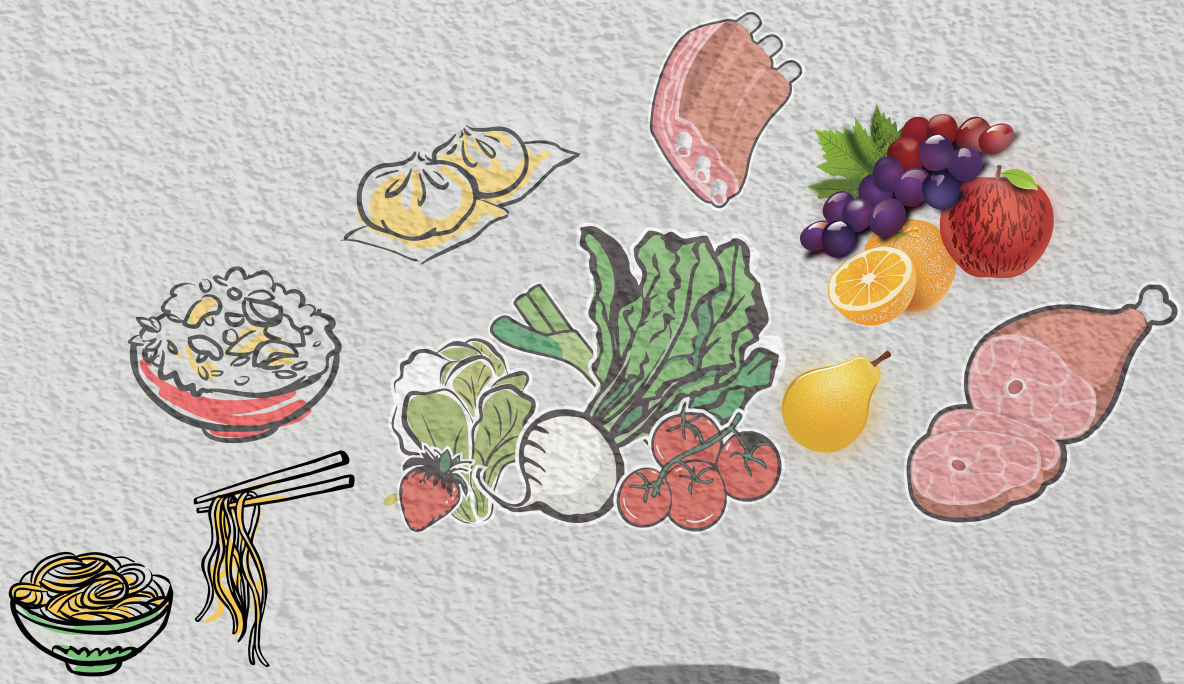
A Behavioral Economic Account of Rural Household Food Consumption

Evidence from Underdeveloped Areas in China



Jiaqi Huang

Propositions

1. The opportunity cost of own-produced food reserves is greatly overlooked.
   (this thesis)

2. Food perception and habit are grossly underestimated in the food and nutrition policies for poor rural households.
   (this thesis)

3. Behavioral economics is shedding new light on the sophisticated cathedral of neo-classical economics.

4. Always being aware of the contexts and considering the applicability of scientific theories is crucial for social sciences.

5. For a sandwich PhD to obtain a doctoral degree requires the mastering of integrative negotiation skills.

6. Migration takes weeks, integration takes decades.

7. The growing self-centered media trap people in information cocoons.

Propositions belonging to the thesis, entitled:
'A behavioral economic account of rural household food consumption'

Jiaqi Huang
Wageningen, 5 July 2021

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Thesis committee

Promoters
Prof. Dr G. Antonides
Emeritus Professor of Economics of Consumers and Households
Wageningen University & Research

Prof. Dr E.S. van Leeuwen
Professor of Urban Economics
Wageningen University & Research

Co-promoter
Prof. Dr F. Nie
Agricultural Information Institute
Chinese Academy of Agricultural Sciences

Other members
Prof. Dr N. Heerink, Wageningen University & Research
Prof. Dr J.C.M. van Trijp, Wageningen University & Research
Prof. Dr E. van Dijk, Leiden University
Dr K. Gardebroek, Wageningen University & Research

This research was conducted under the auspices of the Wageningen School of Social Sciences (WASS)

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Thesis

submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus,
Prof. Dr A. P. J. Mol,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Tuesday 26 October 2021
at 1:30 p.m. in the Aula.

Jiaqi Huang
A Behavioral Economic Account of Rural Household Food Consumption:
Evidence from Underdeveloped Areas in China
198 pages.

PhD thesis, Wageningen University, Wageningen, the Netherlands (2021)
With references, with summary in English

ISBN: 978-94-6395-966-7
DOI: https://doi.org/10.18174/553301

Table of Contents

CHAPTER

1

General Introduction

1.1 Introduction

Food consumption is an important topic and attracts a wide range of public and policy concerns, and market interests. Poor diets or inappropriate food choices may lead to various adverse health outcomes such as undernourishment, micro-nutrients deficiency, and obesity, which may further cause diet-related diseases, high health costs, and lost productivity and well-being. All these adverse outcomes call for appropriate interventions: food policy, good assistance program, or "nudges" that encourage healthier food choices (Mancino et al., 2018).

Research on determinants of food consumption and their potential effects will help to design effective interventions. Scientists from different domains apply various tools to study determinants and their effects on food consumption, using different perspectives. Economists often rely on standard demand theory to study "food demand." Specifically, they explore how changes in food prices, income, demographics, and policy factors influence the demand for food. In contrast, psychologists apply psychological models and behavioral theories to study "food decision making" or "food choices" of people, assuming that people show bounded rationality in decision making under different circumstances. These two stems of research have divergent theoretical roots but can be complementary to each other (Antonides, 2021).

A growing number of studies in behavioral economics have tried to make use of knowledge from these two domains to understand people's food consumption behaviors better. Two drivers trigger this trend. First, people show bounded rationality, and in reality they can hardly choose an "optimal" bundle but make suboptimal "satisfactory" decisions instead (Simon, 1997). On average, people make 200 to 300 decisions regarding food consumption in a day (Wansink & Sobal, 2007), which requires much cognitive effort if everyone thinks rationally and makes clear calculations for each food decision. Instead, people rely on heuristics, norms, and habits. So, without considering behavioral aspects, the standard economic model may fail to explain and predict food behaviors in actual life. Also, food policies based on the standard economics framework, such as influencing price, providing information, and limiting the set of choice alternatives, were found to be not as effective as expected (Bennett et al., 2013; Just & Gabrielyan, 2016; Tiffin & Arnoult, 2011), and even to bring about unwanted adverse effects (Timmer, 2012). Therefore, one branch of primary literature tried to modify standard economic models of food consumption by incorporating known psychological phenomena. Another branch aims at finding more and more successful applications of behavioral economics-based "nudges" that only make subtle changes in the food environment but have a prominent effect on achieving healthy diets (Just & Gabrielyan, 2016). These alternative branches of literature are more diverse, showing scattered and subtle findings, than the standard economic literature, but may be more effective in designing policy alternatives influencing people's food consumption.

Although the application of behavioral economics in food consumption research looks promising, the existing literature is still sparse and shows an apparent imbalance concerning

geographical location and population. The overwhelming majority of related studies were conducted in developed countries (Just & Gabrielyan, 2016), where overweight, obesity, and unsustainable food consumption are the main concerns, and healthy diets and sustainable food consumption are the primary targets. In contrast, little research applying behavioral economics in food consumption has been found in developing countries, where a considerable number of people are still suffering from hunger and micronutrient deficiency, in addition to many who are overweight and obese. The main food-related objectives in developing countries are ensuring food security for everyone and improving nutritional status. Thus, an imbalanced tendency of research in developed and developing countries implies an imbalanced interest in applying behavioral economics to address different food problems. We have some knowledge about how behavioral economics can contribute to healthy and sustainable diets, but we know little about how behavioral economics can contribute to improving food security and dietary diversity for people who live in underdeveloped circumstances.

With respect to an imbalanced focus on populations, existing behavioral economic research in food consumption mainly focuses on pure consumers who are mostly urban residents. Some researchers have focused on particular food environments such as grocery stores, supermarkets, and schools, and analyzed the food behavior of customers and students (Greene et al., 2017; Payne & Niculescu, 2018; Sutherland et al., 2010). This topic is popular in consumer and marketing studies. However, little is known about how behavioral economics can contribute to understanding the food consumption of rural residents, who face different food environments, and who often are both food producers and consumers. Some literature has called for considering and researching the behavioral dimensions of food security, especially for the poor (Just & Gabrielyan, 2016), and for the hundreds of millions of small farmers (Timmer, 2012) in developing countries.

Noticing the research gaps of behavioral economics in food consumption for rural residents in developing countries, this dissertation aims to bring behavioral economic insights to provide additional explanations of food consumption of rural households in underdeveloped areas of China. More specifically, this dissertation examines loss aversion and asymmetric price effects on food demand; explores mental accounting application in dealing with self-produced food and its dietary outcome; and tests how attitudes, subjective norms, perceived behavioral control, perceived need, and habit influence food consumption of rural households.

In this chapter, we first provide an introduction to the applications of behavioral economics in food consumption and identify research gaps and motivation of this research. Next, we discuss the main aspects of food consumption of rural households and their possible relations to behavioral economics that form the basis for the five main empirical chapters (Section 1.2). After that, we briefly introduce the context of the research (Section 1.3), then explain the main research questions (Section 1.4), methods (Section 1.5), and provide an overview of each of the chapters (Section 1.6).

1.2 Key aspects of food consumption of rural households and relation to behavioral economics

1.2.1 From quantity to quality

Ending hunger, food insecurity and all forms of malnutrition by 2030 are the main targets of the Goal 2-Zero Hunger of the 17 Sustainable Development Goals (SDGs) (United Nations). The food security and nutrition status in the world is still threatening. According to the latest estimation for 2019, almost 690 million people are undernourished, meaning people whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life (FAO et al., 2020). Undernourishment usually is estimated based solely on energy, indicating a certain quantity of energy intake. However, beyond quantity, people also need quality food for a healthy life. There are around 2 billion people, or 25.9% of the world population, experiencing micronutrient deficiencies, caused by poor quality diets and inaccessibility to regular nutritious and sufficient food (FAO et al., 2020). Micronutrient deficiency hits the low-income countries and the poor the most. Also, smallholder farmers in developing countries, despite being food producers and contributing a high share of food production in Asia and Africa, are the group particularly suffering from micronutrient deficiencies due to low income and low dietary diversity (IFPRI, 2016).

Ensuring food quality is much more difficult than ensuring food quantity. First of all, a nutrient-adequate diet is more expensive than an energy-adequate diet. On average, the cost of a nutrient-adequate diet exceeds the cost of an adequate-energy by a factor of 2.66 (Bai et al., 2021). Due to the high cost, the poor are being priced out of nutrient-adequate diets (Global Panel on Agriculture and Food Systems for Nutrition, 2020). Moreover, even though income has increased, increasing income does not always lead to increased consumption of nutritious food. Instead, people may increase their expenses on non-food commodities or services, or buy foods that are not nutritious but simply more expensive (Banerjee & Duflo, 2011).

Clearly, policies aiming at combating nutrient deficiency require better information and evidence about people's nutrient intake responses to price and income changes. Traditional food demand analysis, however, mainly estimated food price and income elasticities, focusing only at food expenditures and food quantities. A certain kind of food can be conceived of as a bundle of nutrients that have want-satisfying properties to consumers. This approach is consistent with the characteristics approach in demand theory (Lancaster, 1979). Not much effort has been put into estimating nutrient elasticities, although some research has estimated calorie elasticity (Subramanian & Deaton, 1996; Abdulai & Aubert, 2004), and little effort has been made in estimating other macro- and micro-nutrient elasticities (Ecker & Qaim, 2011; Santeramo & Shabnam, 2015), for example, protein, fat, iron, zinc, vitamin A and iodine. The combination of a high-calorie income elasticity and a low macro- and micronutrient income elasticity may imply that with income increase, people would consume more calorie intensive foods than foods with rich

nutrients, which is not befinicial for people's health. The majority of studies show that calorie quantity has lower income elasticity than other nutrients (Santeramo & Shabnam, 2015; Skoufias et al., 2009).

In this dessertation, we address the food cosnumption of rural households in underdeveloped areas of China not only from a perspective of food quantity, but also food quality. Particularly, we give a fresh estimate of nutrient intake and nutrient elasticities for rural households who are living in a rather poor and remote mountainous areas (Chapter 2). Moreover, we attach great importance to dietary diversity throughout the dissertation, which was used as an indicator of food quality in many cases. We focus on food items with high nutritional value but low consumption frequency (suggesting deprivation) in the survey areas, and analyse the reasons of low consumption from a behavioral and psychological perspective (Chapter 6).

1.2.2 Consumption from own production

Most rural households in developing countries are smallholder farmers who produce food for the markets and for own consumption. Unlike pure consumers who can only consume food from purchasing, many smallholders consume considerable amounts of food from their own production (Fanzo et al., 2013; Sibhatu & Qaim, 2018). The main good side of consuming own production is the buffer effect in periods of sharp food price increase (Park, 2006). Practice like homestead food production are promoted in many countries aiming at increasing dietary diversity of smallholder farmers by increasing production diversity (Ruel et al., 2013).

Considering own production in food demand analysis

Production and consumption decisions are linked. For the consumption side, households need to make a decision: how much food should be sold and how much should be left for own consumption. Economists have developed the Agricultural Household Model (AHM) to tackle this issue (Singh et al., 1986). Different from a pure consumer demand model, the household budget of an AHM is not exogenous and fixed but endogenous and depends on production decisions that contribute to income. In agricultural household models, 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 own-produced products is higher than the market price minus transaction costs, then it is better to keep the product for own consumption (Taylor & Adelman, 2003).

Although the AHM is more appropriate than pure consumer demand models to analyze food consumption demand of agricultural households, in reality very few researchers choose to apply AHM. This is mainly because AHM has very strict assumptions and even the most simplified AHM requires substantial data. In many cases, information on both consumption and production is hardly available at the same time. Moreover, due to its complexity, AHM can hardly meet the interest to discuss effects of economic factors on various kinds of food, implying further impacts

on diet diversification and nutrition. For many agricultural households, there are several kinds of food that can be consumed, sold, or purchased (Sibhatu et al., 2015). However, AHM usually can only deal with one commodity which is produced and consumed by the household (Key et al., 2000). Therefore, many studies still use pure consumer demand models to estimate food demand of rural households.

Due to data constraints, existing food and nutrient demand studies for rural households either did not include food consumption from own production, or estimated all food consumed without distinguishing the food sources, which may cause evaluation bias since the part of consumption from own production may react differently to price and income changes. Tekgüç (2012) found that ignoring the consumption from own production led to significant overestimation of food expenditure elasticity for dairy products and eggs and own-price elasticity for bread and cereals in Turkey.

Mental accounting and consumption of own production

Besides the question of how to allocate the quantities of own production to consume, and demand estimation with or without considering consumption from own-production, limited research has dealt with the question of how the consumption of own produce would be influenced by the allocation.

In low-income rural contexts where small-scale farming is prevalent, own-produced food, especially grain, is often used first to meet agricultural households' own consumption needs. Households are frequently observed to first reserve a "pre-committed quantity" from own production (Park, 2006), and the "pre-committed quantity" is usually more than what a household needs in a harvest period (Barrett & Dorosh, 1996; Park, 2006). Storing a more-than-needed amount of grain serves as a consumption smoothing strategy for agricultural households. The "pre-committed quantity" of food reserve, however, tend to respond hardly to price changes (Huang et al., 2018; Park, 2006; Piggott, 2003). It seems that even when market price is high, and the market is accessible, households may still be reluctant to sell part of the "pre-committed quantity" for cash income. Little is known about whether this inflexible use of food reserve influences household food consumption, and what the dietary outcome might be.

The inflexible use of a "pre-committed quantity" may come at a cost. When the market is accessible, the increased cash income from selling part of the grain reservation can be used to purchase other food varieties and other commodities or services. Nevertheless, an outcome of excess consumption of own-produced grains and tubers was found as compared with the dietary recommendation (Huang et al., 2020). It seems that with excess grain reservation, households consume more than needed and overlook the opportunity cost of consuming the excess part of grain reserve. This excess consumption raises nutritional concerns, since grain-producing households, for example, could have sold the overconsumed part of grain for cash income and could have bought more varieties of food to achieve a more diversified diet.

Considering the process of allocating own-produced food, the inflexibility of using own-produced food reserve, and the overconsumption result all together, we expect that the allocation and consumption process of own production is very similar as the financial budget setting and expenditure tracking behavior predicted by mental accounting theory.

Mental accounting was introduced by Thaler (1985), who defined a mental account as an outcome frame set up for a specific consumer choice. Mental accounting theory states that people tend to set mental budgets for specific categories of expenditure and then track their consumption against the set budgets, for monitoring their actual spending (Thaler, 1985, 1999). Just, Mancino, and Wansink (2007) point out that because of mental accounting, household may also allocate a portion of income specifically for food, and when food prices decline, one may overlook the opportunity to shift the surplus "food money" to spending for another purpose. Instead, one will buy more food. In this case, a low price of an item may lead to overconsumption rather than substitution. It may also work for agricultural households, who set the pre-committed reserve of their own production as a mental budget for consumption, and this budget is guiding their consumption to some extent.

To our knowledge, we are the first to apply insights from mental accounting theory to explain the consumption of own-produced food of agricultural households, particularly addressing the insensitivity to price change (Chapter 4), and the dietary outcome (Chapter 5).

1.2.3 Price effect and its asymmetry

Food price is the main factor that influences people's food choice and food security. Food crises, driven by sharp spikes in food prices, enormously damage the life and well-being of the poor (World Bank, 2005).

Price elasticities usually are estimated from food demand analysis to indicate how people's food consumption react to price change. The information of price elasticity for a certain group of people is very useful for designing food policies aiming at influencing food prices for a particular dietary goal (Babu et al., 2016). However, food price elasticities are volatile and vary by food item, time, context, demographic situation, and income level of households. Some evidence shows that rural agricultural households are more sensitive to food price changes than urban households (Ecker & Qaim, 2011), while others found the opposite result (Deaton, 1987). Some found own-price elasticity of animal-sourced foods being higher than that of staple foods (Zhang et al., 2012; Chang & Li, 2006), while others showed own-price elasticity of staple foods to be higher (Huang, 1999; Xu et al., 2015).

Loss aversion and asymmetric price effects

Food demand analysis based on standard demand models all assume that the price effect on food demand is symmetric. This means that an equal movement in price increase and price decrease leads to the same change in quantity of food consumption. However, asymmetric demand sensitivity under different directions of price change has been observed in reality, and particularly

consumers show stronger sensitivity to price increases than price decreases (Kalwani et al., 1990; Hardie et al., 1993; Neumann & Böckenholt, 2014).

Loss aversion as proposed in prospect theory (Kahneman & Tversky, 1979) may be the psychological foundation to explain the observed asymmetry of price effects. General loss aversion theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991), based on a certain reference point, shows that 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). People may perceive a price increase as a loss, and perceive price decrease as a gain, and react to them differently. 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 for food demand research (exceptions are Putler, 1992; Maynard & Subramaniam, 2015). 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 et al., 2005).

The limited previous research on loss aversion and 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 is a profitable situation for farmers, so they sell more products for higher income and consume less of their produce.

Kahneman Knetsch, and Thaler (1991) made an experiment aiming at comparing reluctance to buy and reluctance to sell of buyers and sellers, respectively. They randomly assigned 77 students to three conditions: the Sellers, who were given coffee mugs and were asked for the price at which they would be willing to sell; the Buyers, who were asked the price at which they would be willing to buy; and the Choosers, who were not given a mug but were asked to choose between having a mug or an amount of money from a series of prices. The results showed that the Choosers behaved more like Buyers, who had much lower reservation prices than the Sellers, indicating the endowment effect of the Sellers. The Sellers who owned the mugs were more reluctant to part with their endowment that the Buyers wanted to acquire it, thus showing that the endowment effect was mainly due to the Sellers. In this dissertation, we incorporate loss aversion in demand models to explore possible asymmetric food demand of rural households, compare different methods of modeling reference prices in demand models, and test for loss aversion effects separately for pure consumers and farmers in rural areas for the first time (Chapter 3), which is helpful to understand the complexity of price-change effects under different directions.

1.2.4 Attitudes, norms, behavioral control, and habits

Adapted economic demand models could well explain effects of external factors on consumption but cannot disclose how consumers translate external information and incentives into consumption decision making. Facing the same context and equal economic status, consumption might be different across households because of different perceptions and beliefs. Social-psychological models are useful tools to analyze decision-making factors and processes, and thus informative to design interventions to change target behaviors into favorable directions (Hardcastle et al., 2015). Among those models, the theory of planned behavior (TPB) has been widely applied in predicting consumer intentions and behaviors in many domains, including food choice (Conner & Armitage, 2006).

Planned behavior theory (TPB), which is extended from expectancy-value theory and reasoned action theory, explicitly captures mental processing of information in an optimal way (Antonides, 2008). TPB describes the relationships between attitudes, subjective norms, perceived behavioral control, behavioral intention, and behavior (Ajzen, 1991), and has been applied to predict food choice intentions and behaviors successfully (McDermott et al., 2015).

Although existing food-related research often applies TPB to healthy diets, which intends to address overweight and obesity issues, few studies address undernutrition issues. Moreover, perceived need and habit are two constructs suggested to be added to the standard TPB to predict food choice and dietary behaviors (Verbeke & Vackier, 2005; Paisley & Sparks, 1998), but they were never included jointly in one study. Furthermore, most food-related studies including perceived need or habit stopped at the stage of predicting intention. To what extent perceived need and habit affect behavior is not clear.

In addition to the external economic factors, in this dissertation, we also aim to explore the psychological factors of food choice by looking at how attitudes, subjective norms, perceived behavioral control, perceived need and habit jointly influence food consumption of rural households (Chapter 6). This will be helpful to develop a broader array of policies or strategies to improve dietary diversity and nutrition of rural residents.

1.3 The context: food consumption of rural residents in China

China, containing one-fifth of the world population, has contributed the most to the reduction of undernutrition over the last two decades: about two-thirds of hunger population reduction has been attributed to China (FAO et al., 2020). The estimated prevalence of undernutrition for China sharply decreased, and in 2017 it was below 2.5% (FAO et al., 2020). Despite this widely acknowledged success, China still faces malnutrition challenges. According to the latest statistics, there are still 7% of children in China that are stunted, and 5% are underweight. As for symptoms of micronutrient deficiencies, the anemia rate for residents aged 18 years and

above is 8.7%, for children and adolescents aged 6–17 years it is 6.1%, and for pregnant women it is 13.6% (National Health Commission of China, 2020).

China has been through a food consumption and nutrition transition in the past decades. The food consumption in China has dramatically shifted from a simple "grains plus vegetables" pattern to a more diversified pattern with more consumption of animal-sourced food (Burggraf et al., 2015; Zheng et al., 2015). From 1990 to 2019, per capita consumption of grain and vegetables has declined, while the per capita consumption of edible oil, meat, poultry, aquatic products, eggs, and dairy products has increased. Although general dietary changes were observed in the whole of China, the differences in food consumption between urban and rural residents are still remarkable. In 2019, per capita grain consumption of rural residents was 40% higher than that of urban residents, while per capita consumption was lower than that of rural residents for dairy products (56.3%), beef and mutton (48.8%), aquatic products (42.5%), fresh fruits (35.5%), eggs (16.5%), and poultry (12.3%) (National Bureau of Statistics of China, 2020; Nie, Huang, & Bi, 2014). The consumption level of dairy products, aquatic products, fruits, and eggs of rural residents in China is largely lagging behind that of urban residents (Zhou et al., 2012). Micronutrient deficiency is also more prevalent in rural areas (Luo et al., 2011; Wong et al., 2014). Most of the stunted children are also living in these areas.

The existing food demand studies in China mainly focus on global urban or rural populations, but not on the most food insecure and vulnerable people living in underdeveloped rural areas. A limited number of food demand studies for residents in underdeveloped rural counties in China showed that, compared with the average rural residents, residents in underdeveloped rural counties seemed to have lower income elasticities for grains but higher income elasticities for animal origin foods, and fruits (Huang et al., 2016). As for nutrient demand studies, none has been found particularly focused on rural residents in underdeveloped areas. Therefore, we chose underdeveloped rural areas in China as the research context for both its practical significance and research gap.

1.4 Objectives and research questions

Based on the research gaps and issues considered above, the main objective of this dissertation is integrating behavioral economic insights into food consumption studies to provide additional explanations of food consumption determinants and their effects on rural households in underdeveloped areas of China. The relevant behavioral economic insights have been identified because of their expected contribution to explain rural household decisions about food consumption. To fulfil this broad objective, five research questions will be addressed in five chapters of this dissertation:

(1) To what extent do price, income, and demographic factors influence consumption of different food groups and intake of different nutrients? How is it different for agricultural households and other households? (Chapter 2).

(2) To what extent does loss aversion affect food demand in response to food price changes in different directions? How is it different for pure consumers and farmers? (Chapter 3).

(3) How does rural household consumption of own-produced food fit the mental accounting hypothesis? To be specific, the following hypotheses were tested: 1) the consumption of self-produced food is not significantly influenced by market price, taking into account transaction costs; 2) the consumption of self-produced food is increasing in the quantity of production if production is lower than the set budget; 3) the consumption of self-produced food is independent of the quantity of production if production is higher than the set budget. (Chapter 4).

(4) Do rural households set mental budgets for own-produced food for self-consumption and do they track their consumption against the set budget possibly leading to overconsumption? Which households are more likely to apply mental accounting on own-produced food? (Chapter 5).

(5) How do attitudes, subjective norms, perceived behavioral control, perceived need, and habit jointly influence the intention and actual consumption of different food items? (Chapter 6).

1.5 Overview of research methods

1.5.1 Theories

Four theories fulfil a central role in this dissertation, namely demand theory, loss aversion theory, mental accounting theory, and the planned behavior theory. Using demand theory, we study the role of economic factors and demographics on food consumption and apply this theory to nutrient intake. Applying behavioral economic insights, this dissertation builds a bridge between psychological and economic insights by testing for loss aversion effects on food demand. Furthermore, the theory of planned behavior will be applied to study the role of psychological factors on food consumption decision making. This interdisciplinary research is expected to increase the explanatory power of the determinants of food consumption.

1.5.2 Sampling and data collection

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 the Chinese Academy of Agricultural Sciences. I participated in the questionnaire design, survey organization, and data collection process in years 2012, 2015, and 2018. Additional questions were designed and added in the household survey in year 2018 to fulfil the research aims of Chapters 5 and 6.

This dataset was gathered from face-to-face interviews in six underdeveloped rural counties of three provinces (Shaanxi, Yunnan, Guizhou) in China. The first round of survey was supported by the UN-Spanish Joint Programme, "Improving nutrition, food safety and food security for China's most vulnerable women and children." The six counties were selected from the 592

Nationally Defined Key Poverty Counties[1] where the food security status was considered to be the worst and where they showed capacity and willingness to participate the UN-Spanish Joint Programme. The six counties are Zhen'an and Luonan in Shaanxi province, Huize and Wuding in Yunnan province, and Pan and Zheng'an in Guizhou province. Shaanxi province is located in the middle of China; Zhen'an and Luonan county both are located in the south of Shaanxi. Guizhou and Yunnan provinces are next to each other, and both are located in the southwest of China. Zheng'an county is in the north of Guizhou, and Pan county in the south. Huize and Wuding are both in the north of Yunnan province. All six counties are in remote mountain areas.

The required sample size for the survey was calculated using standard sample size calculations with each county representing a stratum. After the sample size was calculated, a two-stage clustering approach was applied. The first stage was the selection of villages. In each county, 19 villages were selected using the probability-proportional-to-size (PPS) method. Then, in the second stage, 12 households within each village were randomly selected. In each county, 228 households from 19 villages were sampled. The total sample size for each wave was 1,368 households in 76 villages. A total number of 4,104 observations in all three waves were collected from 2,124 households.

The dataset of all three waves includes comprehensive household information on food consumption (consumption amount from the market, consumption amount from own-production, market price, and expenditure on different food items), income, expenditure, production, market access, and demographics. The third-wave survey included hypothetical scenario questions on food reserve and consumption, and questions reflecting attitudes, subjective norms, and perceived behavioral control, perceived need, and habit concerning each kind of food.

1.5.3 Methods

In Chapter 2, we estimated the food and nutrient elasticities based on the Quadratic Almost Ideal Demand System (QUAIDS) proposed by Banks et al. (1997). A two-stage budgeting approach was applied. For the first stage, total food demand was estimated with a double-logarithmic regression. In the second stage, eight major food groups: grains, bean products and nuts, tubers, vegetables, fruits, meats and aquatic products, eggs and dairy products, and oil, were estimated with the QUAIDS model. Since a considerable fraction of households in rural areas consumed part of their own food production, we controlled for food production variables and instrument prices to account for possible endogeneity. We calculated demand elasticities for the whole sample population as well as at group means for households with agriculture as main income source and other households. Then, based on the estimated price and income elasticities and the

[1] In 1994 the Chinese government identified 592 counties as Nationally Defined Key Poverty Counties based on annual net per capita income of less than 400 RMB (around 58 US dollars). The list of counties was updated in 2006 but with the same number of counties. The 592 counties spreading across 21 provinces accounted for 233 million people. The counties are mostly in the western region of China and in mountainous areas. A third of them are within three provinces: Yunnan (73 counties), Guizhou (50 counties), and Shaanxi (50 counties).

food nutrient composition information derived from the China Food Composition Table (FCT), nutrient elasticities were calculated for important macro- and micronutrients such as energy, protein, iron, zinc, vitamin A and vitamin C by the algorithm suggested by Ecker and Qaim (2011). For the simulation scenarios, the nutrient elasticities were used to estimate the nutritional changes in the individual households' daily food purchases when prices or income would change.

In Chapter 3, it is assumed that every household has an internal reference price. When the actual price of a certain food is higher (lower) than its internal reference price, a *loss* (*gain*) is experienced. The reference price is assumed to be equal to the price in the previous period. We identified two different model specifications to test loss aversion effects in food demand. The different model specifications reflect different ways to model reference price effects in demand models. One specification, called the segmented price model, compared price elasticities of households facing a price increase with those facing a price decrease (Yan et al., 2016; Talukdar & Lindsey, 2013). The other specification, called the price increase and price decrease model, added the difference of logged market price and logged reference price in price increase and decrease situations in addition to the standard demand model (Putler, 1992; Vande Kamp & Kaiser, 1999; Maynard & Subramaniam, 2015). We applied a fixed-effects approach in double-log demand form with two 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). If the estimated coefficients of the variables of losses and gains were significantly different from zero, and if the absolute value of the coefficient in the case of a loss was greater than that in the case of a gain, then existence of the loss aversion effect was confirmed.

In Chapter 4, we applied a double-log model to study how production, food prices, and transaction costs influenced consumption of self-produced food, and whether the influence was different below and above the point where production equaled 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. Production is also a very important explanatory variable, since the consumption of self-produced food could be highly related with production quantity. 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.

