.214*		−0.124	−0.254***		−0.309***
(β)	(0.10)		(0.12)	(0.06)		(0.06)
D*Log of potato price[a.]		−0.237*			−0.234***	
(β_1)		(0.09)			(0.06)	
(1 − D)*Log of potato price		−0.082			−0.308***	
(β_2)		(0.12)			(0.07)	
D*(Logged price − logged reference price)			−0.231			0.104
(α_1)			(0.27)			(0.13)
(1 − D)* (Logged reference price − logged price)			0.318			−0.268
(α_2)			(0.20)			(0.15)
Log of flour price	0.179*	0.163*	0.186*	−0.054	−0.065	−0.058
(γ_1)	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)
Log of rice price	−0.376*	−0.404*	−0.400*	−0.516***	−0.518***	−0.510***
(γ_2)	(0.16)	(0.16)	(0.16)	(0.10)	(0.10)	(0.10)
Log of staple food expenditure	0.666***	0.687***	0.679***	0.794***	0.797***	0.788***
(ρ)	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)
Log of adult equivalents	0.145	0.146	0.161	0.239**	0.237***	0.248**
(φ)	(0.11)	(0.11)	(0.11)	(0.08)	(0.08)	(0.08)
Gender of household head	0.205*	0.213*	0.212*	0.054	0.047	0.049
(δ)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
Distance to market	0.009*	0.008	0.008*	−0.001	−0.001	−0.002
(ϑ)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	−0.994*	−1.070*	−1.118*	−0.613*	−0.598**	−0.552
	(0.44)	(0.45)	(0.45)	(0.30)	(0.30)	(0.29)
Observations	1417	1417	1417	2342	2342	2342
R-squared (within)	0.265	0.273	0.271	0.316	0.317	0.319
Number of households	1028	1028	1028	1476	1476	1476
F-value	18.35	16.14	15.65	37.50	32.99	29.14
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan-Hansen statistic	21.764	28.756	30.106	48.069	59.850	55.779
P-value	0.0028	0.0003	0.0004	0.0000	0.0000	0.0000
Test β_1=β_2		3.93			1.24	
P-value		0.0477			0.2660	
Test $\alpha_1+\alpha_2 = 0$			0.07			0.67
P-value			0.7910			0.4120

Robust standard errors in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
a. “D” indicates whether the household experienced a loss (D = 1), or a gain (D = 0).

Table 3
Estimated coefficients, goodness-of-fit, and statistical tests for the fixed effect models of the demand for pork of pure consumer sample, and farmer sample by different model specifications.

	Pork pure consumers (47.3% of total)			Pork farmers (52.7% of total)		
Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 1	(5) Model 2	(6) Model 3
Log of pork price	−0.504***		−0.433**	−0.658***		−0.584***
(β)	(0.10)		(0.14)	(0.06)		(0.07)
D*Log of pork price[a.]		−0.482***			−0.608***	
(β_1)		(0.12)			(0.06)	
(1 − D)*Log of pork price		−0.476***			−0.582***	
(β_2)		(0.12)			(0.06)	
D*(Logged price − logged reference price)			0.445			−0.074
(α_1)			(0.26)			(0.15)
(1 − D)* (Logged reference price − logged price)			0.208			0.142
(α_2)			(0.18)			(0.10)
Log of mutton price	0.005	0.007	−0.013	−0.023	−0.012	−0.029
(γ_1)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Log of beef price	0.081	0.079	0.066	0.057	0.047	0.051
(γ_2)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)
Log of chicken price	−0.224**	−0.230**	−0.224**	−0.182**	−0.198**	−0.189**
(γ_3)	(0.07)	(0.08)	(0.07)	(0.06)	(0.06)	(0.06)
Log of egg price	−0.085	−0.091	−0.092	−0.106*	−0.132*	−0.121*
(γ_4)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)
Log of fish price	−0.024	−0.018	−0.041	0.170*	0.193**	0.171*
(γ_5)	(0.10)	(0.10)	(0.09)	(0.07)	(0.07)	(0.07)
Log of animal-sourced food expenditure	0.725***	0.724***	0.726***	0.845***	0.843***	0.845***
(ρ)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Log of adult equivalents	0.173**	0.173**	0.168**	−0.007	−0.000	0.002
(φ)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)
Gender of household head	−0.002	0.001	−0.003	−0.056	−0.043	−0.047
(δ)	(0.07)	(0.07)	(0.07)	(0.06)	(0.05)	(0.06)
Distance to market	−0.004	−0.004	−0.004	0.003	0.003	0.003
(ϑ)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	−0.218	−0.283	−0.291	−0.424	−0.568	−0.576
	(0.45)	(0.48)	(0.52)	(0.41)	(0.41)	(0.42)
Observations	1619	1619	1619	1801	1801	1801
R-squared (within)	0.663	0.663	0.666	0.715	0.718	0.716
Number of households	1167	1167	1167	1186	1186	1186
F-value	66.38	60.27	55.97	120.02	112.07	100.39
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan-Hansen statistic	41.355	42.776	47.307	43.705	48.430	44.321
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test $\beta_1 = \beta_2$		0.24			7.07	
P-value		0.6223			0.0080	
Test $\alpha_1 + \alpha_2 = 0$			3.43			0.14
P-value			0.0643			0.7066

