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Mental accounting and consumption of self-produced food

HUANG Jia-qi[1, 2], Gerrit ANTONIDES[2], Christian H. KUHLGATZ[3], NIE Feng-ying[1]

[1] *Agricultural Information Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China*
[2] *Urban Economics Group, Department of Social Sciences, Wageningen University, Wageningen 6706 KN, The Netherlands*
[3] *Market Analysis Unit, Federal Office for Agriculture FOAG, 3003 Bern, Switzerland*

Abstract

This is an exploratory study on mental accounting and food budgeting of agricultural households, in which we assumed that agricultural households may have a mental account for consumption of their self-produced food. Accordingly, they may reserve a certain quantity of self-produced food as a set budget for own consumption, implying that they may keep on consuming their own produce until they have consumed the quantity set for the mental budget. By making the mental accounting assumption, we hypothesized that the consumption of self-produced food is independent of market price. Also, we hypothesized that the consumption of self-produced food is increasing in the quantity of production if production is lower than the set budget, and independent of the quantity of production if production exceeds the set budget. By applying a double-log demand model and using survey data from six poor rural counties in China, we tested these hypotheses for five food items, which are rice, flour, potatoes, pork, and eggs. We found that the hypothesis of no significant effect of price holds for flour, potatoes, and pork if production is lower than the set budget, and for rice, pork, and eggs if production is higher than the set budget. Production has a significant positive effect on consumption of self-produced food but with a much greater influence when production is lower than the set budget for all five food items. These findings partly support our assumption of mental accounting of self-produced food. Limitations, policy implications, and possible future studies are discussed.

Keywords: mental accounting, food consumption, self-produced food, agricultural household

1. Introduction

Food consumption of agricultural households is an important research topic since it is highly related to the issue of food security and nutrition of household members. Although they are the producers of food, agricultural households are the most food insecure and malnourished group in many developing countries (Pinstrup-Andersen 2007; FAO 2014). Food price is one of the most important factors to influence people's food consumption decisions (Babu *et al.* 2016). Evidence shows that rural agricultural households are more sensitive to food price changes than urban households (Ecker and Qaim 2011). Also, most poor people are living in rural areas, are engaged in farm work, and suffer the most from food-price shocks (Cudjoe and Breisinger 2008; Robles *et al.* 2010).

However, it is not easy to precisely evaluate food

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HUANG Jia-qi, E-mail: huangjiaqi@caas.cn; Correspondence NIE Feng-ying, Tel: +86-10-82109901, E-mail: niefengying@caas.cn; Gerrit ANTONIDES, E-mail: gerrit.antonides@wur.nl

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demand reactions to price changes of agricultural households because of their dual role as producers and consumers. Unlike pure consumers, who can only acquire food at the market, agricultural households can also consume self-produced food. For this reason, the production and consumption decisions of agricultural households are very likely linked (Singh *et al.* 1986). The question of how agricultural households exactly determine the quantity of food that is sold and the quantity that is kept for eating at home still remains. It is of vital interest to answer this research question, because on one hand, many households in rural areas consume a considerable quantity of self-produced food (Sibhatu and Qaim 2018), affecting both their food security and the provision of food to the markets. On the other hand, ignoring the consumption of own produce may lead to significant bias in food demand estimations (Tekgüç 2012).

Agricultural household models (AHMs) offer a framework to analyze the question of how agricultural households allocate self-produced food (Sadoulet and De Janvry 1995). In brief, in AHMs, market prices and transaction costs play important roles in the choice of households to be self-sufficient or not (Goetz 1992; Key *et al.* 2000). Agricultural households will thus make a rational calculation of market prices, transaction costs, and subjective valuation of their produce. If the subjective valuation of self-produced products is higher than the market price minus transaction costs, then it is better to keep the product for own consumption (Taylor and Adelman 2003). However, in the empirical study of Chinese rural households, a behavior is revealed that is not easily set in line with the traditional AHMs. For example, households in developing countries are inclined to reserve a quantity of the self-produced food for own consumption, and the use of this pre-committed quantity is inflexible and will not be adjusted in response to the market price (Piggott 2003; Park 2006).

Moreover, our data shows a significant difference in rice, flour, potato, and pork consumption between households who produce the corresponding food and households who do not produce. Producers tend to consume more, and often even overconsume. For example, Chinese food pagoda recommends an upper limit for the combined consumption of grain and tuber of 400 grams per adult equivalent per day (Chinese Nutrition Society 2016). For rice-producing households, the percentage of households whose rice consumption level surpassed this upper limit was 34.0%, which was significantly higher than that of non-rice-producing households (16.5%). This may lead to some nutritional concerns since grain-producing households, for example, could have sold the overconsumed part of grain for cash income and bought more varieties of food to achieve a more diversified diet. A diversified diet is important since the prevalent micronutrient deficiencies are related more to low dietary quality and diversity than to food shortages (Headey and Ecker 2013).