In Chapter 5, we examined whether mental accounting theory was applicable to consumption of own-produced food of rural farm households by using hypothetical scenarios. We set a food reserve condition (exceeding their consumption needs), creating surplus and shortage situations with respect to the quantities of "food-needed-to-consume" in the middle of a harvest period, and

observed the farmer's choice of food consumption in the next half of the period. In this way, we investigated whether people use "food-needed-to-consume" or "food reserve" as the mental budget, and whether people tracked their food consumption against the set budget and compensated. We further examined who were more likely to apply mental accounting and whether mental accounting had an effect on actual consumption of own-production by using logit and ordinary least squares regression models.

In Chapter 6, we applied the standard theoretical framework of the theory of planned behavior (Ajzen, 1991) and further extended it by adding constructs of perceived need and habit. Structural equation modeling was applied to test the relationships among constructs.

1.6 Outline of the thesis

After this general introductory chapter, each of the proceeding chapters addresses a specific objective stated in Section 1.4. Chapter 2 provides food and nutrient demand analysis of rural households with a special look at contribution of own production. Chapter 3 examines the loss aversion and asymmetric price effects on food demand, with a comparison of pure consumers and farmers. Chapters 4 and 5 both deal with the hypothesis of mental accounting on consumption of own-produced food, while Chapter 5 focuses more on the dietary outcome of applying mental accounting. Chapter 6 explores how social-psychosocial factors jointly influence people's intentions as well as actual behavior of food consumption. Chapter 7 concludes with a summary of the main findings, and discussion of theoretical as well as policy implications, together with the limitations and suggestions for future research.

As a remark, this dissertation consists of research papers that are either published (Chapter 4, 5, and 6) or submitted to scientific peer-reviewed journals for publication (Chapter 2 and 3). Hence, Chapters 2 to 6 can be read independently. The references of all chapters are collected together at the end of the dissertation.

CHAPTER

2

The Effects of Food Prices, Income, and Own-produced Food on Food and Nutrient Demand

This chapter was a selected paper for presentation at AAEA as:
Kuhlgatz, C. H., Huang, J., Antonides, G., & Nie, F. (2018).
The effect of food prices and own-produced food on food security of Chinese rural households.
2018 Agricultural and Applied Economics Association (AAEA) Annual Meeting , August 5 7, Washington, D.C

Abstract

Given the relevance of economic factors in contributing to undernutrition, this study analyzes survey data of 1368 households from underdeveloped rural areas of China to find out the links between income and food price changes on nutrition insecurity. A two-stage budgeting approach is applied. In the first stage, total food demand is estimated with a double-logarithmic regression. In the second stage, the demands of the major food groups (grains, meats, fruits, etc.) are estimated with the QUAIDS model. Since a considerable fraction of households in rural areas consume part of their own food production, we control for food production variables and instrument prices to account for possible endogeneity. Based on the estimated price and income elasticities and the average nutrient content of these food groups, nutrient elasticities are computed for important macro- and micronutrients. We then simulate the effect of grain price and income shocks on nutrient intake. We find that income changes have a greater nutritional effect on agricultural households than on other households. Grain price increases have greater effect on nutritional status of the group of other households, while a grain price reduction is not clearly favoring the nutritional situation of a particular household group. This demand study contributes to the literature by taking into account differences in consumption of own production between households, and the potential endogeneity of prices resulting thereof. We also demonstrate that the sole report of nutrient elasticities might not be sufficient for policy recommendations. Thus, we conclude that simulations are essential in evaluating the effect of price or income changes on the nutrition situation of households.

2.1 Introduction

Inability to afford food is a major factor contributing to food insecurity. As a consequence of poverty and high prices, households in many parts of the world cannot purchase the quantity and variety of food needed to prevent hunger and malnutrition. In order to determine policy measures aimed to reduce food insecurity, it is therefore vital to know how vulnerable households respond to food price and income changes.

Given that economic progress in developing countries its greatest impact on urban areas have often lagged behind in rural areas, most of the population vulnerable to food insecurity nowadays lives in rural regions. For instance, 70% of the 1.4 billion extremely poor people live in rural areas, and 75% of these rural poor are smallholder farmers (FAO, 2015). Facing imperfect markets, agricultural households in such underdeveloped regions still use significant fraction of their produced food for own consumption. This is reflected in the sample of underdeveloped rural areas in China that we analyze, in which on average 12% of the fruits, 33% of the grains and 62% of the vegetables consumed came from own production. An analysis of food insecurity in underdeveloped rural areas therefore needs to take into account two issues: a) the nutrient supply of food coming from own production, and b) the effects of agricultural production on food demand decisions. While the former depends on whether the data on self-produced food is available, the latter is a methodological issue, which stems from the fact that agricultural households might have different opportunity costs than reflected in the market price (Sadoulet & De Janvry, 1995). This is because when farmers face imperfect product- or input-markets, an agricultural household would not separately optimize production and consumption decisions, and the separability assumption inherent to typical demand analyses does not hold anymore. The willingness to pay the price for food purchases (or willingness to accept a price for farmers) then becomes a function of market prices and individual farm attributes such as inaccessibility of certain inputs or high price bandwidths between the consumer's buying price and the producer's selling price. When the agricultural household's willingness to pay the price for purchasing food is different from the observed market price, estimation of the household's food demand response based on the observed price can be biased. This potential bias is likely to be high in poor rural areas, where market infrastructure is lacking.

In the literature on links between food demand and nutrient supply, few studies have taken into account own produce with respect to the points raised above. As Tekgüç (2012) pointed out, studies on food demand in developing countries have typically applied demand analysis models designed for an industrial country context without adjusting for consumption of own production. Han (2001) estimated demand elasticities in rural China for three household groups that have different degrees of self-sufficiency in fruits and vegetables consumption and found that elasticity estimates varied considerably between the groups. He concludes that self-sufficiency should be an important consideration when modeling consumption behavior in the rural areas of China. Tekgüç tackled this issue in his estimation of food demand elasticities for Turkey by introducing the

household's budget share of own-produced food as a control variable. Ignoring this variable would have led to significant overestimation of several food expenditure and own-price elasticities (Tekgüç, 2012). This approach was also used by Wardhani (2017) in her analysis of Indonesian food demand. Given that expenditure survey data (employed by Tekgüç, 2012, and Wardhani, 2017) typically lack farm-specific data, Tekgüç (2012) mentions that his approach is limited in capturing the effects of own production on food demand. Furthermore, the approach of adding control variables to the demand model allows the demand response to shift but cannot correct that observed prices might not be the prices that farm household use for their food purchase decisions. Without such correction, an unbiased estimation of the average demand response on the aggregated demand curve is not possible. To the best of our knowledge, no further study has accounted for non-separability.

Our study fills this research gap and sheds new light on how price and income changes affect food insecurity in rural areas. We do this by employing the quadratic almost ideal demand system (QUAIDS) proposed by Banks et al. (1997) in a two-stage budgeting framework. The bias correction is implemented by using an augmented instrumental variable method, in which each market price is instrumented with farm-specific variables (Lecocq & Robin, 2015). We further refine the demand model by introducing socio-economic variables such as household composition and wealth into the demand equation. Given that a simultaneous determination of food budget shares and the total food expenditures might induce endogeneity in the QUAIDS estimation (Blundell & Robin, 1999), we follow Bopape (2006) by using income as an instrument for total food expenditures. We then use a version of the formulas in Ecker and Qaim (2011) to calculate average nutrient price and income elasticities for a) households with agriculture as main income and b) other households (of which still many have agriculture as a side business). Finally, we use these elasticities to simulate how changes in income or grain prices affect the food and nutrition security in the studied underdeveloped rural areas. In those simulations, the consumption from own-produced food is taken into account.

We use a rich dataset from China collected in 2015, which covers data from 1368 households in six underdeveloped rural counties of the Shaanxi, Yunnan, and Guizhou provinces. China is an interesting case, given that it has contributed much to the reduction of the worldwide hunger population (FAO, 2017) but still faces malnutrition challenges especially in underdeveloped rural areas. In China, most of the undernourished population lives in rural areas, a fact that is associated with higher rates of micronutrient deficiencies and stunting in rural areas than in urban areas of China (Luo et al., 2011; Wong et al., 2014). Furthermore, Chinese policy aims to improve the food security situation in rural areas and does this by an array of policies such as producer subsidies, minimum purchase prices for producers, and consumer price subsidies. The purpose of this study is thus twofold. Firstly, we demonstrate the relevance of considering production side effects on demand estimates in rural areas. Secondly, we provide simulation results that are useful as an input for tailor-made economic nutrition security policies.

The paper is structured as follows. Section 2.2 explains the econometric method applied and highlights the method to account for potential endogeneity. In Section 2.3 we describe the data, and Section 2.4 discusses the elasticity estimates of food and nutrients and presents simulation results based on these estimates. The results and its policy implications are discussed in the conclusion Section 2.5.

2.2 Method

2.2.1 Demand system framework

We estimate a complete demand system by employing the almost ideal demand system (AIDS) originally proposed by Deaton and Muellbauer (1980). The AIDS allows flexible price responses that are in line with demand theory, assuming a utility-maximizing household facing a budget constraint. Deaton and Muellbauer (1980) developed the theoretical framework of the AIDS, in which originally the following budget share demand functions are estimated in a system of equations:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{m}{P}\right) + \varepsilon_i \quad (1)$$

where w_i is the share of product i in the total expenditures of the product group, which is milk and milk products composed of k=8 products in our case. On the right-hand side, p_j indicates the price of product j, m represents the total expenditure allocated to the analyzed commodity group, P is a price index defined later, $\alpha_i, \beta_i,$ and γ_{ij} are parameters to be estimated, and ε_i is the error term for the equation of product i. Demand systems defined as in (1) are linear in the Engel function, and therefore called linear approximated AIDS models (LA/AIDS). In the estimation procedure of the demand system, the following parameter restrictions are imposed in order to get elasticity estimates that are consistent with the behavior of a rational utility-maximizing consumer:

Adding up restriction: $\sum_i^k \alpha_i = 1; \quad \sum_i^k \gamma_{ij} = 0; \quad \sum_i^k \beta_i = 0$ (2)

Homogeneity restriction: $\sum_{j=1}^{k} \gamma_{ij} = 0$ (3)

Symmetry restriction: $\gamma_{ij} = \gamma_{ji}$ (4)

While negativity cannot be imposed, it can be checked whether the estimates are consistent by checking the Hicks own-price elasticities. We complement these data with socioeconomic variables, which allows for shifting levels of demand.

Banks et al. (1997) have shown that for many product groups Engel curves are non-linear, and that in those cases the estimates of the LA/AIDS are biased. For example, the LA/AIDS does not allow a product to change from a luxury to a necessary good when the consumer's income

rises. This inflexibility results in an estimation bias that is particularly significant at low and high ends of the income distribution. Consequently, Banks et al. (1997) developed the quadratic almost ideal demand system (QUAIDS), which lifts this restriction and allows flexible price and income responses. Using their QUAIDS specification, the demand equations estimated in this paper are specified as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)} \left\{\ln \left[\frac{m}{a(p)}\right]\right\}^2 + \varepsilon_i \quad (5)$$

where $a(p)$ is the translog price aggregator, and $b(p)$ is the Cobb-Douglas price aggregator. They are defined as follows (Banks et al., 1997):

$$\ln\ a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \quad (6)$$

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad (7)$$

For adding-up to hold, the additional parameter constraint $\sum_i \lambda_i = 0$ is imposed. The parameter α_0 in the first price aggregator equation (6) is unidentified and was set equal to 1.

The influence of socio-demographic variables is considered using the demographic translation approach proposed by Pollak and Wales (1978). The intercept is modified into $\alpha_i = \alpha_{i0} + \sum_{j=1}^{S} \alpha_{ij} d_j$, where d_j is the *j*th variable of a total number of S variables (e.g., Abdulai, 2002). The budget share equation using Pollak and Wales' (1978) approach is therefore:

$$w_i = \alpha_{i0} + \sum_{j=1}^{S} \alpha_{ij} d_j + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)} \left\{\ln \left[\frac{m}{a(p)}\right]\right\}^2 + \varepsilon_i \quad (8)$$

2.2.2 Accounting for potential endogeneity

In the AIDS model applied to rural household data, different sources of endogeneity can emerge, which will be explained next. Food demand models as specified in equation (8) implicitly assume separability, i.e., that production and demand decisions for food-producing households are taken separately. A number of reasons and the empirical evidence of high shares of own-produce consumption indicate that separability might be not the case for the underdeveloped rural regions we analyze. Firstly, households with own production are expected to respond differently than pure consumers to changes in market prices, because their farm produce can serve as additional substitute of the market goods, for instance in times of unexpected purchase price increases. We therefore added an additional dummy variable to indicate whether the household has agriculture as its main income, and, for each of the relevant food categories, the quantity produced.

Another potential bias may occur in the case of farm households facing market failure. In such a situation, separability does not hold and the decisions on production and demand volume

become interrelated. 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 (Taylor and Adelman 2003). The shadow price in an imperfect market is considered as a markup to the market price and, as a consequence, farm households base their purchasing quantity on the comparison of an unobservable shadow price and the observed market price (Sadoulet & De Janvry, 1995).

Since different farm households face varying degrees of market failure and thus may have different price markups, the estimation of the demand response to market price changes is likely to be biased. While information on market failure has not been surveyed, we do have information on the price at which transactions occurred, which is a function of the unobserved shadow price. Specifically, the prices employed in (8) were not market prices of a standardized product but are household-specific weighted averages of the food item prices reported by the household. For each food group, we instrument the weighted average prices with farm characteristics using the augmented instrumental variable (Lecocq & Robin, 2015). In the first step of this procedure, for each food group the logarithm of the weighted average price is regressed on all explanatory variables of the demand system as well as the following identifying instruments: land size, land rented in, rented out, livestock assets, debts, family labor and village dummy variables, which capture immovable production factors. Assuming that these production side characteristics are uncorrelated with food demand, the unobserved component of the shadow price can be identified.[2] The residuals of these first step regressions are then introduced as additional variables in the budget share equations (8) of each food group *i*.

In the assumed two-stage budgeting framework a potential estimation bias can arise, because households may determine total food expenditures and the budget shares of the estimated food groups simultaneously. For example, common shocks could affect the error terms of the budget share equations in equation (8) as well as the total food budget variable m, resulting in a correlation of m with ε_i. To avoid inconsistent estimation of equation (8), the augmented regression technique described above is applied (as suggested by Blundell and Robin, 1999). We follow Bopape (2007) in the assumption that income is exogenous in the household expenditure allocation model and used non-agricultural income as instrument.[3]

The estimation of the QUAIDS with endogenous prices and expenditures is carried out with the iterative procedure that was proposed by Blundell and Robin (1999). The iterative AIDS is computationally quick and has been implemented in Stata by Lecocq and Robin (2015), who provided the aidsills package. The relevance of endogeneity is verified with an *F*-test of joint

[2] Location also plays a role on the demand side, as reflected by the inclusion of county dummy variables in equation (8), which account for the different consumption patterns of the various ethnicities in the different counties. We argue that village differences are far pronounced on the production side. The reason is that farm production is strongly affected by immovable production factors captured by the village dummy variables, such as soil and microclimate conditions.

[3] The use of non-agricultural income is used in order to ensure that income is not interrelated with food demand decisions for agricultural households, for which separability might not hold. Only ten households did not have non-agricultural income.

significance of the residual variables that were added to the AIDS estimation. With the aidsills command we computed demand elasticities at group means for the two groups, i.e., 1) households with agriculture as main income source, and 2) other households. The computed price elasticities are conditional on constant total food expenditures, and the expenditure elasticity refers to food expenditures.

2.2.3 Estimation of nutrient demand responses

In order to derive income elasticities and unconditional price elasticities, we assume that the households follow a two-stage budgeting process. Thus, the household first decides how much to spend on food (1st stage), and then allocates its food budget on the different food groups defined in Section 2 (2nd stage). This requires the assumption of weak separability of the utility function.

In this framework, the income elasticities $e_i{}^{uc}$ for each food group i are calculated as:

$$e_i{}^{uc} = e_{f,i}{}^{c} * e_f{}^{uc} \tag{9}$$

where $e_{f,i}{}^{c}$ is the expenditure elasticity (conditional) for food group i with respect to overall food expenditures, and $e_f{}^{uc}$ is the income elasticity for food. The unconditional, uncompensated price elasticity $\varepsilon_{ij}^{M,uc}$ is calculated as:

$$\varepsilon_{ij}^{M,uc} = \varepsilon_{ij}^{H} + e_i{}^{c} * w_j \;\; \varepsilon_f{}^{M} \tag{10}$$

ε_{ij}^{H} is the compensated price elasticity for item i and price j (conditional); w_j is the budget share of item j in the food budget, and $\varepsilon_f{}^{M,uc}$ is the unconditional, uncompensated own-price elasticity of food.

To calculate the elasticities of equations (9) and (10), the food income elasticity and the own price elasticity of food have to be obtained. To do this, we specify a total food demand model (1st budgeting stage) as a single equation model of the double-log type:

$$\ln q_f = \alpha + \beta_1 \ln p_f + \beta_2 \ln m + \gamma \mathrm{D} + \eta_f \tag{11}$$

where q_f is the total food quantity consumed, p_f is the aggregate food price, m is the household income, measured as total expenditures, D is a vector of socioeconomic variables. Equation (11) is estimated separately for the two household groups of interest (agricultural households and other households). A 2SLS instrumental variable regression has been employed, in which the price is instrumented with the same production, household characteristics and village dummy variables as prices in the AIDS. Of relevance are the parameters β_1, which is the own price elasticity of food $\varepsilon_f{}^{M}$, and β_2, which represents the income elasticity of food $e_f{}^{uc}$.[4] These

[4] The results of the first budget stage are not shown here but can be obtained from the authors on request.

are used to calculate the income elasticities (9) and unconditional price elasticities (10) of each food group *i*.

The nutrient demand elasticities of energy, protein, iron, zinc, vitamin A and vitamin C have then been derived with a variation of the formulas suggested by Ecker and Qaim (2011):

$$\text{Income elasticity:} \quad E_k = \frac{\sum_i n_i e_i^{uc}}{\sum_i n_i} \tag{12}$$

$$\text{Price elasticity:} \quad e_{kj} = \frac{\sum_i n_i \varepsilon_{ij}^{M,uc}}{\sum_i n_i} \tag{13}$$

where E_k is the income elasticity of nutrient *k*; e_{kj} is the price elasticity of nutrient *k* with respect to a price change of commodity *j*, and n_i is the nutrient content of the *i*th food group.

The nutritional heterogeneity in the analyzed food groups is taken into account by computing the nutrient demand elasticities for the individual households' nutrient composition.[5] Moreover, each household's nutritional minimum nutrient requirement has been calculated based on the age/sex groups living in the household. Given the individual households' daily food purchases and food consumed from own production, it is then evaluated for each of the analyzed nutrients whether the household meets its minimum daily requirement. For the simulation scenarios, the nutrient elasticities are used to estimate the nutritional changes in the individual households' daily food purchases when prices or income changes. Based on this estimate it is then evaluated how many households cross the minimum requirement threshold.

2.3 Data description

The study uses the 2015 wave of household data gathered from face-to-face interviews in six underdeveloped rural counties of three provinces (Shaanxi, Yunnan, Guizhou) in China. The six counties were first selected from the 592 Nationally Defined Key Poverty Counties where the food security status was considered to be the worst and based on viability. They are located in mountainous areas, where road infrastructure was poor and economic level of development was lagging behind. The required sample size for the survey was calculated using standard sample size calculations with each county representing a stratum. After the sample size was calculated, a two-stage clustering approach was applied. The first stage was the selection of villages. In each county, 19 villages were selected using the probability-proportional-to-size (PPS) method. Following the selection of the villages, 12 households within each village were randomly selected, resulting in a

[5] A further step could have been done by estimating a 3rd stage of more detailed food groups. However, with more detailed food groups, there is a considerable number of zero consumption observations which makes the model increasingly unsuitable, as the AIDS assumes a continuous left-hand side variable. A common approach to deal with this is the two-step method proposed by Shonkwiler and Yen (1999). This comes at the cost of theoretical consistency as the adding-up constraint cannot be imposed, which reduces the applicability for scenario simulations. Moreover, since the number of zero values in the demand variables of the AIDS drastically increases for smaller defined food groups, there is little variation left in our study sample. We therefore argue that it is a more reliable approach to estimate the average demand response to those eight food groups of the 2nd stage.

total sample size of 1368 households. The dataset includes comprehensive household information on food consumption, income, expenditure, assets, debts, production, demographics, shocks, and coping strategies. In order to obtain comprehensive data on food demand, the past 30 days was chosen as the recall period.

Table 2.1 Descriptive statistics

Variable name	Description	Mean	Min	Max
w1	Budget share: grains, including coarse grains	0.30	0.03	0.84
w2	Budget share: beans, bean products and nuts	0.04	0	0.41
w3	Budget share: tuber	0.05	0	0.48
w4	Budget share: vegetables	0.14	0	0.58
w5	Budget share: fruits	0.06	0	0.38
w6	Budget share: meat and aquatic products	0.23	0	0.87
w7	Budget share: eggs and dairy products	0.06	0	0.69
w8	Budget share: oil of plant and animal origin	0.12	0	0.71
p1	Price: grains, including coarse grains	4.70	1.57	15.75
p2	Price: beans, bean products and nuts	5.44	1.00	41.29
p3	Price: tuber	1.91	0.20	6.00
p4	Price: vegetables	3.61	0.67	18.28
p5	Price: fruits	4.09	0.80	15.38
p6	Price: meat and aquatic products	26.72	4.00	80.00
p7	Price: eggs and dairy produces	16.87	3.00	300.22
p8	Price: oil of plant and animal origin	17.11	2.00	64.00
foodexpend	Monthly food expenditures	765.01	50.90	19846
Socio-economic, agricultural and location variables:				
hhsize	Household size	3.34	1	11
children_share	Share of children<=14 years in total household members	0.16	0	0.75
elder_share	Share of elder household	0.15	0	1
weath	Wealth index, computed as principal component on assets	0	-0.86	2.85
shock	1=natural shock occurred this year,0 otherwise	0.62	0	1
market	Market distance	6.17	0	150
country_1	1 if in Pan (Guizhou), 0 otherwise	0.17	0	1
country_2	1 if in Zheng'an (Guizhou), 0 otherwise	0.17	0	1
country_3	1 if in Wuding (Yunnan), 0 otherwise	0.17	0	1
country_4	1 if in Huize (Yunnan), 0 otherwise	0.17	0	1
country_5	1 if in Zhen'an (Shaanxi), 0 otherwise	0.17	0	1
country_6	1 if in Lounan (Shaanxi), 0 otherwise	0.17	0	1
prod_grain	Production quantity of grains, including coarse grains	1213	0	24000
prod_beannut	Production quantity of beans, bean products and nuts	62.8	0	3000
prod_tuber	Production quantity of tuber	847.4	0	90000
prod_vegetable	Production quantity of vegetable	431	0	63900
prod_fruit	Production quantity of furies	55.3	0	5000
prod_meat	Production quantity of meat	583.8	0	58577
prod_eggs	Production quantity of eggs	10.1	0	1000
type_agri	1=main income source is agriculture,0 otherwise	0.49	0	1
inc_nonagric	Monthly non-agriculture income/1000	1.63	0	83.34
debt	Debt/1000 to the three main credit sources	20.51	0	600.00
livestock	Number of livestock, in livestock units	0.98	0	50.00
landsize	Land owned	4.45	0	45.00
landrent	Land rented in	22.79	0	422.50
landlend	Land rented out	4.00	0	44.30
agrilbor	Number of household members engaged on the farm	1.66	0	7

Notes: Village dummy variables not reported Prices, expenditure, income and debt entered the equations in logarithmic terms. For values<=0, the ln(1+x) transformation was used. Aquatic, dairy and oil crop production was negligible.

All specific food items the household consumed in the past 30 days were recorded. There were 180 specific food items in total, which could mainly be divided into coarse grain, rice and its products, maize and its products, flour and its products, beans and its products, tubers, fruit vegetables, leafy vegetables, bean vegetables, other vegetables, fungus, fresh fruits, melons, nuts, aquatic products, poultry, meats, eggs, dairy, and oil. For the demand estimation, food items were aggregated into eight food categories, which were 1) grains (including coarse gain, rice and its products, maize and its products, flour and its products), 2) bean products and nuts (including beans and its products, nuts), 3) tubers, 4) vegetables (including fruit vegetables, leafy vegetables, bean vegetables, other vegetables, fungus), 5) fruits (including fresh fruits, melons), 6), meats & aquatic products (including meats, poultry, aquatic products), 7) eggs and dairy products, and 8) oil of plant and animal origin. The unit value of price of each food category was calculated by aggregated food expenditure of the category divided by aggregated food consumption amount of the same category. Missing values of food price were interpolated by the village average unit value of price of that food category. In the survey 49% of the households had agriculture as their main income source and 84% had at least some agricultural activity. Table 2.1 shows descriptive statistics on the variables employed in the demand model.

2.4 Results

The first-stage regression results can be found in the Appendix (Table A2.2). The results show that the income elasticity of food in the study region was 0.30 for households with agriculture as main income source and 0.21 for the other households. Own-price elasticities for total food were −0.63 and −0.72 respectively.

The results for the instrumental variable regressions of potentially endogenous prices and total food expenditures are reported in Table 2.2. The R^2 of the IV regressions range from 0.21 for the price regression of eggs & dairy products up to 0.63 for the price regression of oils. In all price and expenditure regressions, some identifying instruments were significant, although not the same in the different equations. The inclusion of village dummy variables contributes significantly to the explanatory power of the equations, as can be seen in the *F*-test of their joint significance ($p<.01$). This is not surprising given the remoteness of the villages in these areas.

For the sake of space, the results of the QUAIDS parameters can be found in the Appendix (Table A2.1), and will be summarized briefly here. The eight QUAIDS equations have R^2s ranging from 0.20 (oils) to 0.56 (meats & aquatic products), which we consider as sufficient for a cross-sectional analysis. Interesting patterns are that the wealth index has significant effects on the budget share of meats & aquatic products, and the budget share of grains, but with different direction. The budget share of meats & aquatic products increases with the wealth index, but the budget share of grains decreases. Grain, clearly serving as a staple food, is also the only product of which the budget share rises when a natural shock has occurred to the household. Grains and tubers also have higher budget shares when the market distance increases. With increasing household size, the

budget share of grain increases, while the opposite is true for bean products & nuts, and meats & aquatic products. Household composition has a significant effect on the demand pattern. A higher share of children among the household members significantly increases the budget share of fruits, but also reduces the budget share for grains as well as vegetables. Households with agriculture as main income have smaller budget shares spent on vegetables and eggs & dairy products compared to the other households that have less than 50% income from agricultural activities. Own production has only effect on the demand for some products, so for example none of the production quantity variables significantly affect the demand for grains, fruits and eggs and dairy products.

Table 2.2 IV regression results

	1n(p1) Grains	1n(p2) Bean products & nuts	1n(p3) Tubers	1n(p4) Vegetables	1n(p5) Fruits	1n(p6) Meat & aquatic products	1n(p7) Eggs & dairy products	1n(p8) Oils	1n (foodexpend)
1n(inc_nonagric)	0.010**	−0.004	0.000	0.011	0.005	0.001	−0.007	−0.001	0.054***
1n(debt)	−002**	0.004*	0.002	−0.001	−0.005**	−0.001	−0.003	0.001	−0.002
livestock	0.000	0.003	−0.004	0.000	0.003	−0.002	−0.012	−0.008*	−0.004
landsize	0.000	−0.002	0.002	0.002	−0.002	0.002	0.000	0.001	−0.002
landrent	0.000	0.000	0.000	0.000	0.000	−0.001***	−0.001**	0.001**	0.000
landlend	0.001	0.001	−0.001	−0.006	−0.009***	−0.002	0.012***	0.003	−0.004
agrilabor	−0.010	−0.009	−0.021**	−0.038***	−0.013	−0.002	0.005	−0.002	0.000
prod_grain	−0.008*	0.004	−0.005	−0.005	0.004	0.008*	−0.006	0.012*	0.021**
prod_beannut	0.012	0.066	0.061	−0.030	−0.017	0.035	0.082	−0.047	0.122*
prod_tuber	−0.005***	−0.007**	−0.003	0.005	−0.004	−0.004*	−0.004	0.000	−0.008*
prod_vegetable	0.000	0.007*	0.001	−0.005	0.002	0.000	0.016***	0.000	0.005
prod_fruit	0.011	0.034	0.001	0.084***	−0.030	0.008	0.024	−0.069**	−0.015
prod_meat	−0.001	0.002	0.001	−0.002	0.001	0.003	0.002	0.005	0.004
prod_eggs	0.025	0.095	0.289	−0.280	−0.017	0.029	−0.165	0.190	0.320
hhsize	0.001	−0.002	0.000	0.018*	0.000	0.004	0.022*	−0.013*	0.142***
children_share	0.022	−0.003	0.042	−0.003	0.047	−0.042	0.196**	0.012	−0.064
elder_share	−0.008	−0.071*	−0.006	−0.071*	0.035	0.002	−0.092*	0.024	−0164***
wealth	0.022**	0.020	0.015	0.056***	0.017	−0.006	0.035	0.007	0.193***
type_agri	0.000	−0.065**	−0.007	−0.005	−0.058**	−0.022	0.007	−0.010	0.125***
shock	0.001	−0.022	0.004	0.025	0.023	0.014	−0.013	0.003	−0.030
market	0.000	0.001	0.001	−0.002	0.000	−0.002*	0.001	−0.001	−0.002
constant	1.604***	1.893***	0.711***	1.487***	1.988***	3.360***	2.431***	2.920***	5.771***
F-test: village Dummy variables	6.02***	3.07***	7.30***	2.87***	5.73***	5.71***	2.47***	14.22***	3.50***
F-test: all variables	5.66***	3.01***	3.01***	3.06***	5.25***	5.48***	2.49***	15.75***	9.08***
R^2	0.38	0.24	0.44	0.25	0.36	0.37	0.21	0.63	0.49

Notes: Number of observations=1368. ***, ** and * indicate 10%, 5% and 1% significance levels. For log-transformed variables with values<=0, the ln(1+x) transformation was used. For the sake of brevity, parameter results for village dummy variables are not reported.

2.4.1 Food elasticity estimates

With the parameters obtained from the QUAIDS model, we calculate demand elasticities for the whole sample population as well as at group means for households with agriculture as main income source (from here on: agricultural households) and other households. Despite this differentiation, it has to be kept in mind that in our sample more than 70% of the other households still have some agricultural activities and may produce food.

The results for conditional expenditure and own-price elasticities are shown in Table 2.3. For all groups the compensated own-price elasticities estimates are negative. Most of the elasticities are different from zero at the 1% significance level. This is however not the case for grains, eggs & dairy products, and bean products & nuts. Grain has the lowest expenditure elasticity, showing that with an increase in food expenditures, the households' budget share of grain in food expenses decreases. Expenditure elasticities higher than 1 indicate that with rising food expenditures, the food budget shares increase. For all household groups, the food categories of meat & aquatic products and bean products & nuts and have the highest expenditure elasticities with values above 1.3.