Robust standard errors in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
a. "D" indicates whether the household experienced a loss (D = 1), or a gain (D = 0).

4.2. Comparison of results of different model specifications

As explained in Section 3.2, we studied asymmetric price effects by comparing coefficients of segmented log-prices in loss and gain situations in Model 2 (β_1 and β_2), and the coefficients of segmented difference of logged present price and logged reference price in situations of loss and gain in Model 3 (α_1 and α_2). Both Models 2 and 3 had better fit than the standard Model 1 in terms of within R-squared (see the statistics in the rows of "R-squared (within)" in Tables 1–3. Taking regressions of pure rice consumers as an example, the within R-squared of Model 1 was 0.571, whereas those of Models 2 and 3 were 0.574 and 0.576, respectively), indicating that models considering reference prices explained the data better. Four out of a total of six regressions showed better fit for Model 3 than Model 2, although the difference is slight.

In Model 3, the coefficients of segmented price increase and price decrease terms indicated how households responded to deviations of present prices from reference prices, in addition to the effect of present price. Results showed that the effects of price decrease terms were statistically different from zero for rice demand only (pure consumers: 0.245, $p = 0.018$; farmers: 0.420, $p = 0.002$), but not for demand of potatoes and pork. Also, the price increase terms were not significant for any product. Therefore, in general the hypothesis that price difference had an additional effect on food demand did not hold for the Model 3 specification.

However, as described in Section 4.1, in Model 2, asymmetric price effects were statistically significant for rice and potatoes (pure consumers), and for pork (farmers). It seems that the asymmetric price effects were detected more easily by Model 2, comparing price elasticities in loss and gain situations without considering the effects of deviations of present price and reference price. This suggests that, when consumers saw the present price, the comparison between reference price and the present price had been done before they finally made the consumption decision, thus it is possible that the price effects estimated by Model 2 have already captured some behavioral response to the price difference. In Model 3, the additional price difference effect may have been weakened for the same reason.

To sum up, statistical inference of asymmetric price effects on food demand differed by demand model specification. Asymmetric price effects on food demand could hardly be detected by the price increase and price decrease model (Model 3), but were detected more easily by the segmented price model (Model 2), although Model 3 had a better fit to the data.

5. Discussion

This study examined asymmetric price effects on food demand, and showed the phenomenon was only partly applicable to rural household demand in China. Asymmetric price effects of rice and potatoes were only found for pure consumers, and of pork for farmers, when estimated by the double-log model with segmented price specification. Theoretical as well as policy implications, limitations and future research are discussed next, based on our findings.

5.1. Implications

Evidence of asymmetric price effects on food demand shows that the standard demand model, assuming symmetry, is not able to uncover the complexity of the mechanism of price effects on demand under different price change directions. In our study, we found that in rural China, households had a significantly higher price elasticity when prices had increased than when prices had decreased for demand of rice and potatoes (pure consumers), and pork (farmers). When price had increased, households perceived a loss, and reacted stronger to price changes. This phenomenon was not detected by the standard demand model. An adjusted demand model incorporating this asymmetric nature of price effects can help to assess a less biased price elasticity.