Generally, it seems that agricultural households overlook the opportunity cost of own consumption of the produced food. One possible explanation is that agricultural households reserve a quantity of self-produced food for consumption, which is typical for agricultural households, especially for smallholders (Fanzo *et al.* 2013; Sibhatu and Qaim 2018). Furthermore, they may track their consumption against the reserved quantity, leaving consumption insensitive to price change, which has not been studied empirically. In order to explain this type of behavior, we turn to the theory of mental accounting, developed in behavioral economics (Thaler 1985, 1999), because we found it quite similar as the financial budget setting and expenditure tracking explained in the mental accounting theory of consumption expenditures.

Mental accounting theory describes how people set mental budgets for specific categories of expenses and then consume with that budget in mind (Thaler 1985). This process is contradicting a key assumption of standard economics implying that money is fungible. Pretnar *et al.* (2016) state that this non-fungibility characteristic of mental accounting implies that consumers may maximize their utility subject to separate budget constraints for different good categories rather than to a single budget constraint as neo-classical economic theory predicts. Heath and Soll (1996) show that people tend to track their consumption against the pre-set mental budget neglecting expenses in other accounts, which consequently may lead to either overconsumption or underconsumption. This could be relevant in explaining the overconsumption of grain for grain producers as mentioned above.

Just *et al.* (2007) point out that, because of mental accounting, households may also allocate a portion of their income specifically to buy food. When food prices decline, they may overlook the opportunity to shift the surplus “food money,” caused by cheaper acquisition of the quantity of food needed, to a category with another purpose. In this case, a low price of a food item may lead to overconsumption rather than substitution. For agricultural households, especially smallholders, who consume a sizable quantity of food from self-produce, the “food budget” may not be presented in the form of “food money,” but in the form of a “food quantity budget,” at least for the food they consume from self-produce. Mental accounting of food quantities has, for example, been found in chocolate consumption (Cheema and

Soman 2008).

In applying mental accounting theory, we assume that agricultural households set a mental budget for consumption of a quantity of self-produced food. Mental accounting theory implies that agricultural households keep on consuming their own produce until they have consumed the quantity set for the mental budget, rather than sell it to the market for extra income, even in times of increasing food prices. Therefore, the consumption of self-produced food may not significantly be influenced by market price. Likewise, for agricultural households who have already consumed their budget, the consumption of self-produced food may not be influenced by market price, since they sell all of their excess produce, even in times of decreasing food prices.

This paper studies farmers' consumption of self-produced food by applying mental accounting theory. It does so by analyzing a rich household dataset stemming from rural households of six poor counties in China. This study will contribute to the literature in the following ways: first, by offering additional explanations of price insensitivity of self-produced food consumption of agricultural households; second, by enriching the application of mental accounting theory to non-monetary resources and non-pure consumers. The results of this study provide new insights for both academia and practitioners in developing countries, especially where smallholder agriculture is prevalent. Better understanding of agricultural household decision making processes and mechanisms of allocating and consuming self-produced food can be used to adapt agricultural and food demand models for a better explanation of farmers' behaviors.

Section 2 elaborates on the theoretical background of agricultural household behavior concerning self-produced food, and mental accounting. Section 3 explains the survey and the plan of analysis. Section 4 reports the results. Section 5 discusses with implications and then Section 6 concludes.

2. Theory

2.1. Agricultural household models (AHMs)

In AHMs, market prices and transaction costs play important roles in the choice of households to be self-sufficient or not (Goetz 1992; Key *et al.* 2000). According to the economic logic of AHMs, market participation is determined by comparing the utility obtained from selling, buying, and remaining self-sufficient, for a particular food commodity (Key *et al.* 2000). The AHMs assume that a household will make a rational calculation of transaction costs of selling and opportunity costs of consuming their own produce. Transaction cost is considered as the main determinant of the choice of households to be self-sufficient or not. According to Key *et al*. (2000), transaction costs include both proportional transactions costs (PTCs) and fixed transactions costs (FTCs). PTCs, which include per-unit costs of accessing markets associated with transportation and imperfect information, have been used to explain food market participation decisions in developing countries (Goetz 1992; De Janvry and Sadoulet 1994). FTCs that are invariant to the quantity of a good traded also affect a household's decision to participate in markets. FTCs may include the costs of: 1) search for a customer or salesperson with the best price; 2) negotiation and bargaining costs; and 3) screening, enforcement, and supervision costs. However, transaction cost are very hard to measure in reality. Many studies, including ours, use other observable factors as proxies for transaction costs, for example, distance to markets and transportation costs. Transaction costs create a "price band," which is the gap between the consumer's buying price and the producer's selling price. If the producer's "shadow price," defined as the subjective valuation of a product, is higher than market price minus transaction costs, then it is better to keep the product for own consumption. If the consumer's "shadow price" is lower than the market price, it is better not to purchase the product from the market but use the self-produced food for consumption (Taylor and Adelman 2003). Therefore, if the household's "shadow price" of the product lies within the "price band" determined by transaction costs, then it will choose to be self-sufficient.