Unconditional income and price elasticities (uncompensated) are reported in Table 2.4. In general, income elasticities of agricultural households are on a somewhat higher level than those for other households. In line with recent research on rural China, the income elasticity for grain is the lowest compared to the other food groups (Zheng et al., 2015). The price elasticities of energy, protein, iron and zinc with respect to price changes of grain and meat & aquatic products are smaller for agricultural households than for the other households group. The differences are however often very small. While agricultural households can switch consumption to own produced food if purchasing prices are increasing and thus a more elastic demand than the one of other households could have been expected, one should bear in mind that these are uncompensated price elasticities for which an income effect also plays a role.

Table 2.3 Food elasticities estimated by the QUAIDS model (conditional)

	Whole Sample (n=1368)			Other households (n=700)			Agricultural households (n=668)		
	Expenditure elasticity	Own price elasticity (uncompensated)	Own price elasticity (compensated)	Expenditure elasticity	Own price elasticity (uncompensated)	Own price elasticity (compensated)	Expenditure elasticity	Own price elasticity (uncompensated)	Own price elasticity (compensated)
Grains	0.593***	−0.271*	−0.124	0.615***	−0.312**	−0.149	0.567***	−0.223	−0.092
	(−0.089)	(−0.147)	(−0.14)	(−0.083)	(−0.137)	(−0.13)	(−0.097)	(−0.16)	(−0.152)
Bean products & nuts	1.355***	−0.189	−0.128	1.349***	−0.207	−0.145	1.362***	−0.169	−0.109
	(−0.124)	(−0.177)	(−0.173)	(−0.122)	(−0.173)	(−0.169)	(−0.127)	(−0.184)	(−0.18)
Tubers	1.115***	−0.861***	−0.813***	1.101***	−0.872***	−0.821***	1.133***	−0.846***	−0.802***
	(−0.172)	(−0.183)	(−0.181)	(−0.159)	(−0.168)	(−0.166)	(−0.188)	(−0.202)	(−0.2)
Vegetables	0.823***	−0.446***	−0.327***	0.835***	−0.476***	−0.348***	0.808***	−0.410***	−0.301***
	(−0.09)	(−0.105)	(−0.1)	(−0.085)	(−0.099)	(−0.094)	(−0.097)	(−0.113)	(−0.107)
Fruits	1.163***	−0.600***	−0.500***	1.166***	−0.620***	−0.515***	1.160***	−0.576***	−0.481***
	(−0.098)	(−0.1)	(−0.097)	(−0.093)	(−0.095)	(−0.092)	(−0.103)	(−0.106)	(−0.102)
Meat & aquatic products	1.409***	−0.733***	−0.381***	1.491***	−0.660***	−0.350***	1.348***	−0.788***	−0.391***
	(−0.066)	(−0.094)	(−0.092)	(−0.078)	(−0.113)	(−0.111)	(−0.057)	(−0.08)	(−0.079)
Eggs & dairy products	0.958***	−0.215	−0.146	0.970***	−0.317***	−0.236**	0.941***	−0.071	−0.013
	(−0.168)	(−0.142)	(−0.137)	(−0.146)	(−0.12)	(−0.116)	(−0.199)	(−0.18)	(−0.174)
Oils	0.932***	−0.559***	−0.454***	0.927***	−0.547***	−0.446***	0.937***	−0.571***	−0.463***
	(−0.103)	(−0.116)	(−0.114)	(−0.106)	(−0.12)	(−0.117)	(−0.1)	(−0.113)	(−0.111)

Notes: Standard errors reported in parentheses. ***, ** and * indicate 10%, 5% and 1% significance levels, respectively.

Table 2.4 Unconditional food demand elasticities

	Income	Grains	Bean products & nuts	Tubers	Vegetables	Fruits	Meat & aquatic products	Eggs & dairy products	Oils
Agricultural households (n=668)									
Grains	0.167	−0.246	−0.031	−0.004	−0.004	−0.051	0.071	−0.096	0.006
Bean products & nuts	0.403	−0.337	−0.146	0.006	0.118	0.214	−0.503	0.015	−0.225
Tubers	0.307	−0.117	0.025	−0.842	−0.073	−0.017	0.149	0.023	0.198
Vegetables	0.223	−0.060	0.060	−0.016	−0.311	−0.020	−0.081	−0.079	0.033
Fruits	0.357	−0.302	0.113	−0.023	−0.090	−0.521	0.171	−0.039	−0.070
Meat & aquatic products	0.387	−0.106	−0.072	0.006	−0.088	0.058	−0.630	0.032	−0.025
Eggs & dairy products	0.334	−0.473	0.010	0.000	−0.205	−0.043	0.125	−0.046	−0.079
Oils	0.301	−0.084	−0.068	0.062	0.020	−0.018	0.026	−0.025	−0.553
Other households (n=700)									
Grains	0.128	−0.336	−0.025	0.000	0.006	−0.035	0.018	−0.069	0.000
Bean products & nuts	0.282	−0.349	−0.189	0.001	0.100	0.199	−0.513	0.010	−0.228
Tubers	0.213	−0.103	0.022	−0.869	−0.058	−0.008	0.097	0.027	0.158
Vegetables	0.164	−0.053	0.053	−0.013	−0.389	−0.014	−0.114	−0.060	0.022
Fruits	0.252	−0.295	0.099	−0.023	−0.091	−0.569	0.122	−0.037	−0.075
Meat & aquatic products	0.299	−0.203	−0.116	−0.001	−0.161	0.055	−0.562	0.023	−0.067
Eggs & dairy products	0.233	−0.366	0.009	0.000	−0.155	−0.028	0.077	−0.274	−0.065
Oils	0.211	−0.106	−0.076	0.064	0.013	−0.024	−0.028	−0.027	−0.543

Note: For the calculation of the unconditional price elasticities, the individual households' price shares were used. The reported elasticities are the averages of the household groups.

Table 2.5 Nutrient elasticities

	Income	Grains	Bean products & nuts	Tubers	Vegetables	Fruits	Meat & aquatic products	Eggs & dairy products	Oils
	Agricultural households (n=668)								
Energy	0.234	−0.204	−0.040	−0.013	−0.012	−0.036	−0.006	−0.063	−0.125
Protein	0.241	−0.238	−0.044	−0.025	−0.021	−0.004	−0.091	−0.061	−0.029
Iron	0.236	−0.222	−0.037	−0.025	−0.023	−0.024	−0.039	−0.063	−0.069
Zinc	0.232	−0.229	−0.036	−0.025	−0.024	−0.027	−0.051	−0.066	−0.035
Vitamin A	0.288	−0.204	0.018	−0.034	−0.169	−0.072	−0.043	−0.050	−0.059
Vitamin C	0.266	−0.148	0.052	−0.160	−0.177	−0.138	0.027	−0.054	0.032
	Other households (n=700)								
Energy	0.173	−0.253	−0.044	−0.003	−0.013	−0.030	−0.047	−0.053	−0.153
Protein	0.177	−0.297	−0.048	−0.020	−0.031	−0.002	−0.113	−0.063	−0.035
Iron	0.171	−0.270	−0.040	−0.017	−0.028	−0.022	−0.068	−0.056	−0.089
Zinc	0.171	−0.288	−0.040	−0.019	−0.030	−0.020	−0.084	−0.059	−0.048
Vitamin A	0.206	−0.201	0.010	−0.029	−0.212	−0.046	−0.072	−0.114	−0.045
Vitamin C	0.193	−0.144	0.049	−0.154	−0.224	−0.143	−0.015	−0.052	0.018

Note: The nutrient elasticities were calculated using the households' individual nutrient composition of the food groups. Reported are averages of the household groups.

2.4.2 Nutrient demand elasticities

The unconditional elasticities are used to calculate nutrient demand elasticities reported in Table 2.5. Nutrient income elasticities are a bit higher for agricultural households than for other households, although not much. The income elasticities range from 0.23 (energy) to 0.29 (vitamin A) for agricultural households, and from 0.17 to 0.21 for other households. Thus, when income rises, the change in nutrient purchases of agricultural households is a bit more pronounced than the one of other households. This is not generally the case for price changes. Price elasticities of energy, protein, iron and zinc for price changes in grain and meat & aquatic products are smaller than in the other household group. For both household groups the grain price has the most important effect on nutrient demand for energy, protein, iron, zinc and vitamin A, which is not surprising given its status as a staple food. Only for vitamin C it is the price of vegetables that has the highest influence. Other products with important effect on nutrient consumption are tuber and fruits on vitamin C and vegetables on vitamin A.

2.4.3 Simulation results

The effects of food price and income changes on the households' nutrient status is simulated using the households' nutrient consumption as a basis and deriving the change in purchased nutrients based on the computed nutrient elasticities. To see the effects, we define three scenarios and compare them to the nutrient consumption of 2015 (status quo). In the 1st scenario, an income increases by +10% is assumed, in the 2nd scenario the households are faced with a grain price increase by 100% (double the original price) and in the 3rd scenario the grain price decreases by 50% (half the original price). We simulate the price change of grains because grains are the most important and common food source of households and the government has price supporting policies on grains. As a cautionary note, the elasticities calculated were based on point estimates, and therefore the evaluation of increasing income and price changes come at an increasing extrapolation risk of being off the demand curve. We did not define scenarios with several price changes, in order to not violate the ceteris paribus condition of the parameters estimated.[6]

Nutrition insecurity is measured at household level, by evaluating the nutritional needs of the age/sex groups within the households and adding their nutritional needs for energy (kcal), protein, iron, zinc, vitamin A and vitamin C from the Dietary Reference Intakes for Chinese (Chinese Nutrition Society, 2013) to derive a household minimum requirement threshold. If a household's nutrient consumption falls below this threshold, allocation to at least one household member will not meet her nutritional requirement, and this regardless of intra-household allocation. A household not meeting the sum of minimum requirements of its members is thus counted as

[6] When no price illusion is assumed however, any scenario of income changes can be also seen as a scenario of an according change in all prices in the opposite direction.

nutrition insecure.[7] The household's overall consumption includes its food used for own consumption as well as purchased food. For simplicity, in the scenarios the consumption of own produce is considered as a fixed nutrient source.

Table 2.6 shows the results of the simulations and compares the scenarios with the status quo. In four columns the results of the status quo and scenario calculations are depicted. The upper section presents results for agricultural households, the middle part for other households and the bottom part for the total sample. The absolute numbers are the number of households considered as food insecure with respect to the nutrient mentioned in the first column.[8] For each scenario, the percentage change of nutrient insecure households compared with the status quo is reported.

In the status quo, it can be seen that nutrition insecurity is by far most severe for vitamin A with a prevalence of 88% in the total households. The highest nutrient security is achieved for iron, with just 8% of the households facing undersupply. Other nutrients have prevalence rates from 23% and 38%. Agricultural households have generally a smaller share of insecure households than other households in poor rural areas. Starting from this initial situation, the changes occurring when the income rises by 10% is depicted in the next column. In comparison with the status quo scenario, such a development reduces the total number of nutrition-insecure households by 4% for energy and iron, 3% for zinc and vitamin C, and 2% for protein. Vitamin A demand remains nearly unaffected. The income effect is for most nutrients more pronounced for agricultural households than for other households, with zinc and vitamin A being exceptions.

In the next column the simulated consequences of an increase in grain prices by 100% is depicted. This price effect has considerable negative effects for energy, protein, iron and zinc supply, while both analyzed vitamins are again relatively irresponsive. With respect to grain prices, the group of other households have mostly a much higher nutrient demand responsiveness than agricultural households. This is a result of the higher grain price elasticity, compared to agricultural households (Table 2.4). In the study sample, the absolute number of households, which become nutrient insecure regarding energy, protein and iron when facing doubled grain prices, is twice as high for other households compared to agricultural households.

As a last scenario, the nutrition situation of households after a grain price decrease by 50% is presented in the last column. Interestingly, agricultural households have a better improvement in nutrition status than other households when iron and protein is considered. In contrast, the group of other households have a larger improvement in nutrition status with respect to energy, zinc and vitamin C. Both groups respond similarly with respect to vitamin A.

[7] For a thorough analysis of nutrition insecurity all nutrient thresholds need to be considered. A household is then seen as insecure as soon as one nutrient supply is below the minimum requirement. Because of the high numbers of vitamin A insecure households and its little responsiveness to prices and income, such a strict definition does not reveal much new insights.

[8] Because household size varies and nutritional requirements are different at different ages and for women and men, the absolute number in term of nutrients is not very informative.

Table 2.6 Nutrition insecurity: status quo (2015) and simulation results

	Status quo		Income Rise		Grain-Price Incr.		Grain-Price Decr.	
	Agricultural households (n=668)							
	below min. requirement	% share	below min. requirement	% change	below min. requirement	% change	below min. requirement	% change
Energy	172	26%	163	−5%	232	35%	142	−17%
Protein	213	32%	206	−3%	271	27%	182	−15%
Iron	50	7%	46	−8%	77	54%	34	−32%
Zinc	124	19%	122	−2%	193	56%	100	−19%
Vitamin A	584	87%	583	0%	593	2%	581	−1%
Vitamin C	263	39%	255	−3%	279	6%	254	−3%
	Other households (n=700)							
	below min. requirement	% share	below min. requirement	% change	below min. requirement	% change	below min. requirement	% change
Energy	219	31%	214	−2%	334	53%	169	−23%
Protein	245	35%	242	−1%	370	51%	211	−14%
Iron	53	8%	53	0%	115	117%	47	−11%
Zinc	186	27%	180	−3%	300	61%	131	−30%
Vitamin A	616	88%	614	0%	627	2%	610	−1%
Vitamin C	256	37%	250	−2%	270	5%	245	−4%
	Total households (n=1368)							
	below min. requirement	% share	below min. requirement	% change	below min. requirement	% change	below min. requirement	% change
Energy	391	29%	377	−4%	566	45%	311	−20%
Protein	458	33%	448	−2%	641	40%	393	−14%
Iron	103	8%	99	−4%	192	86%	81	−21%
Zinc	310	23%	302	−3%	493	59%	231	−25%
Vitamin A	1200	88%	1197	0%	1220	2%	1191	−1%
Vitamin C	519	38%	505	−3%	549	6%	499	−4%

2.5 Conclusion

This study evaluated the effects of income and price changes on the food security status of households in poor rural regions in China. It thereby included own produced food in the demand estimation, in order to correct potential measurement bias when the production and demand decisions become interlinked as it is likely to be for agricultural households in remote areas. For the nutrition analysis, the food groups in the demand models were relatively broadly defined. We did so in order to avoid econometric problems and too little variation when zero consumption values become dominating in smaller food item definitions. However, since we had information on the exact nutrient composition of the broad food groups, we computed individual nutrient elasticities, calculated the individual nutrient response and food insecurity status of each household. Since the food categories studied here do also have cases of zero consumption, it is nevertheless

an interesting way to proceed to check whether a demand model that can account for the agricultural household setting and at the same time properly accounts for limited dependent variables would reveal different results. A further promising approach to refine the simulations is to also estimate production side changes and see how own production changes a households' nutrient supply, and to estimate price change of other important food items such as pork. The estimated food and nutrient elasticities as such are of value for policy analysts to estimate the effects of policies targeted towards those regions, be they income or price related. It was shown that nutrients have generally the highest responsiveness to grain price changes. The food security simulations showed the importance of economic development, and particularly of the grain price levels in the food security status of households. While the nutrient elasticity estimates might indicate that income subsidies or grain price policies could be appropriate methods to tackle a vast range of nutrient deficiencies, the simulation results showed a somewhat different picture, as vitamin A and vitamin C undersupply hardly changed even when prices or incomes show greater movements. The simulations further show that a price reduction and a price increase are not having symmetric effects, as doubling the prices would hurt the group of other households far more than agricultural households while a reduction of prices would not that clearly bring a benefit to them compared to agricultural households. We therefore see simulations as a valuable addition to the report of nutrient elasticities.

Appendix

Table A2.1 QUAIDS parameter estimates

	w1	w2	w3	w4	w5	w6	w7	w8
	Grains	Bean products & nuts	Tubers	Vegetables	Fruits	Meat & aquatic products	Eggs & dairy products	Oils
gamma_p1	0.030	−0.001	−0.014	−0.027	0.019	0.025	−0.001	−0.031
gamma_p2	−0.001	0.036***	0.001	0.006	0.003	−0.032	−0.004	−0.009
gamma_p3	−0.014	0.001	0.005	−0.004	0.002	0.004	0.002	0.005
gamma_p4	−0.027	0.006	−0.004	0.080***	−0.009	−0.026	−0.016	−0.003
gamma_p5	0.019	0.003	0.002	−0.009	0.017	−0.012	−0.019	0.000
gamma_p6	0.025	−0.032***	0.004	−0.026	−0.012	0.057**	0.012*	−0.005
gamma_p7	−0.001	−0.004	0.002	−0.016	−0.019**	−0.012	0.051***	−0.002
gamma_p8	−0.031	−0.009	0.005	−0.003	0.000	−0.005	−0.002	0.045***
beta_ foodexpend	−0.208***	0.022	−0.020	0.000	0.094**	0.080*	−0.068**	−0.036
lambda _foodexpend	0.015**	−0.001	0.003	−0.005	−0.011***	0.001	0.008**	0.005
rho−p1	−0.041	0.013	0.005	−0.031	0.021	0.030	0.018	−0.016
rho−p2	−0.005	0.005	−0.010	−0.005	−0.007	−0.001	0.006	0.017
rho−p3	−0.013	0.000	0.032***	−0.007	0.003	0.005	−0.012	−0.009
rho−p4	−0.027	−0.005	−0.007	−0.003	0.011	0.025	0.019	−0.012
rho−p5	0.005	−0.014**	0.006	0.001	0.005	−0.013	0.003	0.006
rho−p6	−0.038	0.017*	−0.010	−0.010	−0.009	0.054*	0.000	−0.004
rho−p7	−0.005	−0.003	−0.001	−0.005	−0.002	−0.005	0.024**	−0.002
rho−p8	−0.016	0.013	−0.011	−0.006	−0.002	0.001	0.001	0.020
rho−foodexpend	−0.004	−0.011*	−0.012	0.029**	0.005	0.002	0.018	−0.026**
hhsize	0.024***	−0.005***	−0.001	0.001	−0.003*	−0.013***	−0.001	−0.002
children_share	−0.067***	0.006	−0.003	−0.036***	0.023**	0.001	0.069***	0.008
elder_share	−0.013	0.010**	−0.002	−0.007	−0.001	0.006	0.010	−0.002
wealth	−0.035***	0.000	−0.010***	−0.004	0.015***	0.025***	0.012***	−0.003
type_agri	0.014*	−0.001	−0.002	−0.010**	−0.005	0.003	−0.008*	0.009**
shock	0.031***	−0.001	0.004	0.004	−0.011***	−0.012***	−0.007	0.001
market	0.002***	0.000***	0.000***	0.000	0.000**	0.000	0.000	0.000
prod_grain	0.002	0.001*	0.002**	0.003*	−0.001	−0.004	−0.002	−0.001
prod_beannut	−0.026	−0.001	−0.002	0.004	0.012	0.032*	−0.001	−0.018*
prod_tuber	0.001	0.000	0.000	0.000	0.000	0.000	0.000	−0.001*
prod_vegetable	−0.001	0.000	0.000	−0.001	0.000	0.003**	0.000	−0.001
prod_fruit	−0.002	−0.013	0.000	0.006	0.006	−0.001	−0.005	−0.003
prod_meat	−0.002	−0.013***	0.000	−0.001	0.000	0.003**	0.000	0.000
prod_eggs	−0.043	−0.005	0.032	0.055	−0.004	−0.042	0.058	−0.043
country_2	−0.006	0.013***	−0.006	0.047***	−0.008	−0.049***	−0.015*	0.049***
country_3	−0.030*	−0.005	−0.005	0.015	−0.014**	0.032**	0.006	0.001
country_4	−0.041**	0.002	0.021***	0.017*	−0.010*	0.008	−0.013	0.016**
country_5	0.062***	−0.005	0.055***	0.035***	−0.030***	−0.188***	0.037***	0.032***
country_5	0.160***	−0.020***	0.018**	0.049***	−0.004	−0.263***	0.031***	0.028**
cons	0.743***	0.059	0.052	0.273***	−0.072	−0.060	−0.130	0.134**
R^2	0.41	0.208	0.252	0.236	0.197	0.558	0.381	0.204
F−test of joint sign	24.64***	9.470***	12.080***	11.120***	8.810***	45.450***	22.110***	9.210***

Note: Number of observations = 1368. ***, ** and * indicate 10%, 5% and 1% significance levels, respectively.

Table A2.2 First budgeting stage double-log regression results

Variables	Agricultural households	Other households
1n(p)	−0.632***	−0.722***
1n(totexp)	0.297***	0.209***
children_share	−0.078	0.023
elder_share	−0.109	−0.084
hhsize	0.071***	0.108***
wealth	0.093***	0.127***
prod_grain	0.009	0.010
prod_beannut	0.055	0.214
prod_tuber	0.002	0.022
prod_vegetable	0.002	0.073*
prod_fruit	0.011	−0.057
prod_meat	0.003	0.026
prod_eggs	0.636***	0.015
shock	−0.010	−0.016
market	−0.003*	−0.002
county_2	0.007	0.000
county_3	0.201***	0.142*
county_4	0.073	0.105
county_5	−0.005	−0.055
county_6	−0.214**	−0.206***
constant	3.068***	3.751***
Observations	668	700
Chi^2 test of joint	512.7***	604.5***
R^2	0.53	0.54

Notes: 1n(p) has been instrumented with the variables discussed in the method section.

CHAPTER

3

Loss Aversion and Asymmetric Price Effects on Food Demand of Rural Households: Panel Evidence from China

This chapter is under review as:
Huang, J., Antonides, G., & Nie, F.
Loss aversion and asymmetric price effects on food demand of rural households: Panel evidence from China.
Under review at the *Journal of Economic Psychology*

Abstract

This study incorporates loss aversion theory in food demand estimations to detect asymmetric price effects 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 loss aversion 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 segmented price model, comparing price elasticities of households facing a price increase with those facing a price decrease, detected asymmetric price effects the best. Although adding price increase and price decrease terms in addition to the standard demand model has a coherent foundation in demand theory and incorporates acquisition and transaction utility, this method barely showed evidence of asymmetric price effects. 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 loss aversion effects for different food items and types of households are discussed.

3.1 Introduction

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, irreversible demand sensitivity under different directions of price change has been observed in reality, and particularly consumers show stronger sensitivity to price increases than price decreases (Kalwani, Yim, Rinne, & Sugita, 1990; Hardie, Johnson, & Fader, 1993; Neumann & Böckenholt, 2014). General loss aversion theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991), showing 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).

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 (Putler, 1992; Krishnamurthi, Mazumdar, & Raj, 1992; Maynard & Subramaniam, 2015; Talukdar & Lindsey, 2013; and Yan, Tian, Heravi, & Morgan, 2016). However, the results differed across the studies. We notice that these studies use different ways of specifying reference prices in the model. How different ways of modeling reference price effects on demand models have influenced the results is not clear, since none of the five related studies have made such comparisons.

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.

3.2 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), and traveling (Nicolau, 2011).

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 & Subramamiam, 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 loss aversion in food demand, then explain and compare different methods of modeling reference price in food demand analysis.

3.2.1 General findings of loss aversion in food demand analysis

Loss aversion 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, loss aversion effects 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 demanded is reinforced by the impulse to underconsume; when price decreases, the increased quantity demanded 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.

3.2.2 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:

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

where,

d_{it} denotes the food demand 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 with logged present price to get the segmented logged prices as follows:

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

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 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):

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

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, since none of the previous related studies made such comparisons.

3.3 Method

3.3.1 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 the 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 within each village were randomly selected. The total sample size for each wave was 1,368 households in 76 villages. A total number of 4,107 observations in all three waves were collected from 2,127 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.

3.3.1.1 Food consumption

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.

3.3.1.2 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 considerable 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 3,418 observations for pure consumers, and 856 observations for farmers in three waves for the estimation of rice demand, 1,417 and 2,342 observations for pure consumers and farmers of potatoes, and 1,619 and 1,801 observations for pure consumers and farmers of pork, respectively.

3.3.1.3 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.

We gathered information on purchase prices for each individual household at the survey time in each survey wave. 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 purchase prices within the same village.

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 A3.1–A3.3 in Appendix 3.2.

3.3.2 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 3.1–3.3), 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 3.1.

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.

3.4 Results

Tables 3.1–3.3 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.

3.4.1 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.

Table 3.1 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			Rice farmers		
	(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 3.2 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			Potato farmers		
	(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	1,417	1,417	1,417	2,342	2,342	2,342
R-squared (within)	0.265	0.273	0.271	0.316	0.317	0.319
Number of households	1,028	1,028	1,028	1,476	1,476	1,476
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 $\beta_1=\beta_2$		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 3.3 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			Pork farmers		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Model 1	Model 2	Model 3	Model 1	Model 2	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	1,619	1,619	1,619	1,801	1,801	1,801
R-squared (within)	0.663	0.663	0.666	0.715	0.718	0.716
Number of households	1,167	1,167	1,167	1,186	1,186	1,186
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).

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 3.1–3.3), 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 β_1=β_2" in Tables 3.1–3.3) respectively, supporting the loss aversion hypothesis. These significant loss aversion effects were only found for pure consumers of rice and potatoes, not for farmers. However, farmers showed significant loss aversion 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 loss aversion effects on demand were found for rice and potatoes. For the farmers, significant loss aversion effects were only found for pork.

3.4.2 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).

The results of Model 2 generally fit and supported the assumption of loss aversion effects on food demand as explained in Section 4.1. The coefficient signs and magnitudes of price effects in loss and gain situations were as expected for demand of rice, potatoes, and pork for pure consumers, and for demand of rice and pork for farmers, although loss aversion effects were only statistically significant for rice and potatoes (pure consumers), and for pork (farmers).

In Model 3, the coefficients of segmented price increase and price decrease terms indicated how households reacted to proportional price changes in these situations, 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), not for demand of potatoes and pork. Also, the price increase terms were not significant for any product. Therefore, the data do not support the loss aversion hypothesis for the Model 3 specification.

To sum up, statistical inference of asymmetric price effects on food demand differed by demand model specification. Loss aversion effects on food demand could hardly be detected by

the price increase and price decrease model (Model 3), but were detected easier by the segmented price model (Model 2).

3.5 Discussion

This study examined asymmetric price effects on food demand, and showed the phenomenon was also applicable to rural household demand in China. Asymmetric price effects of rice and potatoes were 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.

3.5.1 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, loss aversion 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 loss aversion effects for rice and potatoes may also be consistent 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, and more enjoyable to eat. Thus, the impulse to underconsume rice and potatoes is stronger than for pork, making the loss aversion effects only significant for rice and potatoes for pure consumers. 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 loss aversion 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 is a profitable situation for farmers, so they sell more products for higher income and consume less of their produce. 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.

We further observed that asymmetric price effects on food demand were easier to be detected by the segmented price model (Model 2, similar as the method used by Talukdar & Lindsey, 2013, and Yan et al., 2016), but not detected by the price increase and price decrease model (Model 3, similar as the method used by Putler, 1992, and Vande Kamp and Kaiser, 1999). 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 was not based on the difference between purchase price and reference price, and did not stem from solid demand theory. 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 Model 2 and 3 since they can offer different messages concerning loss aversion effects.

3.5.2 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-produce 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.

Acknowledgements

We would like to express our gratitude to Dr. Reza Kheirandish from Clayton State University, Dr. Hans van Trijp, Dr. Cornelis Gardebroek, and Dr. Eveline van Leeuwen from Wageningen University, the Netherlands, Dr. Christian H. Kuhlgatz from Swiss Federal Office for Agriculture (FOAG), Switzerland, Dr. Xiaohua Yu from the University of Göttingenfor, and Dr. Yuqing Zheng from the University of Kentucky for their constructive comments on the earlier version of the manuscript.

Appendix 3.1 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, …, 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[9] 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,

[9] 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).

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 3.2

Table A3.1 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.

	Pure consumers			Farmers		
Variable	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 A3.2 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.

	Pure consumers			Farmers		
Variable	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 A3.3 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

CHAPTER

4

Mental Accounting and Consumption of Self-produced Food

This chapter has been published as:
Huang, J., Antonides, G., Kuhlgatz , C. H., & Nie, F. Y. (2021). Mental accounting and consumption of self-produced food. *Journal of Integrative Agriculture 20* (9), 2569-2580.

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.

4.1 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 (FAO, 2014; Pinstrup-Andersen, 2007). 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 & 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 & Breisinger, 2008; Robles et al., 2010).

However, it is not easy to precisely evaluate food 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 & 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 (AHM) offer a framework to analyze the question of how agricultural households allocate self-produced food (Sadoulet & De Janvry, 1995). In brief, in agricultural household models, market prices and transaction costs play important roles in the choice of households to be self-sufficient or not (Key et al., 2000; Goetz, 1992). 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 & 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 AHM. 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 (Park, 2006; Piggott, 2003).

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 (Chinese Nutrition Society, 2016) recommends an upper limit for the combined consumption of grain and tuber of 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%). 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 & 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 & 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, Montgomery, and Olivola (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, Mancino, and Wansink (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 & 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. The discussion section concludes.

4.2 Theory

4.2.1 Agricultural household models

In agricultural household models (AHM), market prices and transaction costs play important roles in the choice of households to be self-sufficient or not (Key et al., 2000; Goetz, 1992). According to the economic logic of AHM, 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 AHM assumes 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, Sadoulet, and Janvry (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 & 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 & 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 effect and a positive income effect (Taylor & 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's research (2012), 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 AHM predicts, and whether other mechanisms can explain low price sensitivity for the consumption of self-produced food.

4.2.2 Mental accounting

Mental accounting was 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 & 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, is has also been applied with respect to different types of decisions, including decisions about the use of time (Soman, 2001; Rajagopal & Rha, 2009), emotions (Levav & Mcgraw, 2009) and specific behaviors regarding food items (Abeler & Marklein, 2008; Cheema & Soman, 2008; Krishnamurthy & Prokopec, 2010; Milkman & Beshears, 2009).

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 & 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.

4.2.3 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 & 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.

4.3 Method

4.3.1 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 (Key et al., 2000; Goetz, 1992; Taylor &

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 (Deaton & Muellbauer, 1980; Christensen et al., 1975; Gibson & 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:

$$lny_i = \left(\sum_{f=1}^{n} \beta_f lnp_{fi} + \theta lnm_i + \varphi_q lnq_i + \varphi_d dist_i + \varphi_t trans_i + \omega_e edu_i + \omega_a age_i + \omega_l lab_i + \omega_n adeq_i + \omega_s ds_i + \omega_y dy_i + \omega_g g_i + \omega_{gq} g_i * lnq_i + \omega_{gp} g_i * lnp_{fi}\right) + \boldsymbol{\varepsilon_i} \quad (1)$$

where

lny_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;

lnp_{fi} denotes the log of price[10] of different food items (rice, flour, potatoes, pork, eggs, chicken, beef, mutton, and fish, respectively), of household i;

lnq_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;

lnm_i denotes the log of total food expenditure of household i;

$dist_i$ and $trans_i$ denote distance to market and 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;

[10] 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 & De Janvry, 1995). In order to take price information from both sides into account, we took their average.

lab_i denotes the number of laborers engaged in agriculture, and $adeq_i$ equals the number of equivalent adults of household i 11; 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.