We found that asymmetric price effects differed across food items. The food items we have chosen are rice, potatoes, and pork, and we found that for pure consumers, asymmetric price effects on demand were significant for rice and potatoes, but not for pork (when estimated by Model 2). The results for pure consumers are consistent with those of Talukdar and Lindsey (2013) who studied the household purchase of healthy and unhealthy food items in supermarkets in the northeastern United States. They found that loss aversion effects were more prominent for healthy foods and explained that it is because healthy food is less palatable than unhealthy food. In this case, people will have an impulse to underconsume healthy food, making it easier to diminish consumption when price increases than to increase consumption when price decreases. Our findings of significant asymmetric price effects for rice and potatoes may also be partly related with Talukdar and Lindsey's explanation (2013), because in rural China, although people barely have the idea to distinguish daily consumed food as healthy or unhealthy foods, people tend to group foods by its function or by dietary needs. Rice and potatoes are considered as staple foods, while pork is considered as animal-sourced food, which is more delicious, more enjoyable to eat, and can offer more quality proteins. Traditionally, Chinese diets are characterized by relatively high levels of staple foods and vegetables and low intake of animal-sourced food. However, with rapid economic growth in China, rural residents have been through a dietary transition which is characterized by increasing consumption of animal-sourced food, especially pork, and decreasing consumption of staple foods (Ren et al., 2021). The trend of dietary transition reflects that staple foods are wanted less than pork, leading to an impulse to underconsume. It is possible that the asymmetric effects are only significant for rice and potatoes for pure consumers because the decreased quantity demand is reinforced by the impulse to underconsume when price increases; and the increased quantity demand is counteracted by the impulse to underconsume when price decreases. However, we did not find reverse loss aversion effects for pork as Talukdar and Lindsey (2013) found for beef. This finding is congruent with the view of some previous studies that the loss aversion effect is not universal in consumer goods (Bell & Lattin, 2000) and it is category-dependent (Yan et al., 2016).

Another main addition of this study is that we estimated asymmetric price effects separately for pure consumers and farmers. For pork consumption, the asymmetric price effect is significant for farmers but not for pure consumers. Farmers react significantly stronger to price increases than to price decreases. It is likely that a price increase represents a profitable situation for farmers, so they sell more products for higher income and consume less of their produce. The opportunity cost of consuming self-produced food in periods of price increase makes consumption by farmers more responsive to price changes than consumption by pure consumers. This result was not found for farmers of rice and potatoes maybe because pork has a much higher price and is more commercialized than rice and potatoes, which are produced mostly as staple foods for own-consumption. However, farmers could be both sellers and consumers, and it is hard to tell whether they perceive a price increase as a more favorable or more unfavorable situation for a certain product. It is possible that only when price increases to a certain level that they perceive it is worthwhile to sell their produce, whereas diminished sensitivity to price changes may occur with further price increases. In short, the asymmetric price effects on food consumption in price increases and price decreases for farmers might be a mix of endowment effects for own-production and loss aversion effects of consumption. We leave the separation of these effects for future research.

We further observed that the price increase and price decrease model (Model 3, similar as the method used by Putler, 1992, and Vande Kamp and Kaiser, 1999) had a slightly better fit than the segmented price model (Model 2, similar as the method used by Talukdar & Lindsey, 2013, and Yan et al., 2016), but the asymmetric price effects on food demand were prominent in Model 2, but not detected by Model 3. Model 2 directly estimated price elasticity separately for people who experienced losses and for those who experienced gains. However, compared with Model 3, Model 2 did not include the effect of difference between purchase price and reference price. Instead, Model 3 refers to an underlying theory of demand based on Thaler's distinction between acquisition utility and transaction utility. Model 3 includes both the effect of actual price and the effect of the difference between actual price and reference price. A similar discussion about whether to place the "main effect," thus the actual price, in the model occurred in the meta-analysis of loss aversion in the applications of product choice models by Neumann and Böckenholt (2014). They found that placing the actual price together with price increase and price decrease terms in the model decreased the loss-aversion coefficients, and the loss aversion effects seemed to diminish. They explained this phenomenon by arguing that the coefficient of actual price had already captured and absorbed the effects of loss and gain terms, thus weakening their effects. They therefore suggested always to apply models both with and without the actual price in the estimation, and empirically judge them by statistical criteria. As for applications of demand models, we also suggest to apply both Models 2 and 3 since they can offer different messages concerning asymmetric price effects.