The food price effect on agricultural household food demand is ambiguous and complicated. It allows for food-price insensitivity for agricultural households because a food price increase may induce both a negative Slutsky substitution effect and a positive income effect (Taylor and Adelman 2003). A negative Slutsky effect means that when the price of a food item (normal good) increases, its demand will decrease because of a negative real income effect and a negative substitution effect. However, for producers, a food price increase may lead to an increase of farm production income, pushing the budget constraint outward, resulting in a positive effect on food demand. If the positive income effect and the Slutsky effect are almost equal, the food demand of agricultural households will not be influenced by price. If the positive income effect outweighs the Slutsky effect, the food demand of agricultural households may even increase with the food price.

Tekgüç (2012) has pointed out the importance of separating food consumption from market purchases and from self-production when estimating the price

effect. He found that ignoring self-produced food leads to significant overestimation of own-price elasticity for bread and cereals in Turkey, indicating that when taking self-produced consumption into account, price elasticity is lower.

Inspired by Tekgüç (2012)'s research, we question whether the selling and consumption decisions regarding self-produced food are strongly influenced by the market price and transaction cost as the traditional AHMs predict, and whether other mechanisms can explain low price sensitivity for the consumption of self-produced food.

2.2. Mental accounting

Mental accounting was first introduced by Thaler (1985), who defined a mental account as an outcome frame set up for a specific consumer choice or transaction. Mental accounting theory states that people tend to set mental budgets, as reference points, for specific categories of expenditure and then track their consumption against the set budgets, for monitoring their actual spending (Thaler 1985, 1999). This behavior is plausible in daily life. For example, people may categorize their income by earmarking it for specific purposes or specifying that it be used within a certain time frame (Shefrin and Thaler 1992). Also, consumers may set spending limits representing how much they want to allocate to different expenditure categories (Mazumdar *et al.* 2005).

Although mental accounting theory has been developed in the area of consumer spending, it has also been applied with respect to different types of decisions, including decisions about the use of time (Soman 2001; Rajagopal and Rha 2009), emotions (Levav and Mcgraw 2009) and specific behaviors regarding food items (Abeler and Marklein 2008; Cheema and Soman 2008; Milkman and Beshears 2009; Krishnamurthy and Prokopec 2010).

One key facet of mental accounting contradicting standard economics is non-fungibility. Standard economic theory assumes that money is fungible, such that when utility maximization is achieved, the marginal utility of wealth or income is the same among different consumption categories. However, mental accounting research shows that wealth and income are not equally fungible, no matter how liquid the assets are (Shefrin and Thaler 1988). For example, Heath and Soll (1996) show that people set budgets for specific categories of expenditure, such as entertainment, and will track their consumption expenses against this set budget. As an example of non-fungibility, they find that the budget effect is larger for purchases that are highly typical of the category of entertainment, such as movie tickets and smaller for purchases that are less typical, such as taking a taxi. Mental accounting theory implies that people are not always rational when making consumption decisions.

Although mental budgeting is considered irrational from the standard economic perspective, it may be related to utility maximization, given a particular shape of the utility function. As long as consumption remains within the set budget, utility may be increasing in consumption. However, if consumption exceeds the set budget, utility may no longer increase, in line with the consumer's unwillingness to consume beyond the set budget. Furthermore, the budget for each consumption category may be set such that the marginal utility at the set budget level is the same for all categories, in line with the standard economic assumption of additional spending in each consumption direction leading to equal marginal utility in the optimum.

2.3. Hypotheses

Mental accounting theory may also work for agricultural households, who reserve a certain quantity of self-produced food for own consumption (similar to the mental budget for household expenses). The reserved quantity for own consumption can be seen as a "food quantity budget" from total self-produced food. Households may estimate how much of a certain kind of self-produced food they need to consume for a certain period of time, then take this estimate as the quantity reserved for own consumption.

If the assumption above holds, then agricultural households will track the quantity of own consumption against the planned quantity of own produce for own consumption for each type of food that they produce, similarly to the way households track their expenses against mental budgets (Heath and Soll 1996). Given this assumption, agricultural households may overlook the opportunity cost of the quantity of planned consumption of self-produced food. Opportunity cost neglect appears to be common among consumers (Frederick *et al.* 2009). This means that, even though the market food price increases, households will keep the planned quantity for own consumption rather than sell it to the market for extra income to exchange for other food items or other goods. Therefore, the consumption quantity of self-produced food may not be significantly influenced by price change as long as the set budget has not been consumed. Also, in the case the set budget has already been consumed, no further consumption of self-produced food will take place, so all produce will be sold, regardless of the price level, and taking into account transaction costs. This leads to our first hypothesis.

H1: The consumption of self-produced food is not

significantly influenced by market price, taking into account transaction costs.

Mental accounting theory assumes that consumption is tracked against a set budget. In the case of the farmers' decisions to consume their produced food, this assumption implies that they will consume all of their produced food as long as production is lower than the set budget, regardless of price. Here, we assume that the household's most recent level of annual consumption (both from self-production and market purchase), serves as the set budget, since this is to be served as a reference quantity of how much they need to consume in a year. If they produce more than the set consumption budget, they will sell the rest. This leads to our second and third hypotheses.