$g_i * lnq_i$ is a cross-term of the production group dummy variable and log of production quantity of a certain kind of food, of household i;

$g_i * lnp_{fi}$ 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_e, 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 Appendix (Tables A4.1–A4.5).

4.3.2 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 1368. The dataset included comprehensive household information on food consumption, consumption of self-production, income, expenditure, assets, production, and demographics.

Of the 1368 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,

[11] 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).

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.

Table 4.1 Consumption of rice, flour, potatoes, pork, and eggs of producing households and non-producing households

	Rice		Flour		Potato		Pork		Egg	
	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.	Prod.	Non-prod.
Number of households	236	1132	260	1108	546	822	743	625	393	975
Total Consumption (kg/month)	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/month)	30.53	0	11.52	0	24.20	0	6.17	0	2.55	0
Consumption per adult equivalent (kg/month)	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) [a]	400		400		400		75		50	
% 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%

***$p < 0.001$; Prod. = Producers; Non-prod.= Non-producers; *t*-value in parentheses.

[a] Chinese Food Pagoda (Chinese Nutrition Society 2016) recommended an upper limit for consumption of grain and tuber is 400 grams per adult equivalent per day. Since there is no limit for specific food item, we use this limit of grain and tuber for consumption of rice, flour, and potatoes.

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 (see Table 4.1). 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.

4.4 Results

Tables 4.2 and 4.3 show the regression results of the double-log demand model. We summarize the results for rice, flour, and potatoes in Table 4.2, since they were considered as staple foods, including the log−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 4.3 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 4.2 and 4.3. 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, respectively −0.427 and −0.275. 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 4.2 and 4.3. 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 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 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.

Table 4.2 Regression of per adult equivalent self-produced rice/flour/potato consumption

Variables	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 of 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*Logprice 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)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

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 Appendix (Tables A4.6 and A4.7).

Table 4.3 Regression of per adult equivalent self-produced pork/egg consumption

Variables	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 of 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 of 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

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 Table A4.8, 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.

4.5 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 & 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 (Powell et al., 2015; Fanzo et al., 2013; 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 & 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.

Acknowledgements

We would like to express our gratitude to Dr. Wei Zhang from the International Food Policy Research Institute (IFPRI) for the helpful comments.

Appendix

Table A4.1 Sample statistics for the rice−consumption variables

Variables	N	M	SD
Log of consumption quantity of self−produced rice	236	5.57	0.92
Log−price of rice	236	1.40	0.18
Log−price of flour	236	1.30	0.15
Log−price of potatoes	236	0.66	0.25
Log of total expenditures on food	236	9.27	0.83
Log−production of rice	236	6.49	0.73
Transportation costs of rice	236	3.34	22.80
Distance to the market	236	6.79	6.14
Education of laborers	236	4.92	2.40
Age of laborers	236	42.09	12.24
Number of laborers in agriculture	236	2.11	1.11
Number of adult equivalents	236	3.10	1.23
Yunnan	236	0.60	0.49
Rice production group	236	0.19	0.39
Rice production group*Log−production of rice	236	1.09	2.28
Rice production group*Log−price of rice	236	0.27	0.56

Table A4.2 Sample statistics for flour−consumption variables

Variables	N	M	SD
Log of consumption quantity of self−produced flour	260	4.31	1.09
Log−price of rice	260	1.49	0.12
Log−price of flour	260	1.20	0.23
Log−price of potatoes	260	0.57	0.29
Log of total expenditures on food	260	9.24	0.80
Log−production of flour	260	5.89	0.90
Transportation costs of flour	260	2.65	13.88
Distance to the market	260	6.81	6.19
Education of laborers	260	4.74	2.55
Age of laborers	260	43.15	12.47
Number of laborers in agriculture	260	1.89	0.98
Number of adult equivalents	260	2.87	1.24
Shaanxi	260	0.44	0.50
Yunnan	260	0.39	0.49
Flour production group	260	0.15	0.36
Flour production group*Log−production of flour	260	0.83	1.96
Flour production group*Log−price of flour	260	0.16	0.38

Table A4.3 Sample statistics for potato−consumption variables

Variables	N	M	SD
Log of consumption quantity of self−produced potato	546	5.15	1.02
Log−price of rice	546	1.47	0.15
Log−price of flour	546	1.22	0.21
Log−price of potatoes	546	0.46	0.34
Log of total expenditures on food	546	9.33	0.82
Log−production of potato	546	6.36	1.26
Transportation costs of potato	546	2.68	39.43
Distance to the market	546	6.26	6.43
Education of laborers	546	4.83	2.48
Age of laborers	546	43.10	14.10
Number of laborers in agriculture	546	1.84	0.92
Number of adult equivalents	546	2.83	1.23
Shaanxi	546	0.44	0.50
Yunnan	546	0.33	0.47
Potato production group	546	0.19	0.40
Potato production group*Log−production of potato	546	1.05	2.17
Potato production group*Log−price of potato	546	0.09	0.24

Table A4.4 Sample statistics for pork−consumption variables

Variables	N	M	SD
Log of consumption quantity of self−produced pork	743	4.01	0.74
Log−price of pork	743	3.04	0.18
Log−price of eggs	743	2.68	0.22
Log−price of mutton	743	4.30	0.31
Log−price of beef	743	4.27	0.36
Log−price of chicken	743	3.19	0.33
Log−price of fish	743	2.91	0.25
Log of total expenditures on food	743	9.28	0.79
Log−production of pork	743	5.90	0.96
Distance to the market	743	6.49	6.00
Education of laborers	743	4.75	2.46
Age of laborers	743	42.05	12.96
Number of laborers in agriculture	743	1.96	1.04
Number of adult equivalents	743	3.02	1.19
Shaanxi	743	0.14	0.35
Yunnan	743	0.46	0.50
Pork production group	743	0.04	0.20
Pork production group*Log−production of pork	743	0.18	0.91
Pork production group*Log−price of pork	743	0.12	0.60

Table A4.5 Sample statistics for egg−consumption variables

Variables	N	M	SD
Log−consumption quantity of self−produced eggs	393	3.12	0.75
Log−price of pork	393	3.05	0.16
Log−price of eggs	393	2.66	0.30
Log−price of mutton	393	4.28	0.30
Log−price of beef	393	4.29	0.32
Log−price of chicken	393	3.19	0.35
Log−price of fish	393	2.92	0.23
Log of total expenditures on food	393	9.26	0.76
Log−production of eggs	393	2.81	1.13
Distance to the market	393	6.25	5.45
Education of laborers	393	4.66	2.56
Age of laborers	393	43.17	13.81
Number of laborers in agriculture	393	1.86	1.02
Number of adult equivalents	393	2.92	1.21
Shaanxi	393	0.17	0.37
Yunnan	393	0.42	0.49
Egg production group	393	0.51	0.50
Egg production group*Log−production of eggs	393	1.15	1.29
Egg production group*Log−price of eggs	393	1.33	1.33

Table A4.6 Robustness check: regression of per adult equivalent self−produced rice/flour/potato consumption (using log of income instead of log of food expenditure)

Variables	Rice		Flour		Potato	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Log−price of rice	−0.350	(0.364)	0.054	(0.409)	0.034	(0.238)
Log−price of flour	0.324	(0.387)	−0.422*	(0.245)	0.493**	(0.202)
Log−price of potatoes	0.459*	(0.235)	0.400**	(0.169)	−0.260**	(0.122)
Log of total income	−0.018	(0.081)	0.007	(0.053)	−0.004	(0.040)
Distance to the market	−0.003	(0.009)	0.008	(0.008)	−0.004	(0.005)
Education of laborers	−0.026	(0.024)	−0.015	(0.019)	−0.028*	(0.014)
Age of laborers	0.008	(0.006)	−0.001	(0.004)	−0.002	(0.003)
Number of laborers in agriculture	−0.026	(0.062)	0.031	(0.054)	0.070	(0.043)
Number of adult equivalents	0.243***	(0.069)	0.234***	(0.049)	0.065*	(0.039)
Shaanxi			0.774***	(0.164)	0.601***	(0.111)
Yunnan	0.466***	(0.131)	−0.418***	(0.146)	0.396***	(0.105)
Log−production of rice	0.236**	(0.109)				
Transportation costs of rice	0.000	(0.002)				
Rice production group	1.781	(1.602)				
Rice production group*Log−production of rice	0.082	(0.233)				
Rice production group*Log−price of rice	−1.304	(0.846)				
Log−production of flour			0.152**	(0.067)		
Transportation costs of flour			−0.003	(0.003)		
Flour production group			−3.196**	(1.432)		
Flour production group* Log−production of flour			0.504***	(0.187)		
Flour production group*Log−price of flour			1.463*	(0.816)		
Log−production of potato					0.310***	(0.041)
Transportation costs of potato					−0.001	(0.001)
Potato production group					−1.028*	(0.576)
Potato production group*Log−production of potato					0.407***	(0.099)
Potato production group*Logprice of potato					0.273	(0.255)
Constant	2.709**	(1.169)	2.564***	(0.848)	1.988**	(0.624)
Observations	236		260		546	
R−squared	0.225		0.594		0.431	
Price effect (production lower than the budget)	−1.653**	(0.764)	1.042	(0.792)	−0.013	(0.227)
Production effect (production lower than the budget)	0.317	(0.211)	0.656***	(0.179)	0.717***	(0.094)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A4.7 Robustness check: Regression of per adult equivalent self−produced pork/egg consumption (using log of income instead of log of food expenditure)

Variables	Pork		Eggs	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Log−price of pork	−0.106	(0.151)	0.301	(0.233)
Log−price of eggs	−0.050	(0.118)	−0.167	(0.193)
Log−price of mutton	0.052	(0.113)	0.323*	(0.186)
Log−price of beef	0.028	(0.069)	−0.104	(0.109)
Log−price of chicken	−0.159**	(0.078)	0.222*	(0.114)
Log−price of fish	0.108	(0.111)	0.380**	(0.175)
Log of total income	0.064**	(0.032)	0.043	(0.041)
Distance to the market	0.002	(0.004)	−0.002	(0.006)
Education of laborers	−0.001	(0.014)	0.013	(0.014)
Age of laborers	−0.002	(0.002)	−0.004	(0.003)
Number of laborers in agriculture	0.053**	(0.027)	0.058	(0.038)
Number of adult equivalents	0.130***	(0.028)	0.088**	(0.039)
Shaanxi	−0.204	(0.125)	0.547***	(0.191)
Yunnan	0.167**	(0.068)	0.105	(0.099)
Log−production of pork	0.118***	(0.032)		
Pork production group	2.682	(3.375)		
Pork production group*Log−production of pork	0.382***	(0.137)		
Pork production group*Log−price of pork	−1.138	(1.025)		
Log of production of eggs			0.088**	(0.044)
Egg production group			−0.211	(0.655)
Egg production group*Log−production of eggs			0.347***	(0.070)
Egg production group*Log−price of eggs			−0.124	(0.229)
Constant	2.530***	(0.969)	−1.228	(1.495)
Observations	743		393	
R−squared	0.246		0.279	
Price effect (production lower than the budget)	−1.244	(1.018)	−0.291*	(0.160)
Production effect (production lower than the budget)	0.499***	(0.135)	0.435***	(0.056)

*** p<0.01, ** p<0.05, * p<0.1

Table A4.8 Comparison of own−price elasticity by standard double−log model and the model considering mental accounting

	Standard double−log model		Double−log model considering mental accounting		
	Own−price elasticity	R−squared	Own−price elasticity (Production higher than the set budget)	Own−price elasticity (Production lower than the set budget)	R−squared
Rice	−0.619*	0.198	−0.380	−1.642***	0.226
Flour	−0.549**	0.484	−0.427**	1.032	0.594
Potatoes	−0.334***	0.191	−0.275***	−0.030	0.433
Pork	−0.162	0.187	−0.123	−1.231	0.254
Eggs	−0.291**	0.183	−0.148	−0.296*	0.281

CHAPTER

5

Is Mental Accounting of Farm Produce Associated with More Consumption of Self-produced Food?

This chapter has been published as:
Huang, J., Antonides, G., & Nie, F. (2020).
Is mental accounting of farm produce associated with more consumption of own produced food?.
Journal of Behavioral and Experimental Economics 88, 101594.

Abstract

This study examines whether mental accounting theory is applicable to consumption of own-produced food of smallholder farm households. We are motivated by the farm household's procedure of allocating own-produced food, and some evidence of inflexible use of own-produced food reserve. Using hypothetical scenarios of food reserve and consumption, we find that smallholder farm households show evidence of having a mental budget for own-produced food for self-consumption, tracking their consumption against the budget, and compensating for earlier over- or underconsumption. A substantial number of people used the reserve of their own produced food, exceeding their consumption needs, as their mental budget to guide their consumption, leading to an outcome of overconsumption of own produce. Furthermore, we explored factors of mental accounting and proposed policy implications of the study.

5.1 Introduction

Smallholder farm households, despite being food producers, are the most malnourished group particularly suffering from micronutrient deficiencies due to low dietary diversity in many developing countries (IFPRI, 2016; FAO, 2014; Pinstrup-Andersen, 2007). Unlike pure consumers who can only consume food from purchasing, many smallholder farm households consume considerable amounts of food from their own produce (Fanzo, Hunter, Borelli, & Mattei, 2013; Sibhatu & Qaim, 2018). However, limited research has dealt with the questions of how smallholder farm households allocate the quantities of their produce to sell and to consume, and how their consumption of own produce would be influenced by the allocation. We aim to apply some insights from mental accounting theory to explain the consumption of own-produced food of farm households due to observed deviations from the standard economic prediction.

According to the standard economic model, the consumption of own produce is not influenced by the allocation itself because allocation can be flexible and happening frequently due to changes in market prices and transaction costs (Taylor & Adelman, 2003). However, evidence shows that the allocation is often made once in the harvest season, in which part of the own produce is pre-committed for own consumption, especially for grain (Park, 2006; Piggott, 2003). This "pre-committed quantity" is often larger than the quantity the household needs to consume within a harvest period and does not respond to price changes (Huang et al., 2018; Park, 2006; Piggott, 2003). However, the inflexible use of a "pre-committed quantity" may come at a cost. When the market is accessible, the increased cash income from selling part of the grain reservation can be used to purchase other food varieties and other commodities or services. Nevertheless, an outcome of excess consumption of own-produced grains and tubers was found as compared with the dietary recommendation (Huang et al., 2018). It seems that with excess grain reservation, households consume more than needed and overlook the opportunity cost of consuming the excess part of grain reserve. This excess consumption raises 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.

Considering the process of allocating own-produced food, the inflexibility of using own-produced food reserve, and the overconsumption result all together, we assume that the allocation and consumption process of own-produced food is very similar as the financial budget setting and expenditure tracking behavior predicted by mental accounting theory, which therefore may offer an explanation of the observed overconsumption of own produce.

Mental accounting theory describes how people set mental budgets for specific categories of expenses and then consume with that budget in mind (Thaler, 1985, 1999, 2008), and it violates the standard economic principle of fungibility of money (Thaler, 1999). Mental accounting theory relies on the assumption of two processes: setting budgets for specific expense categories and tracking ongoing expenses against the set budgets. These processes predict that people's

consumption is guided by the set budget. Hence mental accounting may cause economically irrational behavior. If people set budgets too low or too high, and without any flexible adjustments either to budget setting or consumption tracking, either underconsumption or overconsumption may happen (Heath & Soll, 1996).

We expect a substantial part of smallholder farm households to use their food reserve as a mental budget guiding their consumption behavior. In line with existing mental accounting research, we also expect that too high or too low consumption during some time subsequently will be compensated in order to keep within the food budget or to deplete the budget. To test our expectation, in the first part of our study, by using hypothetical scenarios, we set a food reserve condition (exceeding their consumption needs), create surplus and shortage situations with respect to the quantities of "food-needed-to-consume" in the middle of a harvest period, and observe the farmer's choice of food consumption in the next half of the period. In this way, we investigate whether people use "food-needed-to-consume" or "food reserve" as the mental budget, and whether people track their food consumption against the set budget and compensate. We further examine what socio-economic and demographic factors are associated with mental accounting of own-produced food in the second part of our study, and the effect of mental accounting on actual consumption of own produce in the third part of our study. We conducted a face-to-face household survey of 424 agricultural households in four poor rural countries of southwest China in August of 2018 to collect data needed for our study.

Given the limited research on the mental accounting of food consumption quantity (Krishnamurthy & Prokopec, 2010; Sussman, Alter, & Paley, 2016), our study may enrich the application of mental accounting theory to non-monetary resources and non-pure consumers, and bring new insights into understanding the allocation and consumption process of own-produced food of agricultural households, especially in developing countries where smallholder agriculture is prevalent.

We begin by reviewing literature on the allocation of own produce of agricultural households, the application of mental accounting theory to the food area, and factors of mental accounting. We then present methods and results of each of three study parts testing mental accounting hypotheses on consuming own-produced food, factors and effects of mental accounting, respectively. We conclude with a discussion of our findings.

5.2 Literature

5.2.1 Allocation of own-produced food

Smallholder farm households consume a considerable amount of own-produced food, especially in developing countries (Sibhatu & Qaim, 2018). However, the question of how agricultural households exactly determine the amount of food that is sold and the quantity that is kept for eating at home has not been studied sufficiently.

Agricultural Household Models (AHM) offer a framework to analyze the question of how agricultural households allocate own-produced food (Taylor & Adelman, 2003). In brief, in agricultural household models, market prices and transaction costs play important roles in the choice of households to be self-sufficient or not (Goetz, 1992; Key, Sadoulet, & Janvry, 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 own-produced products is higher than the market price minus transaction costs, then it is better to keep the product for own consumption (Taylor & Adelman, 2003).

However, in low-income rural contexts where small-scale farming is prevalent, own-produced food, especially grain, is often used first to meet agricultural households' own consumption needs. Thus, households are frequently observed to first reserve a "pre-committed quantity" from produce for own consumption, then sell the rest for cash income (Park, 2006). The "pre-committed quantity," however, is usually more than what a household needs in a harvest period (Barrett & Dorosh, 1996; Park, 2006). This behavior mainly happens because, in addition to the consumption motive, there is also a precautionary motive, to avoid suffering from price and yield shocks in the next harvest period (Park, 2006). Storing a more-than-needed amount of grain serves as a consumption smoothing strategy for agricultural households.

The "pre-committed quantity" of food reserve, however, usually does not respond to price changes (Huang et al., 2018; Park, 2006; Piggott, 2003). It seems that even when market price is high, and the market is accessible, households may still be reluctant to sell part of the "pre-committed quantity" for cash income. Little is known about whether this inflexible use of food reserve influences household food consumption, and what the dietary outcome might be.

We expect that some part of the households will consider the reserve of their own produce as a mental budget for consumption, and this budget is guiding their consumption to some extent, thus turning part of the precautionary motive into a consumption motive.

5.2.2 Mental accounting theory

Mental accounting refers to people's psychological separation of resources and how people track the use of resources. Mental accounting was broadly defined by Thaler (1999, pp. 183) as "the set of cognitive operations used by individuals and households to organize, evaluate, and keep track of financial activities." Mental accounting has mainly been discussed in the domain of financial decision making (see Zhang & Sussman, 2018 for a review; Antonides & Ranyard, 2017). Grouping or labeling funds into different categories or accounts is the basic element of mental accounting. The accounts can be created either by origin of money (e.g. regular income, windfall money) (Milkman & Beshears, 2009; Thaler, 1999), or by intended use of the money (e.g. money for entertainment, food, and clothing) (Heath & Soll, 1996). Extensive evidence shows that categorizing or labeling funds will influence people's spending decisions, and people have different marginal propensity to spend across categories or accounts (Zhang & Sussman, 2018). For example,

people are more likely to spend on luxury goods (e.g. a vacation, Henderson & Peterson, 1992) from windfall money than from regular income. Thus, mental accounting violates the standard economic principle of fungibility of money (Thaler, 1999).

Although mental accounting facilitates people's financial decisions, acts as a self-control device to avoid excess spending or consumption (Cheema & Soman, 2006), and helps people to reach certain goals, the inflexible characteristics of mental accounting come at a cost and may lead to suboptimal outcomes. In the process of mental accounting, different accounts and budgets are preset. However, consumption opportunities change over time, and the utility of consuming a unit of product or service may also change over time. The preset budgets may not meet the updated need for consumption. If people stick to tracking against the preset budget, and resist transfer across budgets, people may underconsume goods they desire and may overconsume goods that they desire less (Hastings & Shapiro, 2013; Heath & Soll, 1996). For example, if the budget for food is preset, and food prices decline, people may overlook the opportunity to transfer the surplus "food money" to other uses, leading to overconsumption of food (Just, Mancino, & Wansink, 2007). However, Cheema and Soman (2006) showed that mental accounting is not always entirely inflexible and sometimes malleable, through the process of (re-)constructing mental accounts and classifying ambiguous expenses.

Although mental accounting theory has been developed in the area of financial decisions and has been applied mainly to monetary resources, is has also been applied to different types of decisions, including decisions about the use of time (Rajagopal & Rha, 2009; Soman, 2001), emotions (Levav & Mcgraw, 2009) and healthy diets (Krishnamurthy & Prokopec, 2010). So far, applications of mental accounting to other domains and to non-monetary resources remains largely unexplored (Zhang & Sussman, 2018).

Since we aim to explore the application of mental accounting to own-produced food of smallholder farm households, the next subsection will review the application of mental accounting to food consumption, both for food expenditure and food quantity.

5.2.3 Application of mental accounting to food consumption

A branch of studies has aimed at exploring the earmarking or labeling effect of money for specific use for food expenditure in incentivized cases. These studies have apparent policy implications since the policy makers would like to know, with the same monetary value of resources, which way to offer the resources would be more effective to achieve their goals: earmarking funds or cash? Several studies showed that households in the US had a higher marginal propensity to consume food when receiving food stamps and coupons than when receiving an equal amount of cash subsidies (Fox, Hamilton, & Lin, 2004; Fraker, Martini, & Ohls, 1995; Hastings & Shapiro, 2018). This is contradicting rational economic theory, which predicts that when the food budget is larger than the incentives, the same monetary value of cash and coupons would have the same effect. Similarly, in an incentivized case, but more for commercial interest, Abeler and Marklein

(2008) found that wine-restaurant patrons spent 25% more on beverage when receiving an 8 euro voucher labeled for "beverages" than when receiving an 8 euro voucher labeled for "gourmet and beverages." In a non-incentivized context, Villa, Barrett, and Just (2011) found that dietary diversity responses differed by different income sources for pastoral households in East Africa, even after accounting for alternative explanations of intrahousehold bargaining and market failures. These studies show that the type of budget (cash or in kind) influenced consumer spending, pointing to the non-fungibility of resources across different budgets predicted by mental accounting theory.

A few studies investigated people's mental accounting of food consumption quantity rather than food expenditure. They mainly studied whether people use mental accounting of food consumption to help control themselves to achieve a healthy diet. Krishnamurthy and Prokopec (2010) applied mental accounting theory to study consumption of food quantity and calorie intake. They showed that both a mental budget (the number of fun-sized candy bars the respondent think he/she should consume in a day) and an external reference point (the average number of fun-sized candy bars university students eat in a day) are needed to significantly reduce consumption of candy bars. They also showed the importance of unit-compatibility on the effect of mental budgeting on consumption control. To be specific, when the unit of the mental budget (e.g. calorie intake per day) was compatible with the description of consumption (number of calories for a particular dessert), the consumption of desserts was significantly lower than when it was incompatible. This study shows that both mental budgets and reference points may influence the amount of consumption.

5.2.4 Factors of mental accounting

Not everyone behaves as mental accounting theory predicts, neither as standard economic theory predicts. There are a few studies exploring the underlying social-economic and demographic factors of mental accounting (Abeler & Marklein, 2008; Antonides, De Groot, & Van Raaij, 2011; Muehlbacher & Kirchler, 2013). Cognitive abilities, wealth level, experience as indicated by age, and gender were found to be associated with mental accounting as follows.

Frederick (2005), Benjamin, Brown, & Shapiro (2013) showed that people with higher cognitive skills are prone to behave as standard economic theory predicts, while people with lower cognitive skills are more likely to act in accordance with theories of bounded rational behavior. Particularly, Abeler and Marklein (2008) found that subjects with lower mathematical skills were more likely to practice mental accounting. Antonides et al. (2011) found people with lower education level tended to practice more mental accounting.

Antonides et al. (2011) found that less wealthy people with lower income, less savings, and more debts were more likely to practice mental accounting. They explained that people in less wealthy conditions have a stronger need to keep spending within the limits of each account. So they are more likely to use mental accounting as a self-control device. However, Muehlbacher and

Kirchler (2013) found that mental accounting was positively related to income among entrepreneurs.

People with more experience in life (as indicated by age) or having experience with a specific economic behavior were assumed to practice less mental accounting regarding this behavior. It is because with more experience, people have more time and opportunity to learn how to deal with issues without using mental accounting. However, Antonides et al. (2011) found age and being a financial manager of the household had no effects on mental accounting concerning household finance. In contrast, Muehlbacher and Kirchler (2013) found that age was the strongest predictor of mental accounting and older entrepreneurs did more mental accounting. However, they also found that experience of being self-employed had no effect on mental accounting practices.

Mental accounting is also assumed to differ by gender. Men were found to have a higher level of cognitive reflection (Frederick, 2005), and were expected to practice less mental accounting than women. Antonides et al. (2011) found evidence that men tended to use less mental accounting than women, controlling for the role of household financial manager. Summarizing, cognitive skills, wealth, experience and gender may influence the prevalence of mental accounting.

5.3 Part 1: Mental accounting of own-produced food

We aimed to test our expectations concerning mental accounting of own-produced food consumption. Particularly, we aimed to answer the questions of whether households use the "food-needed-to-consume[12]" or the "food reserve" as their mental budget, and whether the budget is guiding households' consumption of own-produce. We asked for the amount of their "food-needed-to-consume" and created a food reserve condition exceeding their consumption needs in hypothetical conditions. Further, we constructed scenarios in which, allegedly, insufficient (or excess) levels of consumption had occurred in the first half of the consumption period as compared with half of the amount of food-needed-to-consume. By asking respondents about their consumption in the remaining consumption period, tracking consumption against the budget, and the type of budget being tracked could be inferred.

5.3.1 Subjects

We conducted a face-to-face household survey of 424 households in 76 villages of 4 poor counties[13] of Yunnan and Guizhou Provinces in southwest China in August of 2018. In each county, 19 villages were selected using the probability-proportional-to-size (PPS) method, and in each village 5–6 households were randomly selected. From those 424 households, 68 were rice

[12] "Food needed-to-consume" in this study means *"the amount of food the household thinks they usually consume in a certain period of time."*

[13] From The National Plan for Poverty Reduction between 2011 and 2020, Chinese government has designated 592 national poor counties. The 4 sampled counties were selected from those 592 national poor counties based on their willingness to cooperate and high prevalence of small-scale farming.

producers and 143 were potato producers. Both rice and potatoes are harvested only once a year in the survey areas.

5.3.2 Scenario design

We used a scenario approach to study people's hypothetical decisions on consuming own-produced rice and potatoes. A 2 × 2 within-subjects design was applied. All subjects were asked questions under two scenarios: insufficient and excess consumption in the first half of the year, and for two products: rice and potatoes.

All 424 subjects, including both producers and non-producers, were asked three questions for each food product. Taking rice as an example, first, subjects were asked how many kilograms of rice the household needed to consume a year[14]. Then, subjects were told they had 120% of the reported amount needed as a reserve of their own rice produce for consumption right after the harvest. This way, we aimed at simulating the common behavior of farmers to reserve a bit more rice than needed due to consumption and precautionary motives. Then, two scenarios with different amounts of rice consumption in the first half year were constructed, one in which less than half (40%) of the amount needed was consumed, the other in which more than half (60%) of the amount needed was consumed, resembling situations of surplus and shortage in the second half year, respectively. Under these two scenarios, subjects were asked how much rice they would consume in the second half of the year. In order to exclude the explanation of observed overconsumption of own produce or opportunity cost neglect due to limited market access or high transaction cost, we added a clause to remind the household that their own produce could be easily sold for cash money. The exact wording of the three questions for rice was as follows.

> Question 1: How many kilograms of rice does your household need to consume each year?
>
> Answer 1:__X__kilograms.
>
> Question 2 (Scenario A): You just said your household needs to consume X kilograms of rice a year. Suppose that your household reserved 1.2X kilograms just after your harvest. Now, half a year has passed since the harvest, and you have consumed 0.4X kilograms of your own-produced rice, less than half of what you think your household needs to consume for a whole year. You have 0.8X kilograms left for the remaining half of the year, and you can easily sell your produce to the market. How many kilograms will you consume from your own-produced rice in the next half year?
>
> Answer 2:_____kilograms.
>
> Question 3 (Scenario B): Now, imagine half a year has passed since the harvest, and you have consumed 0.6X kilograms of your own-produced rice, more than half of what you think your household needs to consume for a whole year. You have 0.6X kilograms left for the remaining half of the year, and you can easily sell your produce to the market. How many kilograms will you consume from your own-produced rice in the next half year?

[14] The Chinese wording actually means "How many kilograms of rice does your household usually consume a year?" The word "need" here does not mean the minimum amount to survive on.

Answer 3:_____kilograms.

After the three questions for rice were asked, the same questions were then asked for potatoes. The exact food amounts stated in the questions (e.g. 0.4X, 0.8X, 1.2X, etc.) were automatically calculated by the electronic questionnaire software, and shown on a tablet (rather than the 0.4X etc.), based on the rice demand (X) reported by the household in response to the first question. If the stated consumption in the second half year plus the consumption in the first half year in the scenario exceeded the pre-determined reserve (1.2X), an error warning appeared on the screen to remind the enumerator to check the answer again with the subject and if necessary, ask the question again. Well-trained enumerators asked the questions to the subjects and recorded their answers on the electronic questionnaire equipment.

5.3.3 Predictions and hypotheses

We were interested in several possible strategies for consumption according to either the standard economic theory or the mental accounting hypothesis, to be considered next. We expected that such strategies would be used by substantial parts of the respondents, leading to the different predictions to be considered next.

Prediction 1: Rational decisions.

If subjects made rational decisions, in line with standard economic consumer theory, stated consumption in the second half year would be 0.5X kilograms, half of what they thought they needed to consume in a whole year. The answer should not be influenced by the consumed amount in the first half of the year, meaning that they would not adjust their consumption to situations of surplus and shortage to compensate. Therefore, under this assumption, it was predicted that in both scenarios A and B, people would consume 0.5X kilograms in the second half year.

Prediction 2: Mental accounting using food needed as the total budget.

If subjects did mental accounting on consumption of own produce and took the food they thought they needed (X kilograms) as the total budget, they would track their consumption against this budget and compensate. Intuitively, they would consume more in the surplus situation and consume less in the shortage situation sticking to the total annual budget of X kilograms. Under this assumption, in Scenario A, subjects would answer 0.6X kilograms, and in Scenario B, people would answer 0.4X kilograms. We tested this prediction by testing whether the proportion of subjects who fit Prediction 2 was significantly different from zero.

Prediction 3: Mental accounting using food reserve as the total budget.