5.2. Limitation and future research

A limitation of this research is that, due to data availability, we can only use the food price of the previous year as the reference price. This interval period may be too long, longer than the actual interval of household purchases. Other similar studies (Putler, 1992; Maynard & Subramamiam, 2015; Ray, Shum, & Camerer, 2015) all used the previous period price (usually weekly price) as reference price. Furthermore, for households who consume self-produced food in our samples, the reference price may not be reflected by the past purchase price because they do not purchase food from the market often. Instead, they may use a kind of "fair price" as their internal reference price. To be specific, the "fair price" for the self-produced food that they consumed might be a reservation selling price. We leave this possibility for future research.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Specifications of models 1–3

Model 1: Standard double-log demand model

$$lnc_{it} = \beta lnp_{it} + \sum_{j=1}^{J} \gamma_j lnps_{ijt} + \rho lnexp_{it} + \varphi lnadeq_{it} + \delta gen_{it} + \vartheta dist_{it} + \sum_{c=1}^{C} \sigma_c d_{ic} + \mu_i + \varepsilon_{it}$$

$(i = 1, 2, \ldots, n;\ t = 2012, 2015, 2018)$ (A1)

where,

lnc_{it} denoted the log of the consumption amount of a certain food item c of household i in the past 30 days at the survey time t;
lnp_{it} denoted the log of purchase price of the food item of household i at the survey time t;
$lnps_{ijt}$ denoted the log of purchase price of another food item j of household i at the survey time t;

$lnexp_{it}$ denoted the log of expenditure of a certain food group (expenditure of staple food when estimating demand of rice or potatoes; expenditure of animal-sourced food when estimating demand of pork) of household i in the past 12 months at the survey time t;

$lnadeq_{it}$ denoted the log of the number of equivalent adults[1] of household i at survey time t;

gen_{it} denoted gender of the household head (1 = male, 0 = female) at time t;

$dist_{it}$ denoted the distance to market for household i at time t;

d_{ic} were dummy variables of county of residence (representing counties of Wuding, Huize, Pan, Zhengan, Zhenan, respectively, county Luonan being the default county);

μ_i denoted the household specific error term, differing between households, which did not vary over time;

ε_{it} was the error term.

β, γ_j, ρ, φ, ω, δ, ϑ, θ, σ_c, μ_i, and ε_{it} were parameters to be estimated.

Model 2: Segmented price model

$$lnc_{it} = \beta_1 D_{it} lnp_{it} + \beta_2 (1 - D_{it}) lnp_{it} + \sum_{j=1}^{J} \gamma_j lnps_{ijt} + \rho lnexp_{it} + \varphi lnadeq_{it} + \delta gen_{it} + \vartheta dist_{it} + \sum_{c=1}^{C} \sigma_c d_{ic} + \mu_i + \varepsilon_{it}$$

(i = 1, 2, …, n; t = 2012, 2015, 2018) (A2)

where,

D_{it} was a dummy variable denoting whether household i experienced a price increase at the survey time t compared to the reference price (RP_{it}), which was the purchase price a year ago at time t-1.

If $p_{it}>RP_{it}$, household i experienced a price increase (loss), D_{it}=1;

If $p_{it}<RP_{it}$, household i experienced a price decrease (gain), D_{it}=0;

β_1 and β_2 represented the own-price elasticity for households who experienced a loss or a gain, respectively.

The definitions for the remaining variables and parameters were the same as in Model 1.