H2: The consumption of self-produced food is increasing in the quantity of production if production is lower than the set budget.

H3: The consumption of self-produced food is independent of the quantity of production if production is higher than the set budget.

We do not assume every farmer to behave strictly according to the mental accounting hypotheses, neither do we believe they all behave according to the standard economic model. Because of this, our hypotheses may only hold partially, indicating partial mental accounting. For example, we may find that the farmers' consumption of their own produced food depends on their production below the set budget, but they may still be sensitive to price to some extent, or *vice versa*.

3. Methods and data

3.1. Empirical model

We applied a double-log model to study how production, food prices, and transaction costs influence consumption of self-produced food, and whether the influence is different below and above the point where production equals the household's most recent level of annual consumption (both from self-production and market purchase) for a household. Different from the standard demand model, the dependent variable was not total consumption of a certain food but the consumption of a certain food from self-production at the household level. We identified the factors that may influence consumption of self-produced food based on the theoretical framework of self-sufficient choices of agricultural households (Goetz 1992; Key *et al.* 2000; Taylor and Adelman 2003). From this framework, market prices, transaction costs, and subjective valuation of their production were the main factors in the decision to be self-sufficient or not. Since the subjective valuation of self-produced food was not available from the dataset, we only took market prices and transaction costs into account. In addition, it is broadly known from demand models that prices of other food items (especially substitutes) and food expenditure may also influence the demand for a certain kind of food (Christensen *et al.* 1975; Deaton and Muellbauer 1980; Gibson and Rozelle 2011). Therefore, we also added log terms of market prices of substitutes and log of total food expenditure as explanatory variables.

Production is also a very important explanatory variable, since the consumption of self-produced food could be highly related with production quantity and we assumed different consumption behaviors below than above a particular production level, associated with the level of the most recent annual consumption for a household. Below this production level, the consumption of self-produced food may increase with the increase of production scale. Once the production meets the level of the most recent annual consumption for the household, the consumption of self-produced food will no longer be influenced by production.

Considering the characteristics of consumption of self-produced food of agricultural households mentioned above, and applying a double-log specification, the empirical model of consumption of self-produced food is given as follows:

$$\ln y_i=(\sum_{f=1}^{n}\beta_f \ln p_{fi}+\theta \ln m_i+\varphi_q \ln q_i+\varphi_d dist_i+\varphi_t trans_i+\omega_e edu_i +\omega_a age_i+\omega_l lab_i+\omega_n adeq_i+\omega_s ds_i+\omega_y dy_i+\omega_g g_i +\omega_{gq} g_i\times \ln q_i+\omega_{gp} g_i\times \ln p_{fi})+\varepsilon_i \quad (1)$$

where $\ln y_i$ denotes the log of the consumption quantity of self-produced food (a certain kind of food) of household i in the past 12 months before the survey time; $\ln p_{fi}$ denotes the log of price[1] of different food items (rice, flour, potatoes, pork, eggs, chicken, beef, mutton, and fish, respectively), of household i; $\ln q_i$ denotes the log of production quantity of a certain kind of food of household i in the past 12 months before the survey time; $\ln m_i$ denotes the log of total food expenditure of household i; $dist_i$ and $trans_i$ denote distance to market and

[1] We calculated the market price of rice, flour, and potatoes by taking the average mean values of buying and selling price as indicated by each individual household. It is because the consumption of self-produced food of households who produce food may be influenced either by selling prices or buying prices or both (Sadoulet and De Janvry 1995). In order to take price information from both sides into account, we took their average.

transportation cost to sell food for household i, considered as proxies of transaction cost, respectively; edu_i and age_i denote average years of education of laborers, and average age of laborers, respectively; lab_i denotes the number of laborers engaged in agriculture, and $adeq_i$ equals the number of equivalent adults of household i[2]; ds_i and dy_i are dummy variables of Shaanxi province and Yunnan province, respectively (Guizhou being the default province); g_i is a dummy variable of production group the household i belongs to by comparing production level and the most recent annual consumption level. This level was calculated by the recalled quantity of a certain kind of food consumed in the 30 days before the survey time, multiplied by 12. This most recent annual consumption level served as the set budget. If production of a certain kind of food was less than or equal to the most recent annual consumption level of the food, g_i=1. If production of a certain kind of food was larger than the most recent annual consumption level of the food, g_i=0; $g_i \times lnq_i$ is a cross-term of the production group dummy variable and log of production quantity of a certain kind of food, of household i; $g_i \times lnp_{fi}$ are cross-terms of each production group dummy variable and the log of price of a certain kind of food; β_f, θ, φ_q, φ_d, φ_t, ω_θ, ω_a, ω_l, ω_n, ω_s, ω_y, ω_g, ω_{gq}, ω_{gp} are parameters to be estimated.

The estimation was conducted using ordinary least squares with the software Stata. Descriptive statistics of the variables are shown in the Appendices A–E.