If subjects did mental accounting on consumption of own-produce and took the food reserve (1.2X kilograms) as the total budget, tracking consumption against this budget and compensating, they would answer 0.8X kilograms in Scenario A, and 0.6X kilograms in Scenario B. We tested this prediction by testing whether the proportion of subjects who fit Prediction 3 (answer 0.8X in Scenario A and 0.6X in Scenario B) was significantly different from zero.

Prediction 4: Adjustment effect.

Subjects may have adjusted their estimation of consumption needed in the second half year based on the information of 0.4X or 0.6X consumption in the first half year given in the scenarios. For example, in Scenario A, subjects may have thought the household needed to consume only 0.4X kilograms in the first half year. Therefore, in the second half year, the household also needed to consume only 0.4X kilograms. In this case, they would answer 0.4X kilograms in Scenario A, and 0.6X kilograms in Scenario B.

Table 5.1 Summary of four predicted answers in Scenarios A and B

Predictions	Mental budget	Answers in Scenario A		Answers in Scenario B	
		Predicted answer	Likely answer range	Predicted answer	Likely answer range
P1: Rational decisions	-	0.5X	[0.475X, 0.525X]	0.5X	[0.475X, 0.525X]
P2: Mental accounting (consumption need)	X	0.6X	[0.570X, 0.630X]	0.4X	[0.380X, 0.420X]
P3: Mental accounting (reservation)	1.2X	0.8X	[0.760X, 0.800X]	0.6X	[0.570X, 0.600X]
P4: Adjustment effect	-	0.4X	[0.380X, 0.420X]	0.6X	[0.570X, 0.600X]

Table 5.1 summarizes the four predictions. Taking possible computation errors into consideration, we allowed for a range of 5% below and above the hypothesized answers as acceptable deviations from the predictions.

The main objective of this part of study was to show that the behavior of mental accounting for consumption of own-produced food existed. Predictions 2 and 3 both were based on the assumption that people did mental accounting of consumption of own-produced food, albeit with different mental budgets in mind.

5.3.4 Results

5.3.4.1 Answers by predictions and evidence of mental accounting

Table 5.2 reports the respondents' answers by each of the four predictions. The results are first summarized by rice and potatoes, then incorporated in the "Overall" column, showing the number of subjects whose answers were consistent with each Prediction, for either rice or potatoes, in order to provide an overall picture.[15]

[15] It is possible that a respondent's answers fit in one Prediction for rice but in the other Prediction for potatoes. After excluding such cases, the percentage that fit each prediction did not change much, and the test results still hold.

Table 5.2 Summary of answers for hypothetical questions by four predictions

Predictions	Mental budget	Rice		Potatoes		Overall (either for rice or for potatoes)	
P1: Rational decisions	-	33	7.78%	31	7.31%	50	11.79%
P2: Mental accounting (consumption need)	X	13	3.07%	18	4.25%	24	5.66%
P3: Mental accounting (reservation)	1.2X	98	23.11%	103	24.29%	125	29.48%
P4: Adjustment effect	-	62	14.62%	60	14.15%	78	18.40%
Mental Accounting (P2+P3)		111	26.18%	121	28.54%	144	33.96%

Table 5.2 shows that the largest proportion of subjects' answers were consistent with Prediction 3. Overall, 29.48% of the subjects' answers were consistent with Prediction 3, followed by 18.40% for Prediction 4, 11.79% for Prediction 1, and 5.66% for Prediction 2. The order of these percentages is the same in each column.

We counted 144 subject answers consistent with either Prediction 2 or 3 (33.96%), which was significantly different from zero (chi2(1) = 229.2898, p = .000), thus showing that a significant proportion of subjects showed some behavior of mental accounting for consumption of own-produced food.

5.3.4.2 Mental budget: food needed or food reserved

There were 125 (29.48%) subjects whose answers fit Prediction 3, which was significantly different from zero (chi2(1) = 195.0071, p = .000), showing that a significant proportion of people took the reserved amount of food as their mental consumption budget. We also noticed that the number of subjects using the reserved amount (1.2X) as their mental budget was significantly higher (chi2(1) = 89.6518, p = .000) than those using the amount of food needed (X) as their mental consumption budget. As a result, these subjects chose to consume more than what they needed, thus signaling overconsumption. This result is all the more striking since they have been informed explicitly that their produce could be easily sold on the market for cash income.

5.3.4.3 Mental accounting in surplus and shortage scenarios

Table 5.3 shows the results by scenario. According to standard economic consumer theory, the answers concerning consumption in the remaining half of the year should not be influenced by the scenario frame. However, in the shortage scenario (Scenario B), with less food remaining than

planned, there were significantly more subjects showing behavior of mental accounting than in the surplus scenario (Scenario A). Specifically, as shown in the last row of Table 5.3, the proportion of subjects whose answers fit Prediction 2 or 3 in Scenario A was 33.49% for rice, and 34.20%, for potatoes, which was significantly smaller than those in Scenario B (rice: 45.75%, chi2(1) = 13.3704, p = .000; potatoes: 44.81%, chi2(1) = 10.0155, p = .002). This result revealed that people did more mental accounting in case of shortage or scarcity, which is in line with the finding that less wealthy respondents with more debts practice more mental budgeting than the wealthy (Antonides et al., 2011).

Table 5.3 Summary of answers for hypothetical questions by scenario

	Scenario A (Surplus)	Rice		Potatoes		Scenario B (Shortage)	Rice		Potatoes	
P1: Rational decisions (-)	[0.475X, 0.525X]	83	19.58%	72	16.98%	[0.475X, 0.525X]	63	14.86%	53	12.50%
P2: Mental accounting (X)	[0.570X, 0.630X]	42	9.91%	40	9.43%	[0.380X, 0.420X]	73	17.22%	71	16.75%
P3: Mental accounting (1.2X)	[0.760X, 0.800X]	100	23.58%	105	24.76%	[0.570X, 0.600X] (Adjustment effect excluded[16])	121	28.54%	119	28.07%
Mental Accounting (P2+P3)		142	33.49%	145	34.20%		194	45.75%	190	44.81%

5.3.4.4 Strict and partial mental accounting

Above, we have defined subjects who did mental accounting for consumption of own-produced food as those whose answers fit either Prediction 2 or Prediction 3 in both Scenarios A and B, which is a rather strict condition. Actually, people who showed food budget tracking behavior in one of the two scenarios could be considered as doing partial mental accounting, which can be seen as a relaxed version of mental accounting. Therefore, we define the former strict version as "strict mental accounting," and the latter relaxed version as "partial mental accounting,"

[16] As described in Section 5.3.3., the adjustment effect is for subjects whose answers fit Prediction 4. They answered 0.4X in Scenario A and at the same time 0.6X in Scenario B. 62 Subjects fit Prediction 4 for rice questions, and 60 for potato questions as shown in Table 5.2. For Prediction 3, the expected answer in Scenario B is also 0.6X. To avoid possible confusion, we hereby emphasize that the statistics here have excluded the adjustment effect by excluding those 62 subjects whose answers fit Prediction 4 for rice, and 60 for potatoes.

referring to subjects whose answers were in line with either Prediction 2 or 3, either in Scenario A or B, and did not show rational decision making (Prediction 1) or adjustment behavior (Prediction 4).

Table 5.4 shows the number and proportion of subjects showing strict and partial mental accounting. Overall, there were 33.96% of subjects showing strict mental accounting and 53.07% showing partial mental accounting (strict mental accounting included). This result indicates that more than half of the subjects showed mental accounting behavior at some level.

Table 5.4 Number and proportion of subjects showing strict and partial mental accounting

	Strict mental accounting		Partial mental accounting (strict mental accounting included)	
Rice	111	26.18%	206	48.58%
Potatoes	121	28.54%	203	47.88%
Overall	144	33.96%	225	53.07%

As a conclusion, this part of study shows evidence of mental accounting of consumption of own-produced food. While rational behavior consistent with standard economic theory also was shown, more than half (53.07%) of the subjects showed mental accounting behavior at some level. Heath and Soll (1996) used the percentage of subjects showing underconsumption of food expenditure within a week after a typical food purchase as an indicator of mental budgeting. They found the percentage to vary from 45% to 55%, which is very close to the percentage we found. Moreover, we found more respondents using "food reserve" than "food-needed-to-consume" as their mental budget, and tracking consumption against the budget, consequently indicating overconsumption of own-produced food. Lastly, we found the percentage showing mental accounting in the food shortage scenario to be higher than that in the food surplus scenario, indicating that people did more mental accounting when recourses were scarce.

5.4 Part 2: Factors of mental accounting of own-produced food

In Part 2, we aimed to study the possible factors associated with mental accounting of consumption of own-produced food. The previous literature regarding factors of mental accounting as summarized in Section 5.2.4 showed that cognitive skills, wealth, experience and gender may influence the prevalence of mental accounting. We expected households who actually produced rice and potatoes, and who were wealthier, would be less likely to practice mental accounting. We also expected respondents who had more years of education, who were male, and who were decision maker regarding selling farm produce would be less likely to practice mental accounting.

5.4.1 Method

We used the same samples as in Part 1 of our study and we applied the method of Logit regression in which the binary dependent variable indicated whether or not the subject showed strict mental accounting based on the classification in Part 1 as shown in Table 5.4. The explanatory variables mentioned in the previous paragraph cover aspects at both household and respondent level.

Table 5.5 Sample statistics in Part 2

Variable	#Obs	Mean	Std. Dev.
Mental accounting (Rice) (1=yes 0=no)	424	0.262	0.440
Mental accounting (Potatoes) (1=yes 0=no)	424	0.285	0.452
Household level			
Producer (Rice) (1=yes 0=no)	424	0.160	0.367
Engaged in agriculture but not rice producer (1=yes 0=no)	424	0.743	0.438
Producer (Potatoes) (1=yes 0=no)	424	0.337	0.473
Engaged in agriculture but not potato producer (1=yes 0=no)	424	0.566	0.496
Log of total income	424	10.530	1.104
Number of household members aged 0–5 years	424	0.309	0.564
Number of household members aged 6–14 years	424	0.432	0.728
Number of household members aged 15–64 years	424	2.203	1.176
Number of household members aged 65+ years	424	0.557	0.773
Respondent level			
Gender (1=male 0=female)	424	0.649	0.478
Age in years	424	52.330	12.659
Years of education	424	5.705	3.768
Training of farm management (1=yes 0=no)	424	0.219	0.414
Occupation as a farmer (1=yes 0=no)	424	0.613	0.488
Decision maker of selling farm produce (1=yes 0=no)	424	0.448	0.498

At the household level, the experience-relevant variables included whether the household produced rice or potatoes, and whether the household engaged in agricultural production activities without producing rice or potatoes. The log of total household income was included as a wealth-relevant variable. The number of household members in the age brackets of 5 years or under, 6–14 years, 15–64 years, and 65 years or over were also included as control variables.

At the respondent level, experience-relevant variables included whether the respondent was the decision maker of selling farm produce, and whether the respondent's occupation was farmer. The years of education of the respondent, and whether the respondent received training in farm management (including producing and selling skills training) in the 12 months before the survey were included as cognitive ability-relevant variables. Also, age and gender of the respondent were included.

We conducted two regressions, using strict mental accounting for rice, and potatoes as dependent variables, respectively. Sample statistics of all variables are shown in Table 5.5.

5.4.2 Results

Table 5.6 shows the regression results for mental accounting by rice and potato farmers. The likelihood ratio statistics show that the two models were both significant. Likewise, the predictive capability of the models, measured as the percentage of correct classification, was 74.76% and 73.35%, respectively.

The coefficient of actual producer of rice/potatoes was negative and statistically significant for rice (Coeff.=−1.014) and potatoes (Coeff.=−0.705), respectively. Odds ratios were 0.362 for rice, and 0.494 for potatoes. This result shows that actual producers were 50%–64% less likely to practice mental accounting than non-rice or non-potato producers. Households who did not produce rice or potatoes, but engaged in other agriculture were around 49% (Coeff.=−0.679 for rice; Coeff.=−0.636 for potatoes) less likely to practice mental accounting than households who were not engaged in agriculture at all. Apparently, the more relevant the real experience of households was, the less likely they were to practice mental accounting on their consumption of own produce.

Household structure was significantly associated with mental accounting of consumption of own produce. The number of household members below the age of 5 years had a significant positive effect on mental accounting for rice and potatoes. However, the number of household members in the age categories of 15–64 years, and 65 years or over both had negative effects. It appeared that with more adult members in the household, mental accounting of consumption of own produce diminished, possibly due to the effect of accumulated life experience. People with more life experience may have learned how to deal with own-produced food reserves. Also, the presence of more adult household members may have led to more rational decisions as a result of joint decision making. Households with children under 5 years old, usually having a relatively young household head, probably had less life experience, apparently leading to more mental accounting.

The male gender of the respondent had a positive effect on mental accounting, and was significant for potato farmers, meaning that men were more likely to practice mental accounting of consumption of own produce than women. The direction of the gender effect is consistent with the finding of Muehlbacher and Kirchler (2013) on mental accounting of self-employed taxpayers, although the effect of gender was not significant in their study. However, the result differed from Antonides et al. (2011), who showed that men did less mental accounting than women.

Table 5.6 Logit regressions of mental accounting

Variables	Rice		Potatoes	
	Coeff.	Odds Ratio	Coeff.	Odds Ratio
Producer (Rice)	-1.014**	0.362		
	(0.508)			
Engaged in agriculture but not rice producer	-0.679*	0.507		
	(0.378)			
Producer (Potatoes)			−0.705*	0.494
			(0.400)	
Engaged in agriculture but not potato producer			−0.636*	0.529
			(0.376)	
Log of total income	-0.092	0.912	0.002	1.002
	(0.125)		(0.114)	
Number of household members aged 0–5	0.636***	1.888	0.483**	1.621
	(0.214)		(0.212)	
Number of household members aged 6–14	−0.014	0.986	−0.027	0.974
	(0.174)		(0.166)	
Number of household members aged 15–64	−0.211*	0.810	−0.252**	0.777
	(0.128)		(0.125)	
Number of household members aged 65+	−0.190	0.827	−0.449**	0.639
	(0.183)		(0.197)	
Gender	0.399	1.490	0.489*	1.631
	(0.285)		(0.287)	
Age	0.008	1.008	0.008	1.008
	(0.012)		(0.011)	
Years of education	−0.023	0.977	−0.038	0.963
	(0.038)		(0.036)	
Training	−0.754**	0.470	−0.222	0.801
	(0.338)		(0.296)	
Occupation as farmer	0.513*	1.671	0.477*	1.611
	(0.283)		(0.268)	
Decision maker of selling farm produce	−0.028	0.972	−0.468*	0.626
	(0.244)		(0.242)	
Constant	0.170	1.185	−0.301	0.740
	(1.457)		(1.257)	
# Of observations	424		424	
LR chi2(14)	31.41		27.04	
Prob > chi2	0.0029		0.0123	
Log likelihood	−228.063		−240.017	
Pseudo R2	0.0644		0.0533	
Correctly classified	74.76%		73.35%	

Robust standard errors in parentheses, *** $p<.01$, ** $p<.05$, * $p<.10$

Training in farm management had a negative effect on mental accounting and was significant for rice farmers. The odds ratio was 0.470. The training in farm management included producing and selling skills training, which may have helped improve the cognitive abilities regarding how to deal with farm produce. This result is in line with the expectation that training improves the cognitive abilities of people, leading to less mental accounting. The effect of education on mental accounting was also negative, although not statistically significant.

The coefficients for occupation as a farmer were both positive and statistically significant in the regressions for mental accounting of rice and potato farmers. Odds ratios were 1.671 for rice, and 1.611 for potatoes. This result shows that farmers were more likely to practice mental accounting than non-farmers. This may partly due to the significant negative correlation between occupation as a farmer and years of education. Being a farmer was associated with having less years of education in our sample, which might have resulted in less cognitive ability, and thus a higher probability of practicing mental accounting. Interestingly, the role of decision making regarding selling farm produce showed a negative effect on mental accounting for both regressions and was statistically significant for potato farmers. This result implies that when respondents made selling decisions in real life, they were less likely to practice mental accounting of consuming own-produced food. When a respondent was a farmer and at the same time the decision maker regarding selling agricultural products, the effects on mental accounting were offset. We further checked the mean values of mental accounting for the 118 respondents who were farmer but not decision maker for selling own produce, and for the 48 respondents who were decision maker for selling but not farmer. The mean value of mental accounting of the former (0.424) was significantly larger than of the latter (0.208) ($chi2(1) = 7.2562$, $p = .007$). This finding was in line with the expectation that people with more selling experience would be aware of the opportunity cost of consuming own produce and would practice less mental accounting of consumption of own produce. Log of total income and age of respondent showed no significant effects on mental accounting.

To sum up, this part of the study revealed that households who actually produced rice or potatoes, households with more members aged over 15 years, and respondents who were trained and who were decision makers regarding selling farm produce, were less likely to practice mental accounting of consuming their own produce. Households with more members aged 5 years or under, respondents whose occupation was farmer, and male farmers were more likely to practice mental accounting of consuming own produce.

5.5 Part 3: Mental accounting and consumption of own produce in real life

In Part 3, we aimed to show evidence of mental accounting of consuming own produce in real life. We tested whether the households' consumption of rice or potatoes from own-produce and from market purchase was significantly influenced by the food reservation, for actual rice or potato producers.

5.5.1 Method

Of the 424 total sampled households, 68 produced rice, and 143 produced potatoes in real life. In addition to the quantity of rice and potato needed by the household in a year, for actual producers, we also gathered information on the reservation of produce, consumption from own produce, and consumption from market purchases, together with other market information such as market price of rice and potatoes, transportation cost for selling them, and distance to market.

In the scenarios of Part 1, we created a pre-condition that households' reservation was more than the quantity that they thought they needed to consume in a year. But in real life, the reservation could be either greater or smaller than household consumption needed. In each of the circumstances, mental accounting was supposed to show different influence on consumption of own produce.

When the food reservation was greater than needed, households' consumption of own produce may have been guided by the more-than-needed reservation. We first calculated the difference between food reservation and food needed. If the difference had a significant positive effect on the consumption of own produce, then this would instigate the budget tracking process of mental accounting.

When reservation was less than needed, households doing mental accounting and sticking to consume what they reserved, in the end might fail to meet their level of consumption needed and experience underconsumption. They could also, on the other hand, purchase food from the market to meet their consumption needs after depleting the food reserve. Therefore, in this circumstance, we aim to test whether households purchase more from the market when the difference between food needed and food reserve is larger. If so, then mental accounting does not influence households much when reservation is less than needed because they compensate the depletion of food reserve by market purchases to meet their consumption needs.

We applied OLS regressions and estimated the effects of difference between reservation and consumption needs from own produce, and consumption from market purchase, respectively, separately for rice and potato farmers. The empirical models are given as follows:

$$Cprod_i = \alpha D_i * (R_i - N_i) + \beta(1 - D_i) * (R_i - N_i) + \gamma p_i + \delta t_i + \eta d_i + \theta in_i + \vartheta adeq_i + \varepsilon_i \quad (1)$$

$$Cmakt_i = \alpha' D_i * (R_i - N_i) + \beta'(1 - D_i) * (R_i - N_i) + \gamma' p_i + \delta' t_i + \eta' d_i + \theta' in_i + \vartheta' adeq_i + \varepsilon_i' \quad (2)$$

where

$Cprod_i$ denotes the consumption amount of own-produced rice (or potatoes) of household i in the past 12 months of the survey time;

$Cmakt_i$ denotes the consumption amount of rice (or potatoes) purchased from the market of household i in the past 12 months of the survey time;

R_i denotes reservation amount of own-produced rice (or potatoes) of household i in the past 12 months of the survey time;

N_i denotes consumption need of rice (or potatoes) of household i in the past 12 months of the survey time;

D_i denotes whether the reservation (R_i) is greater than consumption need (N_i), if $R_i > N_i$, $D_i=1$, if $R_i \leq N_i$, $D_i=0$;

p_i denotes the market price of rice (or potatoes), of household i;

t_i and d_i denote the transportation cost to sell rice (or potatoes), and the distance to market for household i, considered as proxies of transaction cost, respectively;

in_i denotes the total income of household i;

$adeq_i$ denotes the number of equivalent adults of household i (OECD, 1982);

α, β, γ, δ, η, θ, ϑ, α', β', γ', δ', η', θ', ϑ' are parameters to be estimated, ε_i and $\varepsilon_i{}'$ are i.i.d. error terms.

$D_i * (R_i - N_i)$ is a cross-term of the dummy variable D_i and the difference of amount of reservation and consumption needs of household i.

In regression (1) with consumption from own produce as the dependent variable, if the coefficient α is significantly positive, then we know that when reservation is larger than food needed, the budget tracking process of mental accounting occurred, and the more-than-needed reservation partly led to more consumption of own produce.

In regression (2) with consumption from market purchase as the dependent variable, if the coefficient β' is significantly positive, then we know that when reservation is less than food needed, the larger the gap between consumption of own produce and consumption need, the more households will purchase food from the market, and thus limiting the effect of mental accounting.

Descriptive statistics of the variables are shown in Table 5.7 for rice producers, and Table 5.8 for potato producers. Of the 68 rice producers, 43 had reserved more rice than the household needed; their mean rice consumption from own produce was 315.91 kg, and they made no market purchases (Table 5.7). Of the 143 potato producers, 93 had reserved more potatoes than needed; their potato consumption from own-produce was 236.50 kg, and that from market purchases was only 5.16 kg, which is much less than that of the 50 households whose reservation was less than needed (Table 5.8). The consumption from market purchases was substantial for both rice (115.52 kg) and potato farmers (55.74 kg) with less food reserve than needed (Tables 5.7 and 5.8, resp.).

Table 5.7 Descriptive statistics of variables for rice producers

Rice	Total n=68		R>N n=43		R≤N n=25	
	M	SD	M	SD	M	SD
Consumption from own produce	322.53	151.10	315.91	135.73	333.92	176.86
Consumption from market purchase	42.47	100.95	0.00	0.00	115.52	140.21
Reservation	574.53	373.13	718.60	381.88	326.72	179.77
Consumption need	379.56	188.07	319.77	124.93	482.40	232.38
D*(reservation−need)	252.21	329.51	398.84	336.65	0.00	0.00
(1− D)*(need−reservation)	57.24	144.40	0.00	0.00	155.68	205.53
Price	4.72	0.65	4.71	0.69	4.73	0.59
Total income (1,000 Yuan)	51.87	36.11	47.00	32.22	60.26	41.32
Distance to market	6.97	6.24	7.62	6.78	5.85	5.13
Transportation cost for selling	9.87	36.91	8.60	34.41	12.04	41.52
Number of adult equivalents	3.00	1.23	2.78	1.14	3.39	1.31

Table 5.8 Descriptive statistics of variables for potato producers

Potatoes	Total n=143		R>N n=93		R≤N n=50	
	M	SD	M	SD	M	SD
Consumption from own-produce	223.35	263.52	236.50	277.07	198.90	236.98
Consumption from market purchase	22.85	67.48	5.16	22.54	55.74	102.68
Reservation	911.99	1475.85	1260.11	1720.97	264.50	305.75
Consumption need	283.35	268.51	246.23	232.63	352.40	315.99
D*(reservation−need)	659.38	1412.27	1013.88	1647.77	0.00	0.00
(1− D)*(need−reservation)	30.73	83.75	0.00	0.00	87.90	123.28
Price	1.89	0.93	1.80	0.86	2.06	1.03
Total income (1,000 Yuan)	61.26	88.66	68.84	105.92	47.16	37.45
Distance to market	6.36	5.53	6.36	5.75	6.34	5.15
Transportation cost for selling	15.10	94.79	22.58	116.92	1.20	8.49
Number of adult equivalents	2.86	1.19	2.82	1.20	2.93	1.19

5.5.2 Results

Table 5.9 presents the regression results for consumption from own produce and consumption from market purchases of actual rice and potato producers. The F-statistics show that the four models (two for rice producers, two for potato producers) were all significant.

In the regressions that take consumption of own produce as dependent variables (see columns (1) and (2) in Table 5.9), our interest variable—the interaction of the dummy variable (whether the reservation was larger than consumption needed) and the difference between reservation and food needed—had a significant positive effect on consumption of own produce for both rice producers

(α = 0.142, p = .004) and potato producers (α = 0.068, p = .000). These significant positive coefficients indicate that a larger surplus of reservation over consumption needed was associated with more consumption from own produce, indicating the tracking process of mental accounting, in line with our expectation.

Table 5.9 Regressions of consumption from own produce and consumption from market purchases

	Consumption from self-produce		Consumption from market purchase	
Variables	Rice	Potato	Rice	Potato
	(1)	(2)	(3)	(4)
D*(reservation−need) for rice	0.147***		−0.062*	
	(0.050)		(0.0337)	
(1−D)*(need− reservation) for rice	0.346***		0.349***	
	(0.120)		(0.0815)	
D*(reservation−need) for potato		0.068***		−0.001
		(0.015)		(0.002)
(1−D)*(need− reservation) for potato		0.022		0.653***
		(0.246)		(0.042)
Rice price	−5.538		1.303	
	(25.390)		(17.18)	
Potato price		−28.330		−4.296
		(22.610)		(3.818)
Transport cost for selling rice	1.066**		−0.198	
	(0.434)		(0.294)	
Transport cost for selling potatoes		−0.113		−0.017
		(0.217)		(0.037)
Distance to market	−0.601	−1.956	0.846	0.464
	(2.488)	(3.702)	(1.684)	(0.625)
Total income × 1,000	0.260	−0.262	−0.336	0.010
	(0.460)	(0.232)	(0.311)	(0.039)
Number of adult equivalents	39.160***	44.47**	7.121	−2.682
	(13.420)	(17.150)	(9.083)	(2.895)
Constant	154.300	134.600*	24.060	15.810
	(117.900)	(77.200)	(79.780)	(13.040)
Observations	68	143	68	143
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.380	0.209	0.364	0.656

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

As for the influence on consumption from market purchases, we found that when the reservation was less than consumption needed, the coefficients were significant and positive for

both rice producers (β' = 0.349, p = .000) and potato producers (β' = 0.653, p = .000). These results indicate that households purchase from the market to meet their consumption needs when they face reservation shortage or depletion. Therefore, in this case, mental accounting did not influence households much, and the underconsumption outcome is less likely to happen.

Transportation costs of selling rice had significant positive effects on consuming own-produced rice (δ = 1.066, p = .017), which shows that higher transportation cost may make households choose to consume more of their own produce, rather than selling it. The number of adult equivalents in the household had significant positive effects on consuming own-produced rice and potatoes but not on consuming purchased rice and potatoes, indicating that households with more adult equivalents consumed more of their own produce, and they probably only purchases rice or potatoes when the own produce reserve was depleted.

In line with the evidence of mental accounting of consumption of own-produced food, shown in Part 1 by using hypothetical questions, this part of study on one hand shows that when reservation was greater than food needed, the larger the difference was, the more consumption from own produce occurred, indicating the tracking process of mental accounting in real life. On the other hand, this part of study showed that when food reservation was less than the food needed, and larger the gap was, the more households purchased from the market.

5.6 Conclusions and discussion

This study examined whether mental accounting theory is applicable to consumption of own-produced food of smallholder farm households. We find evidence that people use mental budgets of quantities of own-produced food for self-consumption, track consumption against the set budget, and compensate their consumption by consuming less (more) according to the quantity left in the budget (Part 1). This finding extends the application of mental accounting to a non-monetary resource, namely food. Different from the sparse literature on mental accounting of food, focused on the self-control aspect of mental accounting in order to avoid consuming too much indulgent unhealthy food, this study suggests that smallholder farm households, being both food producers and consumers, may overlook the opportunity cost of consuming own produce due to mental accounting. Furthermore, we found that households used food reserve more than the amount of food needed to consume as a mental budget, consequently leading to overconsumption of own-produced food (Part 1).

The first part of our study used hypothetical scenarios, which may be associated with hypothetical bias, since behavior in real life might be different. Further, the setting in Part 1 only considered the situation when households' food reservation was larger than consumption needs. How people react when food reservation is less than consumption needs cannot be known from Part 1. To deal with these two issues, in the third part of the study we selected actual rice and potato producers with either greater or smaller food reserve than the amount of food needed, as in a natural field experiment. We then studied their consumption of own produce (for those having

a larger food reserve), resp. consumption from market purchases (for those having a smaller food reserve). In Part 3 of the study we find indications of the budget tracking process of mental accounting in situations of excess food reserve as in Part 1. Also, we found that mental accounting seemed less obvious in situations where food reserve was lower than consumption needs. Instead, in these situations, households purchase more food from the market to compensate the shortage of the available food, consequently rendering underconsumption less likely. In brief, when the food reserve is greater than consumption needs, the excess reserve is to some extent guiding people's consumption; when the reserve is lower than consumption needs, consumption needs may serve as the mental budget, and people will compensate the shortage from market purchases when the food reserve is depleted.

We also extend the literature on factors of mental accounting. We found some experience-related and cognitive ability-related variables having a negative effect on mental accounting. For example, people who are actual rice or potato producers, and who are the decision maker regarding selling own produce and those who had received farm management training tended to practice less mental accounting. This is in agreement with the findings of List (2003) that market experience eliminate market anomalies. Our evidence may support the idea that market experience may reduce another anomaly in decision making, namely mental accounting. However, the experience effect may be resource-specific, meaning that, if people have more experience in dealing with a specific resource, they will practice less mental accounting regarding this specific resource. We proposed this assumption of the experience effect on specific behavior, because we found that actual rice or potato producers were less likely to practice mental accounting on own-produced rice and potatoes than households who engaged in agriculture but did not produce rice or potatoes. The effect of specific resource may also help to explain why we found no significant income effect on mental accounting of consuming own produce in Part 3, but we found more mental accounting in the food shortage scenario in Part 1. The resource to which mental accounting was applied, is own-produced food in our study, which is more specific than income. In addition, since the experience effect may also be very behavior-specific, we proposed this assumption of the experience effect on specific behavior, because we found that people who are the decision maker regarding selling own produce practiced less mental accounting of consuming their own produce, but not people who were farmers (and not decision makers). Farmers usually engage in production activities, while decision makers regarding selling own produce have gained experience in dealing with the allocation and use of own produce. Decision makers may have become more sensitive to the opportunity cost of consuming the food reserve.

Some policy implications regarding nutrition improvement of smallholder farm households can be generated from this study. Nutrition education programs in rural areas usually focus on telling people what to eat and how to eat, without linking food consumption to their market selling decisions. In addition, 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-committed food quantity budgets. Furthermore, our study suggests that offering information to make smallholder farm households aware of the opportunity cost of consuming own-produced food could be valuable, which could be included in the farm management training offered to farm households.

Although we found some evidence of mental accounting in consuming own-produced food, we need to mention some limitations of our study. First, in Part 1, we created hypothetical scenarios that may not fully reflect reality. People's mental accounting of their own produce might be weak or even disappear when the market price is high enough and when transaction costs are low enough. That is, we are not clear about the boundaries of the behavior of mental accounting on own-produced food. Also, in our hypothetical questions, we created a condition of food reserve being 20% higher than the food needed to consume, and then we observed people tracking their consumption against the food reserve budget. However, we expect that, if the food reserve is high enough to exceed a certain level, people may not track against it anymore. Thus, the boundaries of the effect of mental accounting of consuming own-produced food remain a question. We leave this question for future research.