Model 3: Price increase and price decrease model

$$lnc_{it} = \beta lnp_{it} + \alpha_1 D_{it} L_{it} + \alpha_2 (1 - D_{it}) G_{it} + \sum_{j=1}^{J} \gamma_j lnps_{ijt} + \rho lnexp_{it} + \varphi lnadeq_{it} + \delta gen_{it} + \vartheta dist_{it} + \sum_{c=1}^{C} \sigma_c d_{ic} + \mu_i + \varepsilon_{it}$$

(i = 1, 2, …, n; t = 2012, 2015, 2018) (A3)

where,

If $p_{it}>RP_{it}$, D_{it}=1, $L_{it}=lnp_{it} - lnRP_{it}$;

If $p_{it}<RP_{it}$, D_{it}=0, $G_{it}=lnRP_{it} - lnp_{it}$.

α_1 and α_2 represented the effects of the ratio of price change on food demand for households who experienced a loss or a gain, respectively, in addition to the present price effect.

The definitions for the remaining variables and parameters were the same as in Model 1.

Appendix B

See Table A1–A3.

[1] Equivalent adults is a similar variable as household size, but considering different calorie requirements of people of different gender and age. This study converted every household member into equivalent adult by using Chinese Dietary Reference Intakes (DRIs), which specifies the reference nutrient intake of people in different age and gender groups (The Chinese Nutrition Society, 2016).

Table A1
Descriptive statistics of consumption, expenditure share, purchase price in RMB, reference price in RMB, and other variables used in the estimation of demand for rice.

Variable	Pure consumers			Farmers		
	N	Mean	Std.Dev.	N	Mean	Std.Dev.
Rice consumption (kg)	3148	21.21	18.28	856	32.44	25.33
Rice consumption in 2012	903	21.96	16.83	417	33.37	19.56
Rice consumption in 2015	1094	20.92	18.49	242	32.64	35.10
Rice consumption in 2018	1151	20.87	19.13	197	30.22	21.58
Expenditure share of rice	3148	0.17	0.12	856	0.23	0.13
Rice price (RMB/kg)	3148	5.47	1.23	856	4.67	0.97
Rice price in 2011	3148	4.98	0.83	856	4.42	0.67
Rice price in 2012	3148	5.14	0.84	856	4.58	0.69
Rice price in 2014	3148	5.42	1.10	856	4.74	0.97
Rice price in 2015	3148	5.52	1.10	856	4.83	0.98
Rice price in 2017	3148	5.66	1.14	856	4.94	1.01
Rice price in 2018	3148	5.63	1.35	856	4.99	1.02
Dummy for loss experience (price increase)	3148	0.80	0.40	856	0.86	0.34
Price difference (present price − reference price)	3148	0.07	0.95	856	0.08	0.77
Price increase (present price − reference price)	2529	0.33	0.65	740	0.22	0.55
Price decrease (reference price − present price)	619	0.99	1.19	116	0.83	1.25
Flour price	3148	4.24	1.60	856	4.35	1.49
Potato price	3148	1.86	1.02	856	1.91	1.09
Staple food expenditure	3148	174.99	114.42	856	187.05	127.52
Adult equivalents	3148	2.84	1.21	856	2.96	1.21
Gender of household head	3148	0.90	0.29	856	0.90	0.30
Distance to market (km)	3148	6.51	10.55	856	7.07	7.48
County Wuding	3148	0.10	0.30	856	0.42	0.49
County Huize	3148	0.17	0.38	856	0.16	0.37
County Pan	3148	0.19	0.39	856	0.09	0.28
County Zhengan	3148	0.15	0.35	856	0.26	0.44
County Zhenan	3148	0.20	0.40	856	0.04	0.19

Table A2
Descriptive statistics of consumption, expenditure share, purchase price in RMB, reference price in RMB, and other variables used in the estimation of demand for potatoes.