3.2. Data

The study used the household survey data collected from six poor rural counties of three provinces (Shaanxi, Yunnan, Guizhou) in China in August, 2015. A two-stage sampling approach was applied. The first stage comprised the selection of villages using the probability-proportional-to-size (PPS) method (Nie *et al.* 2011). Following the selection of the villages, 12 households within each village were randomly selected. In each county, all selected 228 households from 19 villages were interviewed. The total sample size was 1 368. The dataset included comprehensive household information on food consumption, consumption of self-production, income, expenditure, assets, production, and demographics.

Of the 1 368 households, there were 236 households producing rice, 260 producing flour, 546 producing potatoes, 743 producing pork, and 393 producing eggs in the 12 months prior to the survey. The rice/flour/potatoes/pork/egg-producing households all consumed part of their production, and most of the total consumption came from self-production. For instance, for rice-producing households, the consumption of self-produced rice was 30.53 kg/month/household, which accounted for 88.42% of total rice consumption (34.53 kg/month/household). The percentages for flour, potatoes, pork, and eggs were 96.32, 98.65, 94.92, and 98.84%, respectively.

Also, we observed a significant difference in consumption of rice, flour, potato, pork, and eggs between households who produced the corresponding food and households who did not produce (Table 1). For example, rice consumption of households who produced rice was significantly higher (34.53 kg/month/household) than of households who did not produce rice (19.99 kg/month/household). Chinese Food Pagoda (Chinese Nutrition Society 2016) recommended an upper limit for consumption of grain and tuber, which is 400 grams per adult equivalent per day. For rice-producing households, the percentage of households whose rice consumption level surpassed this upper limit was 34.0%, which was significantly higher than that of non-rice-producing households (16.5%). The same trend was observed for flour, potato, pork, and egg consumption. Flour, potato, pork, and egg consumption of producing households was 4.66 kg/month/household, 12.25 kg/month/household, 2.80 kg/month/household, and 0.65 kg/month/household higher than that of non-producing households. The fractions of producing households whose flour, potato, and pork consumption levels surpassed the corresponding upper limit were 11.2, 24.5, and 37.8%, respectively, which was higher than that of non-producing households (7.9, 8.8, and 17.0%). These statistics show that overconsumption of a certain kind of food was more prevalent for the households who produced the corresponding kind of food. We estimated our demand equations for households who produced the corresponding food only.

[2] Equivalent adult is a commonly used indicator in food consumption and nutrition related studies (OECD 1982; Tedford *et al.* 1986). An equivalent adult refers to an 18-year-old man engaged in very light physical activity. The energy requirement of people differs by age, gender, and weight. This study converted every household member into equivalent adult units by using Chinese Dietary Reference Intakes (DRIs), which specifies the reference calorie intake of people in different age and gender groups. Unlike per capita measurements, the number of equivalent adults captures differences of food and nutrition required by various household members and thus allows the comparison of food consumption for households with different compositions (Claro *et al.* 2010).

Table 1 Consumption of rice, flour, potatoes, pork, and eggs of producing households and non-producing households

	Rice[1)]		Flour[1)]		Potato[1)]		Pork[1)]		Egg[1)]	
	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.
Number of households	236	1 132	260	1 108	546	822	743	625	393	975
Total consumption (kg mon^{-1})	34.53	19.99	11.96	7.30	24.53	12.29	6.50	3.71	2.58	1.93
Difference	14.54*** (9.18)		4.66*** (4.28)		12.25*** (9.29)		2.80*** (5.62)		0.65*** (3.80)	
Consumption of self-production (kg mon^{-1})	30.53	0	11.52	0	24.20	0	6.17	0	2.55	0
Consumption per adult equivalent (kg mon^{-1})	12.17	7.44	4.85	3.04	9.79	4.80	2.35	1.43	1.00	0.76
Difference	4.73*** (8.12)		1.81*** (4.26)		4.99*** (8.30)		0.92*** (5.60)		0.24*** (3.06)	
Upper limit of recommended consumption (g/adult equivalent/day)[2)]	400		400		400		75		50	
Percentage of households with consumption above the upper limit of recommendation (%)	34.0	16.5	11.2	7.9	24.5	8.8	37.8	17.0	12.7	13.6

[1)] Prod., producers; Non-prod., non-producers.
[2)] Chinese food pagoda recommended an upper limit for consumption of grain and tuber is 400 grams per adult equivalent per day (Chinese Nutrition Society 2016). Since there is no limit for specific food item, we use this limit of grain and tuber for consumption of rice, flour, and potatoes.
***, $P<0.001$; *t*-value are in parentheses.

4. Results

Tables 2 and 3 show the regression results of the double-log demand model. We summarize the results for rice, flour, and potatoes in Table 2, since they were considered as staple foods, including the logged price of rice, flour, and potatoes in each of the rice, flour, and potato regressions as explanatory variables. Results for pork and eggs are summarized in Table 3 since they were both animal-sourced food.