Acknowledgements

We are grateful to the colleagues and enumerators in our research team at the Agricultural Information Institute of Chinese Academy of Agricultural Sciences for assisting the survey implementation.

CHAPTER

6

Social-psychological Factors in Food Consumption of Rural Residents: The Role of Perceived Need and Habit within the Theory of Planned Behavior

This chapter has been published as:
Huang, J., Antonides, G., & Nie, F. (2020).
Social-psychological factors in food consumption of rural residents:
The role of perceived need and habit within the theory of planned behavior.
Nutrients, 12(4), 1203.

Abstract

To address the problem of malnutrition in undeveloped rural areas of China, this study aims to examine the effects of social-psychological factors in food consumption of rural residents in undeveloped counties of Southwest China. In addition, it investigates the role of perceived need and habit within the theory of planned behavior (TPB) in predicting food consumption. A survey with random sampling was conducted on rural residents (n = 424), and the theoretical frameworks of both the standard and extended TPB were applied for comparison purposes. Structural equation modeling was applied to test the relationships among constructs. Consumption of five food items was studied, respectively: meat, eggs, dairy, fish, and fruits. Results showed that incorporation of perceived need and habit substantially increased the explanatory power of the TPB, but these factors only had significant direct effects on intention rather than behavior. Perceived need and habit are stronger predictors of intention than any other TPB construct for consumption of all food items except for meat. We found indirect effects of the constructs in the extended TPB model on consumption to be different across food items. Practical implications to improve consumption of different food items were proposed accordingly.

6.1 Introduction

Eliminating hunger and malnutrition in all forms in the world by 2030 is a fundamental part of the Sustainable Development Goals of the United Nations. Micronutrient deficiency, as one form of malnutrition, is affecting more than two billion people in the world (IFPRI, 2014), and is particularly prevalent in poor, rural areas in developing countries (IFPRI, 2017; Pinstrup-Andersen, 2007). A growing literature has documented that low dietary diversity is the main cause of micronutrient deficiency (Headey & Ecker, 2013). Hence, a varied diet is considered essential to decrease micronutrient deficiency and achieve positive health outcomes (Sibhatu & Qaim, 2018; Otsuka et al., 2016). Many countries have developed and promoted national dietary guidelines and recommended consumption quantities of core food groups, such as grains, vegetables, fruit, meat, fish, eggs and dairy (Tapsell et al., 2016). However, inadequate consumption of certain foods has been observed, particularly in developing countries (Bowen et al., 2011; Zhang et al., 2012). A survey in underdeveloped rural counties in China in 2015 showed that as high as 99.4% of people consumed inadequate amounts of dairy and 93.4% consumed inadequate amounts of fish as compared with the lower limit of the daily intake level as recommended by Chinese dietary guidelines. The percentages for eggs, fruit, and meat were 79.3%, 73.2%, and 37.5%, respectively (Nie et al., 2018). The observed high percentage of inadequate consumption is consistent with other studies showing that malnutrition in China is especially severe in undeveloped rural areas (Luo et al., 2011; Bi et al., 2019).

To improve dietary diversity and increase the consumption of target food groups, it is essential to know the determinants of people's food choices and the magnitude of the effects of those determinants on consumption. Consumer food choices are complex and not only related with economic factors, but also with social and psychological influences (Rozin, 2006). However, food consumption studies of rural residents in developing countries have focused relatively often on economic factors such as prices, income, and market development (Babu et al., 2016), and have rarely covered social and psychological influences.

Social-psychological models are useful tools to analyze decision-making factors and processes, and thus informative to design interventions to change target behaviors into favorable directions (Hardcastle et al., 2015). Among those models, the theory of planned behavior (TPB) is popular and has been widely applied in predicting consumer intentions and behaviors in many domains (Armitage & Conner, 2001), including food choice (Conner & Armitage, 2006). In brief, the TPB proposes that people's behavior is predicted by intention and perceived behavioral control; intention, in turn, is predicted by attitudes, subjective norms, and perceived behavioral control. From systematic literature reviews of the TPB application to dietary behavior and food choice, the TPB predicted food consumption intentions and behaviors well (Conner & Armitage, 2006; McEachan et al., 2011; McDermott et al., 2015). The most recent systematic literature review on food choice shows that attitude was most strongly correlated with intention ($r = 0.54$), followed by perceived behavioral control ($r = 0.42$), and subjective norms ($r = 0.37$). Intention had a larger association ($r = 0.45$) with behavior than perceived behavioral control ($r = 0.27$) (McDermott et al., 2015). However, of the 43 related studies (see the list of studies in McDermott et al.,

2015), only seven were conducted in developing countries, and none were conducted among rural residents.

Although the TPB was proven to be valid in predicting food choice intentions and behavior, critical views exist concerning the constructs of the TPB. Notably, perceived need and habit are two constructs suggested to be added to the TPB to predict food choice and dietary behaviors (Verbeke & Vackier, 2005; Paisley & Sparks, 1998). The former indicates whether a consumer perceives a food item as necessary to consume, the latter indicates whether a person shows habitual behavior of consuming a food item. These two factors were not considered in the standard TPB but were shown to predict intentions quite well. However, each of these two factors were studied independently in a few studies (Verbeke & Vackier, 2005; Paisley & Sparks, 1998; Povey et al., 2000; Payne et al., 2004; Saba et al., 1998; Saba et al., 2000), and were never included jointly in one study together with the TPB constructs. Moreover, most food-related studies including perceived need or habit stopped at the stage of predicting intention. To what extent perceived need and habit also affects behavior is not clear.

This study aims to explore social-psychological factors of food consumption of rural residents in poor counties of Southwest China, with a focus on food consumption far below the dietary recommendation levels but with rich nutritious value, including consumption of dairy, fish, eggs, and fruits. Meat consumption, although not far below the recommendation level, is also studied for comparison. To the best of our knowledge, no similar study with a focus on rural residents has been conducted in China. This study is complementary to existing literature by adding evidence of the TPB application to food consumption of rural residents in developing countries, and by examining the roles of perceived need and habit together with the TPB in predicting food consumption intentions and behaviors. In addition, we aim to know why some people choose to consume more of a certain food item and others do not, and why some food items are less frequently consumed than other food items by comparing detailed TPB items for different types of food. This information, together with the estimated effects of the TPB constructs, will be helpful in designing interventions to improve the consumption of target food items.

In the following sections, the theoretical framework, hypotheses and methods are described. This is followed by a description of the estimated effects of the TPB constructs on the intention and behavior of consuming each food item, and a comparison of differences in detailed TPB items. We conclude with a discussion of the role of habit and perceived need in the TPB and the policy implications to improve consumption of dairy, fish, eggs, and fruits.

6.2 Theoretical framework

6.2.1 Theory of planned behavior

The theory of planned behavior (TPB), described by Ajzen (1991, 2005, 2012), is now one of the most commonly used social-psychological models for understanding human behavior. The TPB proposes that a specific behavior is predicted by the intention to perform the behavior and perceived behavioral control, which reflects the capability of people to perform the behavior.

According to the TPB, intention is determined by three different kinds of beliefs and evaluations of these beliefs: behavioral beliefs, which refer to the perceived consequences of conducting the behavior and the evaluations of these consequences; normative beliefs, which refer to the extent to which other people or groups the person finds important expect the person to conduct the behavior, and the motivation to comply with those important people or groups; control beliefs, referring to the perceived presence of factors that can influence one's capability to perform the behavior, and the perceived power to control these factors.

All three kinds of beliefs are assumed to be readily accessible in memory, and then lead to the formation of three constructs which are *attitudes* towards the behavior (produced by behavioral beliefs), *subjective norms* (produced by normative beliefs), and *perceived behavioral control* (produced by control beliefs). The TPB predicts that if a person has more positive or favorable attitudes and subjective norms and stronger perceived control with respect to performing a behavior, the intention to perform that behavior will be stronger. In turn, in addition to perceived behavioral control, stronger intention predicts higher probability of performing the behavior (Ajzen, 2015).

Attitude reflects how people perceive and evaluate different attributes of a given behavior. As stated by the TPB, attitude (ATT) toward a behavior is proportional to the sum of each strength of the behavioral belief i (b_i) multiplied by the subjective evaluation of that belief's outcome (e_i). For instance, for the behavior of drinking milk, people may have two main behavioral beliefs, one being that drinking milk is healthy, the other that milk is tasty. The strength of the belief that drinking milk is healthy may be stronger (weaker) than the strength of the belief of tastiness. The evaluation of the outcome of tastiness, however, could be higher (lower) than the evaluation of healthiness, thus people may think tastiness is more (less) important than healthiness when making a decision of drinking milk. The outcome of the product of terms is essentially an empirical assessment.

Subjective norms reflect the impact of social aspects on decision making. Subjective norm (SN) is proportional to the sum of each strength of the normative belief j (n_j) associated with a given social referent multiplied by the motivation to comply (m_j) with the referent in question. Still taking drinking milk as an example, a teenager may hear frequent advice from his/her mother that drinking milk is good for his/her growth, and the teenager's motivation to comply with his/her mother's advice may also be high.

Perceived behavioral control reflects the easiness of performing a certain behavior. The easiness may be dependent on abilities (skills, knowledge, etc.), resources (money, time, etc.), obstacles, and so forth. Analogous to ATT and SN, perceived behavioral control (PBC) is proportional to the sum of each strength of the control belief k (c_k) (belief that a control factor is present) multiplied by the perceived power to control that factor (p_k).

6.2.2 Extensions of the TPB and hypotheses

There are mainly two kinds of extensions of the TPB, one focused on specification or classification within one of the TPB constructs, the other aimed at including additional constructs to the TPB to increase the explained variance of the model.

The attitude construct may have both positive and negative components, making the resulting outcome ambivalent (Thompson et al., 1995). For example, eating chocolate is enjoyable, but unhealthy. Several studies suggested capturing both positive and negative aspects to construct the attitude, although they showed that more ambivalent attitudes generally were associated with smaller attitude–intention correlations (Povey et al., 2001; Sparks et al., 2001). Attitude has also been distinguished into an affective component and a cognitive component. The former represents how people feel emotionally (e.g., enjoyable or not), the latter relates more to the evaluation of a utilitarian outcome (e.g., healthy or not) (Scholderer & Grunert, 2001). Evidence on healthy eating showed that in general affective components have a larger effect on intention than cognitive components (Scholderer & Grunert, 2001; Leek et al., 2000).

Subjective norms have been classified into social norms and personal norms. Social norms are related to expectations of third persons and personal norms reflect personal moral obligations or ethical concerns (Conner & Armitage, 2006). In the context of food choice, moral obligations usually refer to food decisions made for the health and well-being of other family members (Verbeke & Vackier, 2005; Leek et al., 2000).

Perceived behavioral control mainly includes facilitating or interfering conditions. Empirically, Verbeke and Vackier (2005) included past behavior and habits as constructs of perceived behavioral control but did not explain why to include them as PBC theoretically.

Habit, however, has more often been discussed as a separate predictor in the TPB (Russell et al., 2017; Klöckner, 2013). It is because the TPB has been found less predictive for less-deliberative-processing decisions or habitual behaviors (Bagozzi, 1981). In other words, including habit as a separate predictor in the TPB tends to increase the proportion of variance explained for habitual behaviors. In food related studies, Verbeke and Vackier (2005) found that, compared with including habit as part of PBC, including habit as a separate regressor in the TPB increased explained variance from 30.8% to 52.0%. Moreover, habit is a significant and important predictor of both intention and behavior. Verbeke and Vackier (2005) found the coefficient of habit to predict the intention of eating fish to be 0.635, and Russell et al. (2017) found the coefficient of habit to predict behavior regarding food waste to be 0.650, larger than any other predictor. Some studies included past behavior, a relevant variable that is not the same as habit, in the TPB to predict food choice (Paisley & Sparks, 1998; Wong & Mullan, 2009). Wong and Mullan (2009) applied the TPB to predict breakfast consumption and found that, after including past behavior, the predictive power of the TPB increased but the effect of intention diminished. However, Ajzen argues that habit differs from past behavior, reflecting the stability of a behavior and theoretically cannot influence intention and behavior (Ajzen, 2005). In general, habit is supported as being a separate regressor in the TPB since presence of the habitual level may change the influence of other TPB constructs on intention and behavior (Bamberg & Schmidt, 2010).

Perceived need is another factor that has been considered for inclusion in the TPB as a separate predictor, especially in the domain of food choice. Paisley and Sparks (1998) first introduced perceived need as an additional predictor, arguing that the TPB constructs do not include information on whether people see themselves in need of performing a certain behavior. It is possible that a person has a positive

attitude, subjective norm, and perceived behavioral control towards performing a particular behavior, but perceives no need to do so. The addition of perceived need was found to explain a further 5% of the variance in intention to reduce fat intake (Paisley & Sparks, 1998), a further 6% and 11% of explained variance in intention to eat a low-fat diet and to eat five portions of fruit and vegetables per day, respectively (Povey et al., 2000), and a further 3% of the explained variance in intention to eat healthy (Payne et al., 2004). Raats et al. (1999) found perceived need to be the most important and independent predictor of intention to make dietary changes. Payne et al. (2004) also found perceived need to be the most predictive of intention to eat healthy, but not predictive of healthy eating behavior. In general, existing studies show that perceived need is an important predictor of food-related intentions, but very few studied its role in predicting behavior.

This study aims to explore social-psychological factors in the consumption of meat, eggs, dairy, fish, and fruits by rural residents. Consistent with the TPB and its extensions regarding specification, we included both affective and cognitive components in attitudes, and both social and personal norms in subjective norms. We expect that attitudes, subjective norms, and perceived behavioral control will predict intention, and intention and perceived behavioral control will predict behavior. Thus:

Hypothesis 1 (H1). *Attitudes towards consuming meat/eggs/dairy/fish/fruits are positively associated with intention to consume meat/eggs/dairy/fish/fruits*.

Hypothesis 2 (H2). *Subjective norms towards consuming meat/eggs/dairy/fish/fruits are positively associated with intention to consume meat/eggs/dairy/fish/fruits*.

Hypothesis 3 (H3). *Perceived behavioral control towards consuming meat/eggs/dairy/fish/fruits is positively associated with intention to consume meat/eggs/dairy/fish/fruits.*

Hypothesis 4 (H4). *Intention to consume meat/eggs/dairy/fish/fruits is positively associated with behavior of consuming meat/eggs/dairy/fish/fruits.*

Hypothesis 5 (H5). *Perceived behavioral control of consuming meat/eggs/dairy/fish/fruits is positively associated with behavior of consuming meat/eggs/dairy/fish/fruits.*

With regard to including habit into the TPB, we believe food consumption decisions are frequent and habitual. Therefore, we think habit is an important predictor. In addition, we found that previous studies including perceived need stopped at the phase of predicting intentions, not predicting behaviors. To our knowledge, no food-consumption-related research has extended the TPB by including both habit and perceived need as separate predictors. Thus, we will examine whether they predict both intention and behavior.

Hypothesis 6 (H6). *Perceived need towards consuming meat/eggs/dairy/fish/fruits is positively associated with intention to consume meat/eggs/dairy/fish/fruits*.

Hypothesis 7 (H7). *Habit towards consuming meat/eggs/dairy/fish/fruits is positively associated with intention to consume meat/eggs/dairy/fish/fruits.*

Hypothesis 8 (H8). *Perceived need towards consuming meat/eggs/dairy/fish/fruits is positively associated with behavior of consuming meat/eggs/dairy/fish/fruits.*

Hypothesis 9 (H9). *Habit towards consuming meat/eggs/dairy/fish/fruits is positively associated with behavior of consuming meat/eggs/dairy/fish/fruits.*

In addition to testing the above nine hypotheses, summarized in Figure 6.1, we also aim to know how different people evaluate each detailed TPB item (belief strength and importance evaluation). We will compare people who consume meat/eggs/dairy/fish/fruits more frequently with those consuming less frequently and compare more frequently consumed food items with less frequently consumed food items. These comparisons are considered exploratory and we do not state hypotheses for them.

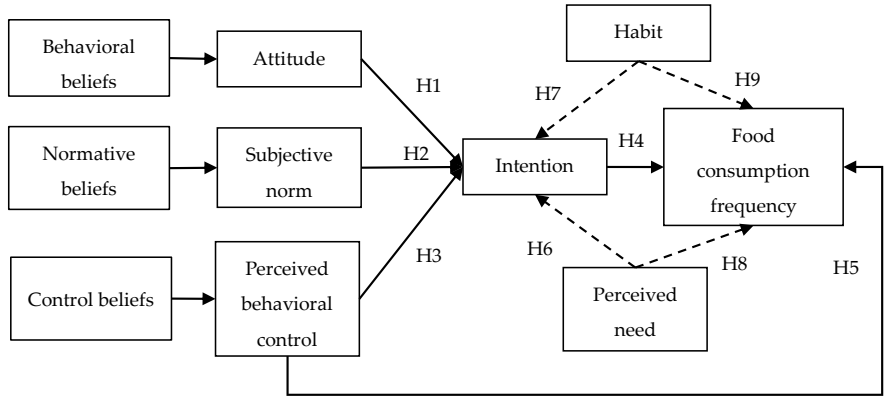


Figure 6.1 Specification of the extended theory of planned behavior (TPB) model and tested hypotheses.

6.3 Method

6.3.1 Data collection and sample

We conducted a face-to-face household survey of 456 households in 76 villages of four poor counties of Yunnan and Guizhou Provinces in Southwest China in August of 2018. From the National Plan for Poverty Reduction between 2011 and 2020, the Chinese government has designated 592 national poor counties. The four sampled counties were selected from those 592 national poor counties based on their willingness to cooperate and high prevalence of small-scale farming.

In each of the four counties, 19 villages were selected using the probability-proportional-to-size (PPS) method, and in each village six households were randomly selected. The survey included self-reported household information on food consumption frequency (in the previous seven days) and food

consumption quantity (in the previous 30 days) for specific food items, household expenditure, income, and demographics. Well-trained enumerators asked the questions to the respondents and recorded their answers on electronic questionnaire equipment.

As part of the survey, a TPB questionnaire with regard to consumption of meat, eggs, dairy, fish, and fruits was presented. Each respondent was asked TPB questions with regard to only one food item. The food item was randomly selected by the enumerator through the random number generator on the electronic questionnaire equipment. After excluding 32 invalid responses (due to, e.g., missing answers) from the total sample of 456 participants, 424 valid responses to the TPB questionnaire were obtained, including 86 responses to the TPB questions for consuming meat, 92 for eggs, 85 for dairy, 83 for fish, and 78 for fruits.

Table 6.1 shows the characteristics of the total sample, of which 64.86% were male and 74.29% were engaged in agriculture. The mean age was 52.33 years, and all respondents were adults above 18 years old. The mean household size was 3.50 persons. Nearly half the sample was from Guizhou province (51.88%), the other half from Yunnan Province.

Table 6.1 Characteristics of the study sample (n = 424)

Gender	%
Male	64.86
Female	35.14
Engaged in agriculture	74.29
Age	52.33 (12.66)
Household size	3.50 (1.53)
Province, County	%
Guizhou Province	51.88
Pan County	25.94
Zhengan County	25.94
Yunnan Province	48.11
Wuding County	23.35
Huize County	24.76

Note: standard deviations in parentheses.

6.3.2 Measures

The measures from the TPB questionnaire with regard to consuming meat/eggs/dairy/fish/fruits will be described next. Internal reliability of the scales for each component was tested by Cronbach's alpha. If Cronbach's alpha was higher than 0.6, then the constructed component was considered reliable (Verbeke & Vackier, 2005).

Attitude. The strengths of four belief attributes (b_i) were measured on 5-point Likert scales, running from 1 (totally disagree) to 5 (totally agree), for each of the statements: "Eating meat/eggs/dairy/fish/fruits is healthy," "Eating meat/eggs/dairy/fish/fruits is nutritious," "Meat/eggs/dairy/fish/fruits tastes good," "I am very satisfied when I am eating meat/eggs/dairy/fish/fruits." The first two statements reflected people's cognitive attitude components, while the latter two represented affective components. The evaluations of belief attributes (e_i) were also measured on 5-point importance scales, running from 1 (totally unimportant) to 5 (very important), for each of the questions: "To what degree do you find the healthiness/nutrition/taste/satisfaction (asked

in sequence) important when making a choice to eat meat/eggs/dairy/fish/fruits?" The responses of strength and evaluation of each belief attribute were multiplied (b_i*e_i), resulting in four scores for each respondent. Cronbach's alphas for the four scores were 0.73 for meat, 0.63 for eggs, 0.79 for dairy, 0.82 for fish, and 0.87 for fruits. An overall attitude towards eating each of the five products (meat/eggs/dairy/fish/fruits) was calculated by taking the mean of the four scores:

$$\text{ATT} = \sum b_i e_i / I \ (i = 1, \ldots, I) \tag{1}$$

where I is the relevant number of attributes comprising the attitude, and in this case, $I = 4$.

Subjective norms. Social norms and personal norms were both considered as components of subjective norms. The strengths of four normative beliefs (n_j) were measured on 5-point Likert scales, for each of the statements: "My family thinks that I should eat meat/eggs/dairy/fish/fruits," "Doctors think that I should eat meat/eggs/dairy/fish/fruits," "To give my family a healthy diet, I buy meat/eggs/dairy/fish/fruits," and "To give my family a nutritious diet, I buy meat/eggs/dairy/fish/fruits." The former two were social norms and the latter two were personal norms. Motivation (m_j) to comply with each normative belief was measured by asking for the level of importance (on 5-point Likert scales) of each normative belief when making a choice to consume meat/eggs/dairy/fish/fruits. Products of strength and motivation for each normative belief were created (n_j*m_j), and Cronbach's alphas for the four products were 0.63 for meat, 0.72 for eggs, 0.73 for dairy, 0.84 for fish, and 0.86 for fruits. The mean of the four products of strength and motivation was calculated for each product for each respondent as the overall subjective norm:

$$\text{SN} = \sum n_j m_j / J \ (j = 1, \ldots, J) \tag{2}$$

where J is the number of relevant social referents, and in this case, $J = 4$.

Perceived behavioral control. Affordability and accessibility of food items were considered as the main aspects of perceived behavioral control of food consumption of rural residents living in poor remote areas, respectively, indicating the beliefs about resources and obstacles that influence the decision of consuming a particular food item. The strengths of two control beliefs (c_k) were measured on 5-point Likert scales for each of the statements: "Meat/eggs/dairy/fish/fruits is easily affordable for me," and "Meat/eggs/dairy/fish/fruits is easily accessible for me." The perceived importance (p_k) of affordability and accessibility was measured by level of importance to them when making a choice to consume meat/eggs/dairy/fish/fruits. Control beliefs and perceived importance of affordability and accessibility were multiplied (c_k*p_k), and Cronbach's alphas for the two scores were 0.69 for meat, 0.63 for eggs, 0.66 for dairy, 0.67 for fish, and 0.62 for fruits. The mean of the multiplications of control beliefs and perceived importance for affordability and accessibility was created for each product and for each respondent as the overall perceived behavioral control:

$$\text{PBC} = \sum c_k p_k / K \ (k = 1, \ldots, K) \tag{3}$$

where K is the number of relevant attributes of perceived behavioral control, and in this case, $K = 2$.

Perceived need. Perceived need to eat meat/eggs/dairy/fish/fruits was measured by the response to the question: "To what extent do you feel that you need to eat meat/eggs/dairy/fish/fruits," running from 1 (not at all) to 5 (to an extremely large extent).

Habit. Habits to eat meat/eggs/dairy/fish/fruits were measured by the response to the question: "To what extent do you agree that eating meat/eggs/dairy/fish/fruits is part of your eating habit?" running from 1 (totally disagree) to 5 (totally agree).

Intention. Intentions to eat meat/eggs/dairy/fish/fruits were measured by response to three statements: "I will consider to eat meat/eggs/dairy/fish/fruits in the next two weeks," "I want to eat meat/eggs/dairy/fish/fruits in the next two weeks," and "I plan to eat meat/eggs/dairy/fish/fruits in the next two weeks." The response to each question was measured on a scale running from 1 (definitely not) to 5 (definitely). Cronbach's alphas for the three questions were 0.94 for meat, 0.96 for eggs, 0.96 for dairy, 0.95 for fish, and 0.96 for fruits. The mean of the three intention scores was calculated for each product and for each respondent.

Behavior. The frequency of eating meat/eggs/dairy/fish/fruits was measured by how many days the respondent had eaten meat/eggs/dairy/fish/fruits in the previous seven days. The responses ranged from 0 to 7 days.

Statistics for all TPB items are presented in Table A6.1 in Appendix.

6.3.3 Analysis

Data were analyzed using STATA 15.1. Relationships hypothesized by the TPB were tested through Structural Equation Modeling (SEM) for each food product separately (Ullman & Bentler, 2003). Different from multiple separate regressions, SEM made it possible to study all of our hypothesized relationships in the TPB model in one analysis and showed how some exogenous variables, for example, attitudes, subjective norms, and perceived behavioral control, were mediated by intention, allowing for indirect effects on behavior (Hankins et al., 2000).

The fit of the TPB and its extended models was assessed by the following goodness-of-fit indices: chi-square and *p*-value, root mean square error of approximation (RMSEA), comparative fix index (CFI), the Tucker-Lewis Index (TLI), and standardized root mean square residual (SRMR). The model fit was considered good if chi-square was not statistically significant (p-value > 0.05), CFI and TLI were larger than 0.90 (Bagozzi & Yi, 1988), and RMSEA and SRMR were less than 0.08 (Marcoulides & Schumacker, 1996; Hu & Bentler, 1999). R^2 of intention, behavior, and overall model were used to indicate the percentage of variance explained by the models.

T-tests were used to analyze the differences in each detailed belief strength and importance evaluation for each construct of attitude, subjective norm, perceived behavioral control, perceived need, and habit between groups of respondents with different consumption levels for a particular food item and between pairs of food items.

6.4 Results

6.4.1 Food consumption frequency

Table 6.2 shows the food consumption status of the study sample. The consumption frequency ranged from 0–7 days per week, and the frequency of meat consumption was the highest (5.70 days), followed by fruit (3.50 days), eggs (1.66 days), dairy (0.75 days), and fish (0.30 days). The consumption quantity per adult equivalent per day was converted from the total household consumption quantity in the previous 30 days for each food item. Comparing the actual consumption quantity per adult equivalent per day with the recommended lower limit for the consumption quantity of meat (40 g), eggs (40 g), dairy (300 g), fish (40 g), and fruit (200 g) by Chinese Food Pagoda (Wang et al., 2016), we were able to know whether each household had inadequate consumption for each food item. As high as 99% of the sample were short of consumption of dairy, followed by 94% for fish, 84% for eggs, 79% for fruit, and 13% for meat.

Table 6.2 Food consumption status of the study sample (n = 424)

	Frequency (Day)		Consumption (g/adult equivalent/day)		Inadequate Consumption (%)	
	M	SD	M	SD	M	SD
Meat	5.70	1.91	88.20	108.79	0.13	0.33
Eggs	1.66	1.98	22.78	41.25	0.84	0.36
Dairy	0.75	2.03	11.34	40.11	0.99	0.07
Fish	0.30	1.08	8.79	19.12	0.94	0.24
Fruit	3.50	2.63	131.11	139.36	0.79	0.40

The statistics show that only meat consumption was not much lower than the recommended quantity in our sample. Consumption of dairy and fish particularly, together with eggs and fruit, were far below the recommended levels.

6.4.2 Differences in belief strength and importance evaluation by consumption frequency level

A considerable percentage of respondents did not consume dairy, fish, eggs, and fruits in the seven days before the survey time. To explore the reasons for these differences in consumption frequency, we tested the differences in belief strength and importance evaluation for each belief item between groups of respondents whose consumption frequency was larger than zero and those whose consumption frequency equaled zero. Table 6.3 displays the results of the relevant *t*-tests. Since consumption frequency of meat was high and no zero frequency was observed, we only compare the differences for eggs, dairy, fish, and fruit.

Table 6.3 Differences in belief strength and importance evaluation by consumption frequency level

	Eggs			Dairy			Fish			Fruit		
	Freq > 0	**Freq = 0**		**Freq > 0**	**Freq = 0**		**Freq > 0**	**Freq = 0**		**Freq > 0**	**Freq = 0**	
	n = 52	*n* = 40		*n* = 16	*n* = 69		*n* = 18	*n* = 65		*n* = 59	*n* = 19	
	Mean 1	Mean 2	Diff.	Mean 1	Mean 2	Diff.	Mean 1	Mean 2	Diff.	Mean 1	Mean 2	Diff.
Intention	3.79	2.87	0.93***	2.67	2.35	0.32	3.65	2.24	1.41***	4.12	2.89	1.23***
ATT	15.23	14.22	1.00**	13.11	13.33	−0.22	16.17	13.97	2.20***	16.44	14.67	1.77*
att1	17.15	15.75	1.40 *	14.94	15.36	−0.42	17.00	15.02	1.98**	18.07	16.32	1.75
att1_str	4.04	3.75	0.29**	3.56	3.59	−0.03	4.00	3.66	0.34 *	4.15	3.89	0.26
att1_imp	4.23	4.17	0.06	4.25	4.26	−0.01	4.22	4.08	0.15	4.31	4.16	0.15
att2	16.23	15.05	1.18 *	15.19	14.87	0.32	16.22	14.75	1.47*	16.80	14.95	1.85 *
att2_str	4.04	3.77	0.26***	3.81	3.75	0.06	3.94	3.77	0.18	4.05	3.79	0.26
att2_imp	4.02	3.98	0.04	4.00	3.94	0.06	4.11	3.89	0.22*	4.12	3.95	0.17
att3	14.52	13.70	0.82	11.94	12.26	−0.32	15.39	13.31	2.08**	15.97	13.79	2.18**
att3_str	3.85	3.52	0.32**	2.94	3.17	−0.24	3.89	3.55	0.34*	3.95	3.68	0.26
att3_imp	3.77	3.90	−0.13	4.13	3.88	0.24	3.94	3.77	0.18	4.00	3.74	0.26*
att4	13.00	12.40	0.60	10.38	10.83	−0.45	16.06	12.78	3.27***	14.93	13.63	1.30
att4_str	3.69	3.27	0.42***	2.63	2.96	−0.33	4.00	3.49	0.51 **	3.78	3.63	0.15
att4_imp	3.52	3.83	−0.31 **	3.94	3.59	0.34 *	4.00	3.68	0.32 *	3.88	3.74	0.14
SN	14.97	13.86	1.11*	14.09	13.34	0.75	14.82	12.70	2.12**	17.03	13.09	3.94***
sn1	14.19	12.75	1.44*	12.25	12.35	−0.10	14.72	11.92	2.80**	16.47	12.11	4.37***
sn1_str	3.44	3.33	0.12	3.25	2.99	0.26	3.72	3.02	0.71***	3.98	3.26	0.72***
sn1_imp	4.12	3.85	0.27**	3.81	4.09	−0.27	3.89	3.89	0.00	4.10	3.68	0.42**
sn2	13.90	12.50	1.40	11.69	12.91	−1.23	14.39	12.20	2.19	17.19	11.21	5.98***
sn2_str	3.25	3.15	0.10	3.06	3.06	0.00	3.50	3.06	0.44*	4.03	2.89	1.14***
sn2_imp	4.21	3.95	0.26*	3.75	4.19	−0.44**	4.06	3.94	0.12	4.22	3.89	0.33*
sn3	15.96	15.20	0.76	16.31	14.33	1.98	15.56	13.29	2.26*	17.22	14.58	2.64**
sn3_str	3.85	3.77	0.07	3.75	3.42	0.33	3.72	3.37	0.35	4.07	3.68	0.38**
sn3_imp	4.13	3.98	0.16*	4.31	4.16	0.15	4.17	3.88	0.29*	4.19	3.95	0.24*
sn4	15.96	15.20	0.76	16.31	14.33	1.98	15.56	13.29	2.26*	17.22	14.58	2.64**
sn4_str	3.83	3.75	0.08	3.75	3.33	0.42*	3.61	3.43	0.18	4.08	3.68	0.40**
sn4_imp	4.10	3.95	0.15	4.25	4.07	0.18	4.00	3.85	0.15	4.17	3.89	0.27**
PBC	14.29	14.16	0.13	16.38	13.20	3.17***	14.44	13.34	1.11	15.93	12.16	3.77***
pbc1	13.92	14.57	−0.65	16.56	13.06	3.50***	14.50	12.95	1.55	15.66	12.42	3.24***
pbc1_str	3.88	3.75	0.13	3.88	3.23	0.64**	3.89	3.42	0.47*	3.90	3.26	0.64***
pbc1_imp	3.62	3.95	−0.33**	4.31	4.06	0.25	3.72	3.88	−0.15	4.02	3.84	0.17
pbc2	14.65	13.75	0.90	16.19	13.35	2.84**	14.39	13.72	0.67	16.20	11.89	4.31***
pbc2_str	3.98	3.75	0.23	3.88	3.49	0.38	3.78	3.54	0.24	4.02	3.26	0.75***

135

pbc2_imp	3.65	3.67	−0.02	4.19	3.80	0.39*	3.89	3.89	0.00	3.98	3.68	0.30
PN	3.79	3.15	0.64 ***	3.25	2.80	0.45*	3.83	2.72	1.11***	4.10	3.11	1.00***
HBT	3.50	2.65	0.85 ***	2.69	2.01	0.67**	3.44	2.09	1.35***	3.78	2.53	1.25***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Because of the moderate sample sizes, we also considered marginally significant coefficients with $p = 0.10$ (similarly hereafter). "Freq = 0" means consumption frequency is zero. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm. "_str" means strength of belief, "_imp" means evaluation of importance. att1 = healthy, att2 = nutritious, att3 = tasty, att4 = satisfactory; sn1 = family's opinion, sn2 = doctor's opinion, sn3 = give family a healthy diet, sn4 = give family a nutritious diet; pbc1 = affordability, pbc2 = accessibility.