Variable	Pure consumers			Farmers		
	N	Mean	Std.Dev.	N	Mean	Std.Dev.
Potato consumption (kg)	1417	13.19	13.64	2342	21.33	25.99
Potato consumption in 2012	318	14.04	12.58	900	21.88	25.64
Potato consumption in 2015	452	13.91	14.81	800	21.50	29.06
Potato consumption in 2018	647	12.27	13.24	642	20.36	22.14
Expenditure share of potato	1417	0.04	0.04	2342	0.05	0.06
Potato price (RMB/kg)	1417	2.14	1.16	2342	1.69	0.98
Potato price in 2011	1417	1.84	1.60	2342	1.54	1.25
Potato price in 2012	1417	1.91	1.65	2342	1.53	1.17
Potato price in 2014	1417	2.08	0.58	2342	1.77	0.55
Potato price in 2015	1417	2.09	0.57	2342	1.79	0.56
Potato price in 2017	1417	2.29	0.63	2342	1.93	0.61
Potato price in 2018	1417	2.15	0.55	2342	1.89	0.59
Dummy for loss experience (price increase)	1417	0.52	0.50	2342	0.58	0.49
Price difference (present price − reference price)	1417	−0.02	0.51	2342	−0.01	0.44
Price increase (present price − reference price)	738	0.26	0.41	1366	0.18	0.38
Price decrease (reference price − present price)	679	0.33	0.41	976	0.27	0.40
Flour price	1417	4.53	1.79	2342	4.05	1.41
Rice price	1417	5.15	1.08	2342	5.44	1.29
Staple food expenditure	1417	173.64	114.88	2342	181.91	122.17
Adult equivalents	1417	2.90	1.22	2342	2.85	1.20
Gender of household head	1417	0.90	0.30	2342	0.90	0.29
Distance to market (km)	1417	6.40	13.19	2342	6.72	7.71
County Wuding	1417	0.29	0.45	2342	0.07	0.26
County Huize	1417	0.13	0.33	2342	0.20	0.40
County Pan	1417	0.25	0.43	2342	0.12	0.33
County Zhengan	1417	0.16	0.37	2342	0.15	0.36
County Zhenan	1417	0.08	0.28	2342	0.23	0.42

Table A3
Descriptive statistics of consumption, expenditure share, purchase price in RMB, reference price in RMB, and other variables used in the estimation of demand for pork.

	Pure consumers			Farmers		
Variable	N	Mean	Std.Dev.	N	Mean	Std.Dev.
Pork consumption (kg)	1619	5.55	5.09	1801	7.60	6.94
Pork consumption in 2012	406	5.30	4.66	706	7.41	5.71
Pork consumption in 2015	522	5.15	4.60	582	7.27	7.99
Pork consumption in 2018	691	6.00	5.63	513	8.23	7.18
Expenditure share of pork	1619	0.18	0.11	1801	0.24	0.13
Pork price (RMB/kg)	1619	24.40	5.23	1801	24.82	6.96
Pork price in 2011	1619	23.96	4.70	1801	23.87	6.51
Pork price in 2012	1619	24.20	4.60	1801	24.33	6.45
Pork price in 2014	1619	25.15	4.31	1801	24.97	5.25
Pork price in 2015	1619	26.75	4.79	1801	26.67	5.75
Pork price in 2017	1619	28.26	5.59	1801	28.38	6.47
Pork price in 2018	1619	23.14	4.90	1801	23.16	5.81
Dummy for loss experience (price increase)	1619	0.46	0.50	1801	0.57	0.50
Price difference (present price − reference price)	1619	−1.69	5.60	1801	−0.61	5.35
Price increase (present price − reference price)	750	2.03	2.40	1025	2.11	2.74
Price decrease (reference price − present price)	869	4.90	5.58	776	4.21	5.82
Chicken price	1619	23.96	7.71	1801	23.65	8.05
Beef price	1619	78.08	18.96	1801	71.40	18.72
Mutton price	1619	66.54	44.00	1801	57.56	44.01
Fish price	1619	18.19	5.53	1801	17.84	6.23
Egg price	1619	13.84	4.98	1801	14.40	4.62
Animal-sourced food expenditure	1619	249.15	280.81	1801	286.64	279.29
Adult equivalents	1619	2.87	1.22	1801	2.97	1.19
Gender of household head	1619	0.90	0.30	1801	0.91	0.28
Distance to market (km)	1619	5.79	11.89	1801	6.95	7.31
County Wuding	1619	0.14	0.35	1801	0.23	0.42
County Huize	1619	0.13	0.34	1801	0.23	0.42
County Pan	1619	0.18	0.39	1801	0.20	0.40
County Zhengan	1619	0.20	0.40	1801	0.19	0.39
County Zhenan	1619	0.18	0.38	1801	0.15	0.36

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