To test Hypothesis 1, we examined the price effect on consumption of self-produced food separately when production was lower or higher than the set budget (the most recent annual consumption for a household). The price effect when production was lower than the set budget is indicated at the bottom parts of Tables 2 and 3. For flour, potatoes, and pork, the price effect was not significantly different from zero, in line with Hypothesis 1. However, for rice and eggs, the price effect was negative. For rice, 1% increase in price was associated with 1.642% decrease of consumption of self-produced rice. For eggs, the decrease was 0.269%. It shows that, when production was lower than the set budget, households would not adjust their consumption of flour, potatoes, and pork from self-production in case of a price change, but would decrease their consumption of rice, and eggs from self-production.

When production was higher than the set budget, the price effect on consumption of self-produced rice, pork, and eggs was not significantly different from zero, in line with Hypothesis 1. But for flour and potatoes, the price effects were significantly negative, –0.427 and –0.275, respectively. It shows that, when production exceeded the set budget, households would not adjust their consumption of rice, pork, and eggs from self-production in case of a price change, but would decrease/increase their consumption of flour, and potatoes from self-production with a price increase/decrease. All together the results show that Hypothesis 1 is only partly supported, and support varied by food item. In another study which evaluated the price effect of self-produced food, the price effects on consumption of rice and potatoes were both not significant (Huang *et al.* 2020), which is generally in favor of Hypothesis 1, although this study did not evaluate the price effect separately in situations where production was larger or smaller than consumption needs.

To evaluate Hypothesis 2, we tested the effect of production on consumption of self-produced food if production was lower than the set budget. This is shown at the bottom parts of Tables 2 and 3. We found significantly positive production effects on consumption of self-produced flour (0.657), potatoes (0.699), pork (0.473), and eggs (0.440), in line with Hypothesis 2, but not for rice (0.306). The results indicate household would consume more from self-production if they produce more.

For testing Hypothesis 3, we estimated the production effects on consumption of self-produced food if production was

Table 2 Regression of per adult equivalent self-produced rice, flour and potato consumption

Variable	Rice		Flour		Potato	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Log(price of rice)	−0.380	(0.362)	0.062	(0.409)	0.032	(0.237)
Log(price of flour)	0.326	(0.387)	−0.427*	(0.245)	0.465**	(0.203)
Log(price of potatoes)	0.446*	(0.237)	0.400**	(0.169)	−0.275**	(0.120)
Log(total expenditures on food)	0.028	(0.072)	0.011	(0.060)	0.066	(0.044)
Distance to the market	−0.003	(0.009)	0.008	(0.008)	−0.004	(0.005)
Education of laborers	−0.029	(0.024)	−0.015	(0.019)	−0.032**	(0.014)
Age of laborers	0.008	(0.006)	−0.001	(0.004)	−0.002	(0.003)
Number of laborers in agriculture	−0.022	(0.061)	0.032	(0.054)	0.074*	(0.043)
Number of adult equivalents	0.250***	(0.069)	0.234***	(0.048)	0.078**	(0.039)
Shaanxi			0.771***	(0.160)	0.589***	(0.111)
Yunnan	0.466***	(0.131)	−0.417***	(0.146)	0.395***	(0.105)
Log(production of rice)	0.226**	(0.106)				
Transportation costs of rice	0.000	(0.002)				
Rice production group	1.722	(1.592)				
Rice production group×Log(production of rice)	0.080	(0.233)				
Rice production group×Log(price of rice)	−1.262	(0.840)				
Log(production of flour)			0.154**	(0.062)		
Transportation costs of flour			−0.003	(0.003)		
Flour production group			−3.188**	(1.432)		
Flour production group×Log(production of flour)			0.503***	(0.186)		
Flour production group×Log(price of flour)			1.459*	(0.815)		
Log(production of potato)					0.302***	(0.039)
Transportation costs of potato					−0.001	(0.001)
Potato production group					−0.969*	(0.575)
Potato production group×Log(production of potato)					0.397***	(0.099)
Potato production group×Log(price of potato)					0.245	(0.255)
Constant	2.376*	(1.240)	2.508***	(0.944)	1.402**	(0.660)
Observations	236		260		546	
R-squared	0.226		0.594		0.433	
Price effect (production lower than the budget)	−1.642**	(0.762)	1.032	(0.795)	−0.030	(0.227)
Production effect (production lower than the budget)	0.306	(0.211)	0.657***	(0.179)	0.699***	(0.094)

***, $P<0.01$; **, $P<0.05$; *, $P<0.1$.

higher than the set budget. We found significant positive effects of production for all five food items (0.226 for rice, 0.154 for flour, 0.302 for potatoes, 0.131 for pork, 0.090 for eggs), refuting Hypothesis 3. However, apart from rice, these values were much lower than the production effects when production was lower than the set budget. This means when production was lower than the set budget, the consumption of self-produced food was much more sensitive to production changes than when production was higher than the set budget. The results show that when production is larger than the set budget (most recent level of annual consumption), households still prone to consume a bit more from self-production, this result is consistent with the finding of Huang *et al.* (2020), which showed for rice and potatoes, when reservation from self-production exceed consumption need, households will consume more from self-production, indicating a consequence of overconsumption.