Compared with subjects whose egg consumption frequency was zero, subjects who consumed eggs had significantly stronger beliefs that eating eggs was healthy, nutritious, tasty, and satisfactory. The differences in subjective norms and perceived behavioral control, however, were mainly due to the importance evaluations rather than belief strengths. Subjects who consumed eggs evaluated family's and doctor's opinions and preparing healthy meals for family as more important, and affordability as less important when making decisions on eating eggs. They also had significantly stronger perceived needs and habits.

Subjects who consumed dairy had significantly stronger beliefs that consuming dairy was good for the family's nutrition and affordable and had stronger perceived needs and habits as well. They also evaluated satisfaction, doctor's opinion, and accessibility as more important.

Subjects who consumed fish had significantly stronger beliefs that eating fish was healthy, tasty, satisfactory, and affordable, and that family and doctors said they should eat fish. They also evaluated satisfaction and giving their family a healthy meal as more important. Habit and perceived need were significantly stronger for them.

As for subjects who consumed fruits, every facet of subjective norm was stronger, and they also evaluated tastiness as more important and had stronger habits and perceived need.

When comparing the magnitude of differences in each belief strength and importance evaluation, habit appeared to be the predictor with the largest differences for all four food items, followed by perceived need. For fish and fruit, the differences in habit and perceived need were both significant and larger than 1.00 on the 5-point Likert scales. In addition to habit and perceived need, beliefs of satisfaction showed large differences for eggs and fish; beliefs of family's and doctor's opinions showed large differences for fish and fruits; beliefs of giving family a nutritious meal showed large differences for dairy and fruit; beliefs of affordability showed large differences for dairy, fish, and fruit; beliefs of accessibility showed large differences only for fruit.

6.4.3 Differences in opinions between substitute products

To gain some information about why people prefer to consume a certain food item rather than its substitute product, we compared the mean values of each belief strength and importance evaluation in each pair of food items (Table 6.4). One pair of substitutes was meat and fish, since they were both animal tissue containing animal protein and used as main dish for lunch or dinner. The other pair was eggs and dairy, since they were both products of animals containing animal protein and were mainly consumed for breakfast. Although the questions regarding meat and fish, egg and dairy were answered by different groups of subjects, the random sampling procedure ensured the validity of this comparison.

For the pair of meat and fish, Table 6.4 shows that subjects had significantly stronger intentions to eat meat than fish (Diff. = 1.58, p = 0.000). Among the differences in all belief strengths and importance evaluations, habit showed the largest difference (Diff. = 1.88, p = 0.000), followed by perceived need (Diff. = 1.12, p = 0.000), belief that eating meat/fish was good for the

family's health (Diff. = 0.56, p = 0.000) and nutrition (Diff. = 0.55, p = 0.000). Subjects also had stronger beliefs that eating meat was healthy, nutritious, accessible, affordable, and that their family and doctor told they should eat meat than for the same beliefs regarding eating fish. When making decisions on eating meat, subjects evaluated healthiness, taste, family and doctor's opinion as being more important than when making decisions on eating fish.

Table 6.4 Differences in belief strength and importance evaluation by food pairs

	Meat (n = 86)	Fish (n = 83)	Diff.	Egg (n = 92)	Dairy (n = 85)	Diff.
Intention	4.12	2.55	1.58 ***	3.39	2.41	0.98 ***
ATT	15.92	14.44	1.48 ***	14.79	13.29	1.50 ***
att1_str	3.83	3.73	0.09	3.91	3.59	0.32 ***
att1_imp	4.31	4.11	0.21 ***	4.17	4.26	−0.08
att2_str	3.86	3.81	0.05	3.92	3.76	0.16 *
att2_imp	3.97	3.94	0.03	3.97	3.95	0.01
att3_str	4.01	3.59	0.42 ***	3.67	3.06	0.62 ***
att3_imp	3.95	3.81	0.15 *	3.70	3.89	−0.20
att4_str	3.92	3.57	0.35 **	3.48	2.82	0.65 ***
att4_imp	3.88	3.75	0.14	3.52	3.55	−0.03
SN	15.26	13.16	2.10 ***	14.49	13.48	1.00 **
sn1_str	3.59	3.17	0.42 ***	3.36	3.04	0.32 **
sn1_imp	4.09	3.86	0.24 **	3.97	4.04	−0.07
sn2_str	3.22	3.16	0.06	3.17	3.06	0.12
sn2_imp	4.09	3.89	0.20 *	4.07	4.11	−0.04
sn3_str	3.97	3.41	0.56 ***	3.78	3.45	0.34 ***
sn3_imp	4.03	3.87	0.17	4.03	4.15	−0.12
sn4_str	3.99	3.43	0.55 ***	3.76	3.34	0.42 ***
sn4_imp	4.01	3.84	0.17	4.00	4.07	−0.07
PBC	14.88	13.58	1.30 **	14.23	13.80	0.43
pbc1_str	3.78	3.52	0.26 *	3.79	3.35	0.44 ***
pbc1_imp	3.86	3.81	0.05	3.73	4.07	−0.34 ***
pbc2_str	3.95	3.59	0.36 ***	3.85	3.53	0.32 **
pbc2_imp	3.71	3.86	−0.15	3.63	3.84	−0.20
PN	4.08	2.96	1.12 ***	3.51	2.88	0.63 ***
HBT	4.27	2.39	1.88 ***	3.10	2.14	0.96 ***

* p < 0.1, ** p < 0.05, *** p < 0.01. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm. "_str" means strength of belief, "_imp" means evaluation of importance. att1 = healthy, att2 = nutritious, att3 = tasty, att4 = satisfactory; sn1 = family's opinion, sn2 = doctor's opinion, sn3 = give family a healthy diet, sn4 = give family a nutritious diet; pbc1 = affordability, pbc2 = accessibility.

For the pair of eggs and dairy, it was observed that subjects had significantly stronger intentions to consume eggs than dairy (Diff. = 0.98, p = 0.000). Habit again showed the largest difference (Diff. = 0.96, p = 0.000), followed by perceived need (Diff. = 0.63, p = 0.000), belief that it was satisfactory (Diff. = 0.65, p = 0.000) and tasty (Diff. = 0.62, p = 0.000). Subjects also had stronger beliefs that consuming eggs was healthy, nutritious, accessible, affordable, and good for the family's health and nutrition. When making decisions on consuming eggs, subjects evaluated affordability as less important than when making decisions on eating dairy products.

6.4.4 Results of SEM analysis

Table 6.5 shows the standardized results of the SEM analysis of the standard and extended TPB models for predicting intention and frequency of consuming meat, eggs, dairy, fish, and fruits. Compared with the standard TPB model, the extended TPB model included perceived need and habit as separate regressors, both for intention and frequency.

The standard and extended TPB model both fit the data perfectly for intention and frequency of eggs, dairy, and fish, as shown by the CFI of 1.000, TLI larger than 1.000, and RMSEA of 0.000. For meat and fruits, the goodness-of-fit statistics were less satisfactory but were still at an acceptable level regarding the SRMR and Chi-square (see Table 6.5).

In general, more variance of intentions was explained than of behaviors, in line with other food-choice-related studies (McDermott et al., 2015). Compared with the standard TPB model, the extended TPB model increased the explained variance of both intention and behavior, but more for intention. For example, for the estimation of dairy consumption, R^2s of the intention and behavior equation were 0.193 and 0.120, respectively, in the standard TPB model, but increased to 0.628 and 0.161, respectively, in the extended TPB model. The same trend was also observed for the other food items.

6.4.4.1 Prediction of intentions

In the standard TPB models, attitudes significantly predicted intentions to consume meat (Coeff. = 0.311, p = 0.007), eggs (Coeff. = 0.341, p = 0.002), dairy (Coeff. = 0.383, p = 0.099), fish (Coeff. = 0.267, p = 0.017), and fruits (Coeff. = 0.279, p = 0.006). Therefore, Hypothesis 1 was supported for all five food items. Subjective norms, however, were only significant in predicting intentions to consume fish (Coeff. = 0.251, p = 0.031) and fruit (Coeff. = 0.401, p = 0.000), confirming Hypothesis 2 only for these two products. Perceived behavioral control, surprisingly, was not significant in predicting intentions to consume any of the food items. Hence, Hypothesis 3 was not confirmed.

In the extended TPB models, perceived need significantly predicted intention to consume all five food items (Meat: Coeff. = 0.460, p = 0.000; Eggs: Coeff. = 0.328, p = 0.001; Dairy: Coeff. = 0.270, p = 0.001; Fish: Coeff. = 0.398, p = 0.000; Fruit: Coeff. = 0.291, p = 0.003), supporting Hypothesis 6. Habit also showed significant effects on intention to consume eggs (Coeff. = 0.227, p = 0.016), dairy (Coeff. = 0.576, p = 0.000), fish (Coeff. = 0.342, p = 0.000), and fruits (Coeff. = 0.254, p = 0.005), but not meat. Hence, Hypothesis 7 was supported for four out of five food items. Moreover, perceived need and habit showed stronger effects on intention than attitudes and subjective norms.

Compared with the prediction in standard TPB models, the role of attitudes, subjective norms, and perceived behavioral control remained the same for intention to consume meat, eggs, dairy, and fruits in the extended TPB models, with the exception of fish. In the extended TPB model,

perceived behavioral control became a significant predictor of intention to eat fish (Coeff. = 0.189, $p = 0.012$), whereas attitude and subjective norms became insignificant. A possible explanation is that for fish consumption, perceived need and habit were significantly correlated with attitude and subjective norms, but not with perceived behavioral control (see the correlation Tables A6.2–A6.6 in Appendix). Introducing perceived need and habit in the extended TPB model weakened the effects of attitudes and subjective norms, which is in line with the prior study that included perceived need to predict intention of healthy eating (Payne et al., 2004), and the study that included habit to predict intention to eat fish (Verbeke & Vackier, 2005).

Table 6.5 Structural equation modeling (SEM) analysis results of standard and extended TPB models for frequency and intention of consuming meat, eggs, dairy, fish, and fruits

	Standardized Coeff. (Standard TPB)					Standardized Coeff. (Extended TPB)				
	Meat	**Eggs**	**Dairy**	**Fish**	**Fruit**	**Meat**	**Eggs**	**Dairy**	**Fish**	**Fruit**
Frequency										
INT	0.197 *	0.295 ***	0.023	0.438 ***	0.418 ***	0.231 *	0.192	−0.228	0.288 *	0.255 *
PBC	0.227 **	0.067	0.345 ***	−0.027	0.149	0.230 **	0.074	0.307 ***	−0.015	0.113
HBT						0.101	0.046	0.205	0.202	0.090
PN						−0.139	0.152	0.170	0.035	0.168
Constant	1.172	−0.439	−0.856	−0.584	−1.105	1.222	−0.95	−1.079	−0.856	−1.293
Intention										
PBC	0.107	−0.011	−0.016	0.143	0.160	−0.107	0.041	−0.080	0.189 **	0.061
ATT	0.311 ***	0.341 ***	0.383 ***	0.267 **	0.279 ***	0.346 ***	0.206 *	0.136 *	0.073	0.154 *
SN	0.143	0.136	0.107	0.251 **	0.401 ***	−0.076	0.061	−0.045	0.058	0.242 **
HBT						0.165	0.227 **	0.576 ***	0.342 ***	0.254 ***
PN						0.460 ***	0.328 ***	0.270 ***	0.398 ***	0.291 ***
Constant	3.142	0.420	0.320	−0.199	0.713	0.695	−0.665	0.179	−0.854	0.261
R^2 (Freq)	0.114	0.096	0.120	0.186	0.265	0.126	0.118	0.161	0.213	0.288
R^2 (INT)	0.206	0.179	0.193	0.275	0.538	0.438	0.384	0.628	0.578	0.677
R^2 (Overall)	0.246	0.183	0.289	0.275	0.547	0.474	0.402	0.688	0.592	0.693
Chi2(χ^2)	4.965	1.078	1.164	0.187	5.950	5.544	0.947	1.925	0.468	8.029
p−value	0.084	0.583	0.559	0.911	0.051	0.063	0.623	0.382	0.791	0.018
RMSEA	0.131	0.000	0.000	0.000	0.159	0.144	0.000	0.000	0.000	0.197
CFI	0.895	1.000	1.000	1.000	0.952	0.936	1.000	1.000	1.000	0.946
TLI	0.631	1.150	1.126	1.172	0.834	0.650	1.126	1.005	1.104	0.703
SRMR	0.060	0.018	0.023	0.008	0.046	0.046	0.012	0.024	0.011	0.038

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm. For the sake of space, the standard errors and p-values are not listed in the table but can be obtained from the authors.

In summary, for most food items, perceived need, habit, and attitudes were significant predictors of intentions, and the effects of perceived need and habit were stronger than the effects of attitudes. As for the predictions by food item, intentions to eat fruit were predicted by perceived need, habit, subjective norms, and attitudes (ordered from the strongest to the weakest, similarly hereinafter); intentions to consume eggs and dairy were predicted by perceived need, habit, and attitudes, but for dairy, habit was the strongest predictor; intentions to eat fish were predicted by perceived need, habit, and perceived behavioral control in the extended TPB, but were predicted by attitudes and subjective norms in the standard TPB; intentions to eat meat were predicted by perceived need and attitudes.

6.4.4.2 Prediction of behaviors

The results from Table 6.5 showed that intentions significantly predicted consumption frequency of meat (Coeff. = 0.197, p = 0.057), eggs (Coeff. = 0.295, p = 0.002), fish (Coeff. = 0.438, p = 0.000), and fruits (Coeff. = 0.418, p = 0.000), supporting Hypothesis 4. Perceived behavioral control was only found to be significant in predicting the consumption frequency of meat (Coeff. = 0.227, p = 0.025) and dairy (Coeff. = 0.345, p = 0.000). Hence, Hypothesis 5 was only supported for meat and dairy, but not for eggs, fish, and fruits.

In the extended TPB models, perceived need and habit were not significant predictors of consumption frequency of any food items; therefore the direct effects stated in Hypotheses 8 and 9 were not confirmed.

However, as shown in Table 6.6, because of the effect of intentions, the indirect effects of attitude were evident on consumption frequency of eggs (Coeff. = 0.083, p = 0.039), fish (Coeff. = 0.041, p = 0.043), and fruits (Coeff. = 0.091, p = 0.032). The indirect effects of subjective norms were significant on consumption frequency of fish (Coeff. = 0.030, p = 0.060) and fruits (Coeff. = 0.119, p = 0.012). In the extended TPB, the indirect effects of attitude and subjective norms on consumption frequency were generally diminished. Attitudes only had significant indirect effects on consumption frequency of eggs. Subjective norms were not significantly predictive of consumption frequency of any food item. Instead, perceived need had significant indirect effects on consumption frequency of eggs (Coeff. = 0.472, p = 0.065), and fruits (Coeff. = 0.768, p = 0.081); habit had significant indirect effects on consumption frequency of fish (Coeff. = 0.320, p = 0.010).

Table 6.6 Indirect effects of TPB constructs on frequency of consuming meat, eggs, dairy, fish, and fruits of standard and extended TPB models

	Standardized Coeff. (Standard TPB)					Standardized Coeff. (Extended TPB)				
	Meat	**Eggs**	**Dairy**	**Fish**	**Fruit**	**Meat**	**Eggs**	**Dairy**	**Fish**	**Fruit**
PBC	0.010	−0.002	−0.001	0.010	0.049	−0.012	0.004	0.010	0.015	0.011
ATT	0.039	0.083 **	0.006	0.041 **	0.091 **	0.051	0.206 *	−0.022	0.007	0.031
SN	0.016	0.021	0.001	0.030 *	0.119 **	−0.010	0.061	0.006	0.005	0.043
HBT						0.370	0.147	0.157	0.320 ***	0.380
PN						−0.093	0.472 *	0.247	0.164	0.768 *

* p < 0.1, ** p < 0.05, *** p < 0.01. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

To sum up, after including habit and perceived need in the TPB, the significant predictors of consumption frequency were intention and perceived behavioral control for meat; perceived need and attitude (indirect) for eggs; perceived behavioral control for dairy; habit (indirect) and intention for fish; and intention and perceived need (indirect) for fruits.

6.5 Discussion

6.5.1 Role of perceived need and habit in the TPB

In this study, adding perceived need and habit in the TPB as predictors of intention and behavior substantially increased the explained variance of intention, but increased the explained variance of behavior by a small amount only. Moreover, perceived need and habit were only significant direct predictors of intention and not of behavior, which means habit and perceived need only influenced behavior indirectly via intention.

As for perceived need, this finding is consistent with the study of Payne et al. (2004), who found that perceived need was a significant and dominant predictor of intention to eat healthy, but not for eating behavior. They interpreted this observation as perceived need only being relevant during the cognitive processing culminating in intention formation.

As for habit, our finding is consistent with Saba et al. (1998), who found that habit only predicted intention to drink milk but not behavior to drink milk. However, Verbeke and Vackier (2005) found that habit had significant effects on both intention and behavior to eat fish, and so did Saba et al. (2000) for a large variety of fat-containing food and Faghih et al. (2019) for junk food consumption, which is different from our finding. Saba et al. (2000) claimed that the different and imprecise definition of habit may have contributed to different effect paths of habit in the TPB.

Another observation is that, apart from the prediction of meat consumption, perceived need and habit had larger effects on intention than other TPB constructs, and the inclusion of perceived need and habit diminished the effects of attitude and subjective norms on intention and the effects of intention on behavior. This observation is in line with the branch of studies including habit (Saba et al., 1998; Bagozzi, 1981). This effect was explained by the less conscious consideration of more habitual behavior. In other words, for frequently decided behaviors, people may apply limited cognitive processing, thus all constructs of the TPB requiring deliberation played a lesser role in making a decision, whereas habit played a larger role (Summer, 2011). However, from our results, meat was the most frequently consumed food among all five food items, but the effect of habit was not significant in predicting intention, and the effects of other TPB constructs were also not diminished after including habit.

Instead, we turn to a possible alternative explanation: food involvement. Food involvement generally describes how deeply a person is involved in and thinks about food acquisition, preparation, cooking, eating, and disposal (Bell & Marshall, 2003). Verbeke and Vackier (2005) found that a lower food involvement level had a relatively strong impact of habit in fish consumption. It is because food involvement is a better indicator to reflect cognitive complexity than frequency or how habitually a behavior is performed. A frequently performed behavior, like consuming meat in our study, may still be accompanied by extensive cognitive effort. For example, people may pay much attention to the quality of meat and spend time to select the piece of meat

they want. This explanation is in line with the point that some behaviors, although containing automatic elements, are still reasoned in nature (Bamberg & Schmidt, 2010; Amalia et al., 2020). However, when looking at the results for dairy, which is the least frequently consumed product, the effect of habit was dominant. This means that for a rarely performed behavior, people may have too little information or experience to make cognitive efforts in decision making, and therefore, habit plays an important role: people who are not in the habit of consuming dairy usually also will not consume dairy. To sum up, the effect of habit on intention or behavior is not necessarily related to the habitual level of the behavior, but may be more related to the cognitive complexity or extensiveness of decision making. A less frequently performed behavior may have a stronger habit effect due to less information processed.

As for the branch of studies including perceived need, although perceived need had significant and considerable influence on intention to eat fruit and vegetables, Povey et al. (2000) found that it did not change the effects of the TPB variables on intention. However, in a study predicting healthy eating, inclusion of perceived need diminished the effects of cognitive attitude and subjective norm on intention, but not the effects of perceived behavioral control (Payne et al., 2004). This phenomenon was not explained by the authors.

Altogether, we found that both perceived need and habit predicted intentions well but did not predict behavior, and it is suggested that they be added to the TPB in similar future studies. However, the conceptualization of habit and perceived need and thus the link and interaction with other constructs in the TPB and the mechanism behind them needs to be studied further.

6.5.2 Practical implications to improve consumption of fish, fruits, dairy, and eggs

To make suggestions for interventions to improve actual consumption of target food items, we need to focus on the significant predictors of behavior. In other words, if we found intention is not a significant predictor of behavior, then interventions targeting on all the other TPB constructs which influence intention may not be effective in changing behavior (Ajzen, 2006). On the other hand, if intention is significant, the effects of TPB constructs on behavior may be smaller as compared with their effects on intention. This is because there may be other factors, e.g., institutional, situational or social, influencing behavior besides the TPB constructs.

For fish and fruit, consumption frequency is significantly predicted by intention, and in both cases perceived need is the strongest predictor of intention, followed by habit. Perceived need can be enhanced in two ways: making rural residents aware of the health benefits of eating fish and fruits; and making rural residents aware of their consumption deficit compared with the recommended level. Both these pieces of information can be included in existing nutrition education programs in poor rural areas. Habit, however, is difficult to change in the short term, especially for adults. The life course development of food choice shows that dietary habits mainly are formed in the early stages of life (Conner & Armitage, 2006). Hence, efforts to form healthy

dietary habits are most effective for children and adolescents. Dietary education and meals at school are therefore essential to form healthy eating habits.

For fruit consumption, other significant predictors of intention are subjective norms and attitude. From the results in Table 6.3, we found that all facets of subjective norms showed significant differences between people who consumed fruits more frequently and those who consumed less frequently. Doctors' and families' suggestions on consuming fruits appeared to play a big role. Hence, promotion of the importance of consuming fruits could be included in local medical service training and in nutritional education programs. Thus, additional communication campaigns focusing on sharing dietary knowledge with people around may be effective. From the aspects of attitude, we know that the affective component, which is tastiness, played a large role. This is in line with other studies on healthy eating, which usually consider eating vegetables and fruits as a manner of healthy eating and that affective attitude is a stronger predictor of intention than cognitive attitude (Payne et al., 2004). Advertisements or other promotion measures to make people feel that fruits are tasty may be effective in improving people's intention to eat fruits.

For fish consumption, besides perceived need and habit, another significant predictor of intention was perceived behavioral control. Comparing people who consumed fish and who did not in the previous seven days of survey time, the significant difference in perceived behavioral control was mainly due to affordability. Comparing the differences in perceived behavioral control in consuming meat and fish, affordability and accessibility both were significant. Since the survey areas were mountain areas where fish supply was low, improving market access of fish and people's purchase power to buy fish are essential measures to improve fish consumption in those areas.

For dairy consumption, intention was not a significant predictor of behavior but perceived behavioral control was. Like in the case for fish consumption, measures to improve accessibility and affordability of dairy both need to be undertaken.

Neither intention nor perceived behavioral control was a significant predictor of egg consumption. However, from Table 6.6 we knew that egg consumption was indirectly predicted by perceived need and attitude. Measures of both these predictors emphasize nutrition value and healthiness of eating eggs, and to diversify recipes of eggs in the nutrition education program may help to increase people's overall attitude towards eating eggs. Measures to improve perceived need as described earlier, aiming to improve consumption of fish and fruits, can also be applied to the consumption of eggs.

Although for our sample the consumption levels of dairy and fish were extremely low and those of eggs and fruit were also relatively low, thus calling for an increase in consumption levels of these food items according to the Chinese dietary guidelines, it does not necessarily mean that more consumption would be better. The healthy reference diet recently proposed by the EAT-Lancet Commission, setting ranges of intakes for food groups to ensure human health (Willett et al., 2019), has recommended intake levels for dairy, fish, and eggs that are even lower than the lower limit of the recommended intake levels in Chinese dietary guidelines. The reference level of

fruit intake is the same. The diverging guidelines exist because the EAT-Lancet Commission suggests a worldwide dietary transition aimed at increasing consumption of plant-based foods (like vegetables, fruits, whole grains, legumes, nuts, etc.) and decreasing consumption of animal-based foods (especially red meat). This dietary transition aims to deal with both diet-related human health issues and environmental problems. Combining the Chinese dietary guidelines and the EAT-Lancet Commission suggestions in designing interventions, information aiming for moderate consumption levels of food groups might be considered, as well as considering possible substitutes from plant-based foods if they are locally accessible.

6.5.3 Criticisms of the TPB

Despite the widespread use of the TPB regarding food choice and other health-related behaviors, there are still some criticisms to TPB. One branch of criticism focuses on the validity or the set-up of the TPB. One criticism is that all components and pathways in the TPB are considered rational without considering unconscious factors and influences on behavior (Sheeran et al., 2013). For this criticism, Ajzen (2015) defended himself by explaining that the "planned" characteristics of the TPB do not imply rationality, and only meant that intention and behavior are consistently formed from readily accessible beliefs. However, beliefs can be informed poorly, which allows for and may reflect irrational processes. Another criticism is that—although Ajzen (2015) claimed that background information such as demographics, emotions, personality traits, general values, etc. only influences beliefs and thus indirectly influences intention and behavior—many studies showed that background information can have direct effects on behavior (Sniehotta et al., 2014; Sniehotta et al., 2013). In addition, other factors, such as habit and perceived need in this study, self-identity (Conner & Armitage, 1998), planning (Carraro & Gaudreau, 2013), etc. that can neither be grouped as background information nor as TPB components proved significant predictors of intention or behavior. That is why many extended TPB studies have been conducted.

The other branch of criticism is about the utility of the TPB; that is, whether the designed interventions based on the TPB results are useful and really lead to behavior change (Sniehotta et al., 2014). Some experimental studies showed failure of the TPB in causing behavior change (Chatzisarantis & Hagger, 2005; Sniehotta, 2009). However, recent studies seem to support the utility of the TPB. Hardeman et al. (2002) reviewed 30 papers and found half of the interventions based on the TPB were effective in changing intention, and two-thirds in changing behavior. A more recent similar study on dietary behavior change showed that nine of eleven TPB based interventions resulted in dietary behavior change of adolescents and young adults (Hackman & Knowlden, 2014).

One more query about the application of TPB in dietary change is that the TPB seems to be most predictive amongst the young, fit and affluent people (McEachan et al., 2011), who differ substantially from the populations in which dietary behavior change is most needed. However, in our study we focused on the population aged over 18 years living in poor, rural areas in China that

is most likely to suffer from malnutrition, and the explained variance of intention and behavior by the extended TPB was still generally high.

6.5.4 Limitations

Our study employed both a standard and an extended version of the TPB, which was estimated using structural equation modeling. Despite the extensive model, the main limitation of this study is that it is cross-sectional, prohibiting conclusions concerning causal effects. Although habits and perceived needs contributed to the explanation of food consumption intentions, the processes of habit formation and need development could not be traced in the cross-section. Hence, the utility of the interventions proposed from the results remains to be tested by more rigorous experiments. However, we think these exploratory associations at least offer important information on directions of efforts taken to improve consumption of target food items in poor, rural areas of China.

Another limitation is that although we had a total sample size of 424 respondents, they were randomly separated for questioning the consumption of five different food items, leading to relatively small samples to study the consumption of each food item. This small sample size restricted us from adding more background information such as demographics into the TPB model, acting as control variables and possibly leading to different estimation results.

6.5.5 Conclusion

In conclusion, this study provides support for the TPB in predicting food consumption of rural residents in poor counties of Southwest China, and to our knowledge, it is the first study to apply the TPB to study social psychological factors of food consumption for rural residents in China, and with a special focus on poor counties. The results are applicable in designing interventions aiming to improve dietary diversity and nutrition in poor rural counties of China where malnutrition is prevalent. Moreover, it shows that extending the TPB by including perceived need and habit substantially increased the explained variance of intention, and perceived need and habit only indirectly influenced behavior. For less frequently consumed food items, perceived need and habit are stronger predictors of intention than other constructs, and diminished effects of the standard TPB constructs were observed after including perceived need and habit. For more frequently consumed foods like meat, habit has no significant effect on intention, and no diminished effects of the standard TPB constructs were observed. This shows that less frequently performed behavior may have stronger habit effects on intention due to less information needing to be processed and cognitively analyzed. This explanation is different from other studies which consider habit only playing an important role in predicting habitual behaviors. Our study suggests that in order to increase dietary diversity by promoting less frequently consumed food, stimulating

perceived needs and developing habits may be more important than strengthening attitudes, social norms and perceived behavioral control.

Acknowledgments

We acknowledge all the rural residents who participated in the study. We are also thankful to students of Yunnan Agricultural University, and every investigator in our research team for assisting the survey implementation.