We found positive price effects of some substitutes on the consumption of self-produced food. The price of potatoes had significant positive effects on consumption of self-produced rice (0.446) and flour (0.400), whereas the price of flour had a significant positive effect on consumption of self-produced potatoes (0.465). For animal-sourced foods, we found significant positive price effects on consumption of self-produced eggs for mutton (0.322), chicken (0.220), and fish (0.380). Those foods are all important sources of protein, so that they can be considered as substitutes. Also, we found a significant negative price effect of chicken on consumption of self-produced pork, which is not in line with the substitution effect expected from standard demand theory.

Transportation costs and distance to markets, which were taken as proxies of transaction cost, had no significant effects on the consumption of self-produced food for any of the food items. The number of laborers engaged in agriculture had a significant positive effect on consumption of self-produced potatoes (0.074) and pork (0.051), indicating that the more laborers were engaged in agriculture in the households, the more they

Table 3 Regression of per adult equivalent self-produced pork and egg consumption

Variable	Pork		Eggs	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Log(price of pork)	−0.123	(0.150)	0.288	(0.233)
Log(price of eggs)	−0.039	(0.117)	−0.148	(0.192)
Log(price of mutton)	0.068	(0.113)	0.322*	(0.186)
Log(price of beef)	0.048	(0.069)	−0.087	(0.109)
Log(price of chicken)	−0.149*	(0.078)	0.220*	(0.114)
Log(price of fish)	0.107	(0.111)	0.380**	(0.175)
Log(total expenditures on food)	0.110***	(0.032)	0.063	(0.047)
Distance to the market	0.002	(0.004)	−0.001	(0.006)
Education of laborers	−0.002	(0.010)	0.013	(0.014)
Age of laborers	−0.001	(0.002)	−0.004	(0.003)
Number of laborers in agriculture	0.051*	(0.026)	0.058	(0.038)
Number of adult equivalents	0.135***	(0.027)	0.090**	(0.039)
Shaanxi	−0.200	(0.124)	0.546***	(0.190)
Yunnan	0.191***	(0.068)	0.118	(0.097)
Log(production of pork)	0.131***	(0.029)		
Pork production group	2.744	(3.357)		
Pork production group×Log(production of pork)	0.342**	(0.136)		
Pork production group×Log(price of pork)	−1.109	(1.020)		
Log(production of eggs)			0.090**	(0.043)
Egg production group			−0.157	(0.653)
Egg production group×Log(production of eggs)			0.349***	(0.070)
Egg production group×Log(price of eggs)			−0.148	(0.229)
Constant	1.809*	(0.997)	−1.545	(1.530)
Observations	743		393	
R-squared	0.254		0.281	
Price effect (production lower than the budget)	−1.231	(1.013)	−0.296*	(0.159)
Production effect (production lower than the budget)	0.473***	(0.135)	0.440***	(0.055)

***, $P<0.01$; **, $P<0.05$; *, $P<0.1$.

would consume potatoes and pork from self-production. The number of adult equivalents had significant positive effects on household consumption of self-produced food for all five food items as expected. Education of laborers had a significant negative effect on consumption of self-produced potatoes (−0.032), but not for other food items. Consumption of self-produced food was also significantly influenced by province, as indicted by the dummy coefficients.

A robustness check was conducted by using the log of total income instead of the log of food expenditure. The results showed no significant difference and the conclusion remained the same. For the sake of space, the results of the robustness check are shown in Appendices F and G.

We compared the results from this study with the one from a standard double-log model which did not consider mental accounting and did not include independent variables regarding the set budget. The *R*-squared of the model considering mental accounting was larger than that of the standard model, indicating better model fit of the mental accounting model. The standard double-log model could not distinguish price effects when production was lower or higher than the set budget, and could only capture one overall price effect. For rice, flour, pork, and eggs, the price elasticity estimated by the standard model was in the interval of the price elasticity when production was lower and higher than the set budget estimated by the adjusted model (See Appendix H; Rice, −0.619; Flour, −0.549; Pork, −0.126; Eggs, −0.291). However, for potatoes, the own-price elasticity is larger than both of the elasticities estimated by the adjusted model.

5. Discussion

In this study, we used mental accounting theory to study the consumption of self-produced food of agricultural households. We assumed that agricultural households may use mental accounting in their decisions to consume self-produced food, which implies they reserve a certain quantity of self-produced food for own consumption, then consume this produce until their consumption needs are met. This reasoning was reflected in our finding that the households to a large extent tend to keep on consuming their own produce until they have consumed the quantity set for consumption, regardless of market

price changes. We observed that consumption of self-produced food was not significantly influenced by price for flour, potatoes, and pork when production was lower than the set budget, and it was also not significantly influenced by price for rice, pork, and eggs when production was higher than the set budget. The evidence for the most part is in favor of Hypothesis 1, indicating partial mental accounting, because it does not apply to all products. Also, we found that the consumption of self-produced food was significantly positively influenced by production, but with a much larger influence for households whose production was less than the most recent consumption level. This also partially fits our assumption of another aspect of mental accounting theory, implying that people consume their produce until their consumption needs are met. However, we still found significant positive effects of production on consumption of self-produced food even when production was higher than the set budget. This finding suggests that people's mental food budget is adjusted upwards with an increasing level of production. This process may explain the overconsumption phenomenon that we observed for agricultural households. Huang *et al.* (2020) used a method of hypothetical questions to support the connection of mental accounting and overconsumption of self-produced rice and potatoes. However, the overconsumption phenomenon of agricultural households may also be due to their higher activity levels and higher calorie requirements (Deaton and Drèze 2009).

We notice that production costs may influence the profit from selling self-produced food, due to economies of scale, in addition to transaction cost. Below the set budget production costs may be relatively high, leading to less profit, so more consumption, than above the set budget. For the same reason, higher production below the set budget may lead to higher consumption. However, our data does not contain production costs at the household level, although we take into account transaction cost which were not significant anywhere in the regressions. We leave the issue of production costs for future research.

Even though some evidence of insignificant influence of price on consumption of self-produced food was found, the evidence still could not fully explain why people set the food budget as they do. Possible further research might focus on why the food budget was set in the first place and on the determinants of the levels of these budgets in the second place. Factors such as perceived safer and better quality of self-produced food, and the habit of eating self-produced food, could be studied in the formation of food budgets in line with the mental accounting hypothesis. In particular, reasons for setting the mental consumption budgets too high should be studied because these budgets serve as anchors for actual consumption of self-produced food, possibly leading to overconsumption of certain food items.

Also, other characteristics of mental accounting such as compensation and non-fungibility (Thaler 1999) could be tested concerning the behavior of food budgeting of agricultural households. Non-fungibility implies a reluctance to consume excess produce from another type of food, if they are short of produce in a particular budget. For example, if they are short of rice, they are reluctant to consume excess produce of flour. In general, this assumption would result in less substitution from different food categories, and insensitivity to cross-prices in food demand. Furthermore, the mental accounting assumption on food budgets may also be applicable to agricultural households in many other developing countries with high prevalence of small farming, subsistence agriculture, and similarly developed markets.

Understanding the possible mental accounting process of consumption of self-produced food has some policy implications. The most obvious one is to correct the estimated food price elasticity of agricultural households. From this study, we know that agricultural households consume a lot from self-produced food, and this part of consumption is not sensitive to price change, thus reducing the own-price elasticity. Therefore, the standard demand model may overestimate food price elasticities of agricultural households, which may send the wrong price impact signal for policy making.

Second, this study contributes to the literature about how production is associated with food consumption and diets of agricultural households and what kind of policy is relevant to this association. Policies like nutrition-sensitive agriculture are related to the associations between production, diets and nutrition. A well-known example is the strategy of enriching production varieties of agricultural households in order to improve their dietary diversity (Fanzo *et al.* 2013; Powell *et al.* 2015; Jones 2017). However, recently this strategy has been found to have no clear association with dietary diversity improvement, and to be less effective than strategies to improve market accessibility (Sibhatu and Qaim 2018). Currently, research on the associations between production, diets and nutrition only stays at the level of "variety," meaning only studying associations between production diversity and dietary diversity, answering the question of whether more diversified food production will lead to more diversified diets. However, our study offers a way of thinking how food production is linked with food consumption, and the possible association between production and consumption quantities behind.

Third, nutrition education programs in rural areas usually focus on telling people what to eat and how to eat, without linking food consumption decisions to their market selling decisions. As another implication of this study, information to make agricultural households aware of the opportunity cost of consuming self-produced food could be offered. Furthermore, information such as recommended food and nutrient intake per adult equivalent and for the whole household could be made more easily available as part of nutrition education programs. Making the reference level of consumption more explicit for the households may contribute to avoiding overconsumption due to inappropriately pre-set food quantity budgets. All these policy implications from taking mental accounting into consideration when study food consumption behavior of farm households would help to improve the food choices of farm households, especially smallholders in developing counties, and achieve a more diversified and nutritious diets.

6. Conclusion

This exploratory study assumed agricultural households might have a mental account for the consumption of their self-produced food. We found that the hypothesis of no significant effect of price holds for flour, potatoes, and pork if production is lower than the set budget, and for rice, pork, and eggs if production is higher than the set budget. Production has a significant positive effect on the consumption of self-produced food but with a much greater influence when production is lower than the set budget for all five food items. These findings partly support our assumption of mental accounting of self-produced food. This study offers a way of thinking how food production is associated with food consumption and diets of agricultural households. Offering information to make agricultural households aware of the opportunity cost of consuming self-produced food would help to improve the food choices for a nutritious diet.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

Appendices associated with this paper are available on http://www.ChinaAgriSci.com/V2/En/appendix.htm

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