Appendix

Table A6.1 Descriptive statistics (means, standard deviations) of the TPB construct items for predicting consumption frequency of meat, eggs, dairy, fish, and fruit

	Meat (n = 86)		Egg (n = 92)		Dairy (n = 85)		Fish (n = 83)		Fruit (n = 78)	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Frequency	5.71	1.70	1.47	1.71	0.93	2.18	0.42	1.05	3.49	2.79
Intention	4.12	0.67	3.39	0.99	2.41	1.03	2.55	1.03	3.82	0.90
ATT	15.92	2.65	14.79	2.06	13.29	3.06	14.44	3.00	16.01	3.57
att1	16.50	3.72	16.54	3.79	15.28	3.64	15.45	3.77	17.64	4.30
att1_str	3.83	0.67	3.91	0.60	3.59	0.74	3.73	0.68	4.09	0.67
att1_imp	4.31	0.54	4.21	0.55	4.26	0.52	4.11	0.44	4.27	0.53
att2	15.41	3.47	15.72	2.89	14.93	3.63	15.07	3.23	16.35	3.87
att2_str	3.86	0.62	3.92	0.47	3.76	0.72	3.81	0.59	3.99	0.69
att2_imp	3.97	0.47	4.00	0.53	3.95	0.55	3.94	0.45	4.08	0.53
att3	16.08	3.30	14.16	3.31	12.20	4.04	13.76	3.79	15.44	4.11
att3_str	4.05	0.59	3.71	0.62	3.13	0.96	3.63	0.73	3.88	0.66
att3_imp	3.95	0.43	3.83	0.62	3.93	0.57	3.81	0.67	3.94	0.57
att4	15.71	3.77	12.74	3.55	10.74	4.23	13.49	4.06	14.62	4.54
att4_str	4.02	0.61	3.51	0.76	2.89	0.86	3.60	0.83	3.74	0.75
att4_imp	3.88	0.56	3.65	0.67	3.66	0.70	3.75	0.64	3.85	0.67
SN	15.26	3.07	14.49	3.19	13.48	3.57	13.16	3.91	16.07	3.94
sn1	14.79	4.47	13.57	4.04	12.33	4.59	12.53	4.62	15.41	4.83
sn1_str	3.59	0.85	3.39	0.82	3.04	0.98	3.17	0.91	3.81	0.81
sn1_imp	4.09	0.63	4.00	0.59	4.04	0.63	3.89	0.62	4.00	0.68
sn2	13.38	5.37	13.29	5.36	12.68	5.31	12.67	5.09	15.73	5.37
sn2_str	3.26	1.05	3.21	1.03	3.06	1.08	3.16	0.98	3.76	0.93
sn2_imp	4.09	0.64	4.10	0.65	4.11	0.66	3.96	0.65	4.14	0.66
sn3	16.42	3.85	15.63	3.56	14.71	4.53	13.78	4.69	16.58	4.13
sn3_str	4.00	0.59	3.82	0.61	3.48	0.87	3.45	0.90	3.97	0.62
sn3_imp	4.07	0.50	4.07	0.44	4.19	0.48	3.94	0.59	4.13	0.47
sn4	16.42	3.85	15.63	3.56	14.71	4.53	13.78	4.69	16.58	4.13
sn4_str	4.02	0.59	3.79	0.73	3.41	0.90	3.47	0.89	3.99	0.67
sn4_imp	4.05	0.55	4.03	0.46	4.11	0.49	3.88	0.55	4.10	0.47
PBC	14.88	3.45	14.23	3.32	13.80	3.89	13.58	3.64	15.01	3.83
pbc1	14.76	3.97	14.21	3.77	13.72	4.37	13.29	4.32	14.87	4.04
pbc1_str	3.78	0.76	3.83	0.81	3.35	0.98	3.52	1.02	3.74	0.80
pbc1_imp	3.93	0.78	3.76	0.79	4.11	0.62	3.84	0.79	3.97	0.70
pbc2	15.00	3.93	14.26	4.24	13.88	4.95	13.87	4.39	15.15	4.93
pbc2_str	3.95	0.63	3.88	0.71	3.56	0.97	3.59	0.95	3.83	0.83
pbc2_imp	3.78	0.68	3.66	0.76	3.87	0.78	3.89	0.64	3.91	0.72
PN	4.08	0.60	3.51	0.78	2.88	0.96	2.96	0.96	3.86	0.88
HBT	4.27	0.64	3.13	1.04	2.14	1.03	2.39	0.99	3.47	1.14

INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm. "_str" means strength of belief, "_imp" means evaluation of importance. att1 = healthy, att2 = nutritious, att3 = tasty, att4 = satisfactory; sn1 = family's opinion, sn2 = doctor's opinion, sn3 = give family a healthy diet, sn4 = give family a nutritious diet; pbc1 = affordability, pbc2 = accessibility.

Table A6.2 Correlation between TPB constructs, perceived need, and habit for meat consumption (n = 86)

	Frequency	**Intention**	**ATT**	**SN**	**PBC**	**HBT**
Intention	0.2563 **					
ATT	0.0081	0.4274 ***				
SN	−0.0581	0.3122 ***	0.4909 ***			
PBC	0.2787 ***	0.2625 **	0.4314 *	0.1518		
HBT	0.2127 **	0.4528 ***	0.2671 **	0.4386 ***	0.3851 ***	
PN	0.1702 ***	0.5821 ***	0.2639 **	0.3534 ***	0.3668 ***	0.5874 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

Table A6.3 Correlation between TPB constructs, perceived need, and habit for egg consumption (n = 92)

	Frequency	Intention	ATT	SN	PBC	HBT
Intention	0.3032 ***					
ATT	0.2090 **	0.4066 ***				
SN	0.0713	0.3092 ***	0.5104 ***			
PBC	0.1048	0.1300	0.3705 ***	0.1054		
HBT	0.2068 **	0.4453 ***	0.1830 *	0.2264 **	−0.044	
PN	0.2562 ***	0.5334 ***	0.3430 ***	0.2651 **	0.0491	0.5147 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

Table A6.4 Correlation between TPB constructs, perceived need, and habit for dairy consumption (n = 85)

	Frequency	Intention	ATT	SN	PBC	HBT
Intention	0.0305					
ATT	−0.0648	0.4297 ***				
SN	0.0894	0.2719 **	0.4405 ***			
PBC	0.3457 ***	0.0230	0.0410	0.2196 **		
HBT	0.1695	0.7355 ***	0.3649 ***	0.3101 ***	0.1520	
PN	0.3265 ***	0.5914 ***	0.3937 ***	0.3564 ***	0.0752	0.5028 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

Table A6.5 Correlation between TPB constructs, perceived need, and habit for fish consumption (n = 83)

	Frequency	Intention	ATT	SN	PBC	HBT
Intention	0.4307 ***					
ATT	0.1958 *	0.4477 ***				
SN	0.1611	0.4549 ***	0.5908 ***			
PBC	0.0981	0.2848 ***	0.2262 **	0.3229 ***		
HBT	0.3952 ***	0.6180 ***	0.3326 ***	0.3701 ***	0.1477	
PN	0.2277 ***	0.6347 ***	0.4601 ***	0.4155 ***	0.0253	0.5069 ***

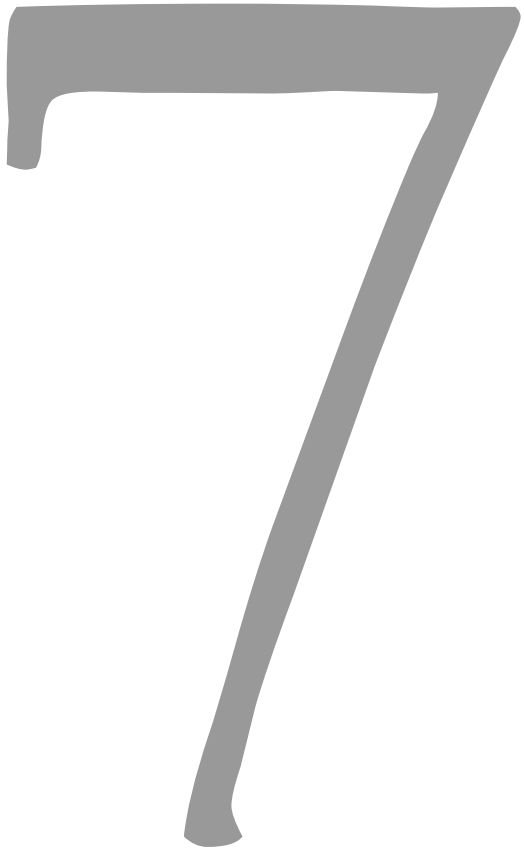
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

Table A6.6 Correlation between TPB constructs, perceived need, and habit for fruit consumption (n = 78)

	Frequency	Intention	ATT	SN	PBC	HBT
Intention	0.4997 ***					
ATT	0.1639	0.6267 ***				
SN	0.3367 ***	0.6844 ***	0.6616 ***			
PBC	0.3788 ***	0.5505 ***	0.5130 ***	0.6167 ***		
HBT	0.4306 ***	0.6796 ***	0.4379 ***	0.5491 ***	0.4672 ***	
PN	0.4645 ***	0.7199 ***	0.5880 ***	0.5652 ***	0.4928 ***	0.6791 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. INT = intention, PBC = perceived behavioral control, HBT = habit, PN = perceived need, ATT = attitudes, and SN = subjective norm.

CHAPTER



General Discussion

7.1 Introduction

This dissertation mainly aimed at bringing behavioral economic insights to provide additional explanations of food consumption of rural households in underdeveloped areas of China. This aim was driven by the research gap caused by the sparse application of behavioral economic theories in food consumption, and the expectation that these insights might help in designing a broader array of policies or strategies to improve diets and nutrition of these households. The subjects of the research—rural households in underdeveloped areas of China—are selected for both theoretical and practical research purposes. Rural households in many developing countries are smallholder farmers who are both food consumers and producers, who consume considerable amounts of food from their own production, and who face food environments different from urban residents.

This dissertation contributes to the literature by: a) examining whether some applications of behavioral economic theories such as loss aversion (Chapter 3), mental accounting (Chapter 4 and 5), and the theory of planned behavior (Chapter 6) in food consumption that are relevant for urban residents and pure consumers also hold for rural residents; b) exploring how farmers behave differently than pure consumers with respect to asymmetric price effects on food demand (Chapter 3), how farmers deal with self-produced food under the mental accounting hypothesis (Chapter 4), how consumption of self-produced food influences nutrient intake and diets (Chapter 2 and 5); and c) investigating social-psychological factors of food consumption (Chapter 6) which are often overlooked in food consumption studies of rural residents in developing countries.

In this final chapter, we first highlight the contributions of the dissertation (Section 7.1). Then we recap the main findings and discuss the theoretical implications (Section 7.2) and practical implications (Section 7.3). Next, we present limitations and recommendations for future research (Section 7.4), and the final conclusion (Section 7.5).

7.2 Synthesis of findings and theoretical implications

7.2.1 Food and nutrient demand

In Chapter 2, we estimated food and nutrient demand elasticities for households with agriculture as main income source and other households. We found that for all household groups, the food categories of meat & aquatic products, and bean products & nuts had the highest expenditure elasticities with values above 1.3. In general, income elasticities of agricultural households were on a higher level than those for other households. In line with recent research in rural China, the income elasticity for grain was the lowest compared to the other food groups (Zheng et al., 2015). Concerning the price elasticities, the own-price elasticities of 7 food categories (except for oil) for agricultural households were higher than for other households. The differences are however often very small. Since agricultural households can switch consumption to own-

produced food if purchase prices are increasing a more elastic demand than for other households could have been expected.

Nutrient income elasticities are a bit higher for agricultural households than for other households, although not much. The income elasticities ranged from 0.23 (energy) to 0.29 (vitamin A) for agricultural households, and from 0.17 to 0.21 for other households. Thus, when income rises, the agricultural households' changes in nutrient purchases are a bit more pronounced than for the other households. This is not generally the case for price changes. Price elasticities of energy, protein, iron and zinc with respect to price changes of grain and meat & aquatic products are smaller for agricultural households than for the other households group. For both household groups the grain price has the most important effect on nutrient demand for energy, protein, iron, zinc and vitamin A, which is not surprising given its status as a staple food. Only for vitamin C it is the price of vegetables that has the highest influence. Other product prices with important effects on nutrient consumption are for tuber and fruits on vitamin C and for vegetables on vitamin A.

The simulations further show that, other things equal, when income rises by 10%, the total number of nutrition-insecure households reduces by 4% for energy and iron, 3% for zinc and vitamin C, and 2% for protein. Vitamin A demand remains nearly unaffected. The income effect is for most nutrients more pronounced for agricultural households than for other households, with zinc and vitamin A being exceptions. As for simulations of price changes, a price reduction and a price increase are not having symmetric effects, as doubling the prices would hurt the group of other households far more than agricultural households while a reduction of prices would not that clearly bring a benefit to them compared to agricultural households. We therefore see simulations as a valuable addition to the report of nutrient elasticities. A further promising approach to refine the simulations is to also estimate production side changes and see how own production changes a household's nutrient supply.

7.2.2 Loss aversion and asymmetric price effects on food demand

Although studies of asymmetric price effects on consumer choice appear in the marketing literature (see Neumann & Böckenholt, 2014, for a review), they are: a) very limited in the economics literature underlying demand theory; b) limited in studies for food consumption; c) not studied for rural residents; and d) showing mixed results by products and by model specifications, indicating that loss aversion in food demand is not a universal phenomenon.

Therefore, in Chapter 3 we extended prior studies by incorporating asymmetric price effects in demand models to explore possible asymmetric food demand patterns of rural households, by applying different ways of modeling reference prices in demand models and comparing the results, by further comparing asymmetric food demand patterns of pure consumers and farmers (who are both food producers and consumers) and comparing asymmetric effects for different food items.

In our study, we found that the phenomenon of loss aversion on food demand was also partly applicable to rural households in 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).

Asymmetric price effects differed across food items

The food items we have studied are rice, potatoes, and pork, and we found that for pure consumers, loss aversion effects on demand were significant for rice and potatoes, but not for pork (when estimated by the double-log model with segmented price specification). 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 and found that loss aversion effects were more prominent for healthy foods. They explained their findings by different perceptions of palatability for unhealthy and healthy food (Raghunathan et al., 2006). Healthy foods are usually perceived as less palatable than unhealthy foods, and thus people have an impulse to underconsume healthy foods. Therefore, for healthy foods, when price increases, the decreased quantity demanded is reinforced by the impulse to underconsume; when price decreases, the increased quantity demanded is counteracted by the impulse to underconsume, resulting in an observed loss aversion effects on demand (Wansink & Huckabee, 2005). Our findings of significant loss aversion effects for rice and potatoes may also be consistent with Talukdar and Lindsey's explanation (2013) on different perceptions of palatability for unhealthy and healthy food. In rural China, although people barely have the idea to categorize daily consumed food as healthy or unhealthy, 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, and more enjoyable to eat. Thus, the impulse to underconsume rice and potatoes is stronger than for pork, making the loss aversion effects only significant for rice and potatoes for pure consumers. 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).

Asymmetric price effects: pure consumers versus farmers

In our study, we estimated asymmetric price effects separately for pure consumers and farmers and compared. For pork consumption, we found that the loss aversion effect was significant for farmers but not for pure consumers. Farmers reacted significantly stronger to price increases than to price decreases. We interpret this phenomenon by reasoning that a price increase is a profitable and favourable situation for farmers who would sell pork to the markets for cash income. When pork price increases, farmers can sell more products for higher income and consume less of their production. The opportunity cost of consuming self-production in periods of price increase makes consumption by farmers more responsive 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.

Our finding may be related to the experiment made by Kahneman et al. (1991) on the endowment effect. They found that sellers who owned mugs were reluctant to part with their endowments and showed higher reservation prices, and thus loss aversion, than buyers. In our study, farmers could be both sellers and consumers, and it is hard to tell whether they perceive a price increase as a more favorable or unfavorable situation for them. It is possible that only when price increases to a certain level that they perceive it is worthwhile to sell their produce, they would sell more as price continues to increase, and are willing to consume less. 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.

Asymmetric price effects: how models matter?

We applied two different methods of modeling effects of reference prices in demand analysis and compare the results within our study. One method we called "segmented price model" in our study, which applied the double-log demand model and constructed a dummy variable representing whether a consumer experienced a loss or a gain by comparing present price and reference price, and then multiplied the dummy variable with logged present price to get the segmented logged prices in the double-log demand model (Yan et al., 2016; Talukdar & Lindsey, 2013). The other method we called "price increase and price decrease model" in our study, which is based on Putler (1992) who 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. We added 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 of experiencing losses or gains with the difference term. This method is also applied in Vande Kamp & Kaiser (1999) and Maynard & Subramamiam (2015). We found that asymmetric price effects on food demand were easier detected by the segmented price model, but not detected by the price increase and price decrease model. The segmented price model directly estimated price elasticity separately for people who experienced losses and for those who experienced gains. Instead, the price increase and price decrease model includes both the effect of actual price and the effect of the difference between actual price and reference price. A similar observation was mentioned in a meta-analysis of loss aversion in the applications of product choice models (Neumann & 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. This finding using choice models is consistent with our findings using the demand model. 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. This explanation may also hold for the demand models. We suggest to apply both models in the estimation, and empirically judge them by statistical criteria.

7.2.3 Mental accounting and consumption of self-produced food

Given the limited research on the mental accounting of food consumption quantity (Krishnamurthy & Prokopec, 2010; Sussman et al., 2016), our studies (Chapter 4 and 5) are the first to examine whether mental accounting theory is applicable to consumption of own-produced food of agricultural households. Our studies may enrich the application of mental accounting theory to non-monetary resources, namely food, and non-pure consumers, and bring new insights into understanding the allocation and consumption process of own-produced food of agricultural households, as well as the dietary outcome of applying mental accounting, and the factors in mental accounting of self-produced food.

Mental budget setting and tracking

We applied different methods to test the mental budget setting and tracking behaviour of agricultural households. In Chapter 4, we assumed that agricultural households reserve a certain quantity of self-produced food for own consumption and overlook the opportunity cost of the quantity of planned consumption of self-produced food. 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. Therefore, the consumption 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. Thus, the consumption of self-produced food is increasing in the quantity of production if production is lower than the set budget, and the consumption of self-produced food is independent of the quantity of production if production is higher than the set budget. 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. The result is consistent with another study which evaluated the price effect of self-produced food, showing the price effects on consumption of rice and potatoes were both not significant (Huang et al. 2020). 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: rice, flour, potatoes, pork, and eggs. These findings partly support our assumption of mental accounting of self-produced food, but could not fully explain and testify the process of budget setting and tracking.

Therefore, we used hypothetical scenarios in Chapter 5 for a further exploration aiming to answer the questions of whether households use the "food-needed-to-consume" or the "food reserve" as their mental budget, and whether the budget is guiding households' consumption of own-produced food. We found more than half of the subjects showed mental accounting behavior at some level. Heath and Soll (1996) used the percentage of subjects showing underconsumption of food expenditure within a week after a typical food purchase as an indicator of mental budgeting. They found the percentage to vary from 45% to 55%, which is very close to the percentage we

found. Moreover, we found more subjects using "food reserve" than "food-needed-to-consume" as their mental budget, and tracking consumption against the budget, consequently indicating overconsumption of own-produced food. Lastly, we found the percentage showing mental accounting in the food shortage scenario to be higher than that in the food surplus scenario, indicating that people did more mental accounting when recourses were scarce, which is in line with the finding that less wealthy respondents with more debts practice more mental budgeting than the wealthy (Antonides et al., 2011).

Outcome of mental accounting on self-produced food

In the hypothetical scenarios study, we show overconsumption of self-produced food since households used food reserve more than the amount of food needed to consume as a mental budget, and tracked their consumption against the budget. However, the hypothetical scenarios only considered the situation when households' food reservation was larger than consumption needs. How people reacted when food reservation was less than consumption needs was not examined. This also has practical interest since if people apply mental accounting, and the preset budget does not meet their needs, people may underconsume goods they desire (Hastings & Shapiro, 2013; Heath & Soll, 1996). To tackle this issue, we further selected actual rice and potato producers with either greater or smaller food reserve than the amount of food needed, as in a natural field experiment. We then studied their consumption of own produce (for those having a larger food reserve), resp. consumption from market purchases (for those having a smaller food reserve). We find indications of the budget tracking process of mental accounting in situations of excess food reserve as in the hypothetical scenarios study. Also, we found that mental accounting seemed less obvious in situations where food reserve was lower than consumption needs. Instead, in these situations, households purchase more food from the market to compensate the shortage of the available food, consequently rendering underconsumption less likely.

In brief, when the food reserve is greater than consumption needs, the excess reserve is to some extent guiding people's consumption; when the reserve is lower than consumption needs, consumption needs may serve as the mental budget, and people will compensate the shortage from market purchases when the food reserve is depleted.

Factors in mental accounting of self-produced food

Since we found partial mental accounting on consumption of self-produced food, we were interested to know who are more likely to practice mental accounting. We found some experience-related and cognitive ability-related variables having a negative effect on mental accounting. For example, people who are actual rice or potato producers, and who are the decision maker regarding selling own produce and those who had received farm management training tended to practice less mental accounting. This is in agreement with the findings of List (2003) that market experience eliminates market anomalies. Our evidence may support the idea that market experience may reduce another anomaly in decision making, namely mental accounting. However, the experience effect may be resource-specific, meaning that, if people have more experience in dealing with a

specific resource, they will practice less mental accounting regarding this specific resource. We proposed this assumption of the experience effect on specific behavior, because we found that actual rice or potato producers were less likely to practice mental accounting on own-produced rice and potatoes than households who engaged in agriculture but did not produce rice or potatoes. In addition, since the experience effect may also be very behavior-specific, we proposed this assumption of the experience effect on specific behavior, because we found that people who are the decision maker regarding selling own produce practiced less mental accounting of consuming their own produce, but not people who were farmers (and not decision makers). Farmers usually engage in production activities, while decision makers regarding selling own produce have gained experience in dealing with the allocation and use of own produce. Decision makers may have become more sensitive to the opportunity cost of consuming the food reserve.

We also found that men were more likely to practice mental accounting of consumption of own produce than women. The direction of the gender effect is consistent with the finding of Muehlbacher and Kirchler (2013) on mental accounting of self-employed taxpayers, although the effect of gender was not significant in their study. However, the result differed from Antonides et al. (2011), who showed that men did less mental accounting than women. Moreover, training in farm management was found to have a negative effect on mental accounting and was significant for rice farmers. This result is in line with the expectation that training improves the cognitive abilities of people, leading to less mental accounting, and in line with the finding of Abeler and Marklein (2008) that subjects with lower mathematical skills, as an indicator of cognitive abilities, were more likely to practice mental accounting.

7.2.4 Social-psychological factors of food consumption

Existing food consumption research of rural residents in developing countries has focused relatively often on economic factors such as prices, income, and market development (Babu et al., 2016), almost neglecting the way social and psychological factors influence food consumption decisions. Banerjee & Duflo (2011) argued that for the poor, things that make life less boring are a priority. With regard to food, the poor choose foods not mainly for prices and nutritional values, but for how good the tastes are (Banerjee & Duflo, 2011). This argument may be a bit strong, but at least, it emphases the importance of knowing the social-psychological factors of food consumption.

Chapter 6 is complementary to existing literature by adding evidence of the theory of planned behavior (TPB) application to food consumption of rural residents in developing country, and by examining the roles of perceived need and habit together with the TPB in predicting food consumption intentions and behaviors.

Social-psychological predictors of consumption of dairy, fish, eggs, meats, and fruits

We found perceived need, habit, and attitudes were significant predictors of intentions. Perceived need and habit are stronger predictors of intention than any other TPB construct for

consumption of all food items except for meat. This is in line with the finding of the dominating role of perceived need for healthy eating (Payne et al., 2004), and the key role of habit for consuming milk (Saba et al., 1998). As for the predictions by food item, intentions to eat fruit were predicted by perceived need, habit, subjective norms, and attitudes (ordered from the strongest to the weakest, similarly hereinafter); intentions to consume eggs and dairy were predicted by perceived need, habit, and attitudes, but for dairy, habit was the strongest predictor; intentions to eat fish were predicted by perceived need, habit, and perceived behavioral control; intentions to eat meat were predicted by perceived need and attitudes.

As for predictors of behaviour, the significant predictors of consumption frequency were intention and perceived behavioral control for meat; perceived need and attitude (indirect) for eggs; perceived behavioral control for dairy; habit (indirect) and intention for fish; and intention and perceived need (indirect) for fruits. In general, more variance of intentions was explained than of behaviors, in line with other food-choice-related studies (McDermott et al., 2015).

To explore the reasons for these differences in consumption frequency, we tested the differences in belief strength and importance evaluation for each belief item, between groups of respondents whose consumption frequency was larger than zero and those whose consumption frequency equaled zero. Results show that habit appeared to be the predictor with the largest differences for all the food items, following by perceived need. In addition to habit and perceived need, beliefs of satisfaction showed large differences for eggs and fish; beliefs of family's and doctor's opinions showed large differences for fish and fruits; beliefs of giving family a nutritious meal showed large differences for dairy and fruit; beliefs of affordability showed large differences for dairy, fish, and fruit; beliefs of accessibility showed large differences only for fruit.

The Role of perceived need and habit in the TPB

In this study, adding perceived need and habit in the TPB as predictors of intention and behavior substantially increased the explained variance of intention, but increased the explained variance of behavior by a small amount only. Moreover, perceived need and habit were only significant direct predictors of intention, not of behavior, which means habit and perceived need only influenced behavior indirectly via intention.

Our finding regarding perceived need is consistent with Payne et al. (2004), who found that perceived need was a significant and dominant predictor of intention to eat healthy, but not for the eating behavior. They interpreted this observation as perceived need only being relevant during the cognitive processing culminating in intention formation. Our finding regarding habit is consistent with Saba et al. (1998) who found that habit only predicted intention to drink milk but not behavior to drink milk. However, Verbeke and Vackier (2005) found that habit had significant effects on both intention and behavior to eat fish, and so did Saba et al. (2000) for a large variety of fat-containing food, which is different from our finding. Saba et al. (2000) claimed that the different and imprecise definition of habit may have contributed to different effect paths of habit in the TPB.

Another observation is that, apart from the prediction of meat consumption, perceived need and habit had larger effects on intention than other TPB constructs and the inclusion of perceived need and habit diminished the effects of attitude and subjective norms on intention, and the effects of intention on behavior. This effect was explained by the less conscious consideration of more habitual behavior in previous research (Saba et al., 1998; Bagaozzi,1981). However, from our results, meat was the most frequently consumed food among all five food items, but the effect of habit was not significant in predicting intention, and the effects of other TPB constructs were also not diminished after including habit. Instead, we proposed an alternative explanation: food involvement. Food involvement generally describes how deeply a person is involved in and think about food acquisition, preparation, cooking, eating, and disposal (Bell & Marshall, 2003). A frequently performed behavior, like consuming meat in our study, may still be accompanied by extensive cognitive effort, for example, people may pay much attention to the quality of meat and spend time to select the piece of meat they want. This explanation is in line with the point that some behaviors, although containing automatic elements, are still reasoned in nature (Bamberg & Schmidt, 2010; Amalia et al., 2020). However, when looking at the results for dairy, which is the least frequently consumed product, the effect of habit was dominant. This means that, for a rarely performed behavior, people may have too little information or experience to make cognitive efforts in decision making, and therefore, habit plays an important role: people who are not in the habit of consuming dairy usually also will not consume dairy.

To sum up, the effect of habit on intention or behavior is not necessarily related to the habitual level of the behavior, but may be more related to the cognitive complexity or extensiveness of decision making. A less frequently performed behavior may have a stronger habit effect due to less information processed.

7.3 Practical implications

In addition to the theoretical implications, the findings of this dissertation have several practical implications. The implications are all aiming at improving food and nutrients status of rural residents.

7.3.1 Adjusting food demand analysis for rural residents

This dissertation offered several ideas to adjust food demand analysis for rural residents who consume considerable self-produced food, which is prevalent in developing counties. These adjustments are important since the estimated price and income elasticities are indicators for designing food policies.

First of all, it is important to consider the effects of self-produced food in demand estimation of food and nutrients, which may correct potential measurement bias when the production and demand decisions become interlinked. In Chapter 4, we compared the results with and without

considering mental accounting and effects of self-produced food. 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.

In addition, ignoring the asymmetric demand pattern under the symmetric demand assumption in standard demand models may lead to misunderstanding of people's reaction to price changes. In Chapter 3, 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). 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 and for pure consumers and farmers.

7.3.2 Improving food and nutrients intake from an economic perspective

The estimated food and nutrient elasticities as such are of value for policy analysts in estimating the effects of policies targeted towards those underdeveloped areas, be they income or price related. Chapter 2 shows the importance of economic development, and particularly of the income and grain price levels in the food security status of households. The nutrient elasticity estimates might indicate that income subsidies or grain price policies could be appropriate methods to tackle a vast range of nutrient deficiencies. However, an income increase was shown to be more effective in decreasing nutrient deficiencies for agricultural households than for other households. However, a price increase may harm other households more than agricultural households. With limited public investment resources, income subsidies and grain price policies could be specified by type of households in this regard.

In Chapter 6, we also find some economic-development-related factors that may improve the consumption of fish and dairy, which is far below the recommended level in the survey areas and for general rural residents in China. We found for the consumption of fish and dairy products, one of the significant predictors was perceived behavioral control, and the significant difference in perceived behavioral control was mainly due to affordability and accessibility. Since the survey areas were mountain areas where supply of fish and dairy products was low, improving market access and people's purchase power are essential measures to improve consumption of fish and dairy products in those areas.

7.3.3 Improving food and nutrients intake from information and education

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. However, in Chapters 4 and 5, we found that agricultural households apply mental accounting on self-produced food, and may overlook the opportunity cost of selling excess own-production for more

cash income and overcome self-produced food which is usually staple food. Some implications from taking mental accounting into consideration could be offered in this regard. Our study suggests that offering information to make smallholder farm households aware of the opportunity cost of consuming own-produced food could be valuable, which could be included in the farm management training offered to farm households. 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.

Results from Chapter 6 of the social-psychological factors showed that perceived need and habit are the strongest predictors for consumption intention of fish and fruit. Perceived need can be enhanced in two ways: making rural residents aware of the health benefits of eating fish and fruits; and making rural residents aware of their consumption deficit compared with the recommended level. Both these pieces of information can be included in existing nutrition education programs in poor rural areas. Habit, however, is difficult to change in the short term, especially for adults. Efforts to form healthy dietary habits are most effective for children and adolescents, thus dietary education and meals at school are essential and need to be enhanced. Subjective norms and attitude are also significant predictors for intention of fruit consumption. Doctors' and families' suggestions on consuming fruits appeared to play a big role. Hence, promotion of the importance of consuming fruits could be included in local medical service training and in nutritional education programs. Additional communication campaigns focusing on sharing dietary knowledge with people around may be effective. From the aspects of attitude, the affective component, which is tastiness, played a large role. Advertisements or other promotion measures to make people feel that fruits are tasty may be effective in improving people's intention to eat fruits.

7.4 Limitations and suggestions for future research

Although this dissertation contributes to better understand the food consumption behaviour of rural residents particular with behavioural economic perspectives, it still has some limitations. In this section, I discuss a number of limitations of the study together with suggestions for future research.

7.4.1 The actual reference price: endowment effects may play a role

A key aspect or a prerequisite of studying loss aversion and asymmetric price effects is to determine what is the reference price. In our study, a limitation 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 et al., 2015) all used the previous period price (usually weekly price) as reference price. Reference price formation itself, needs to be further studied. The internal reference price has been estimated as either the most recent price paid, the weighted mean of the logarithms of past prices, or as an exponential smoothing of past prices (Kalyanaram & Winer, 1995).

Furthermore, it is questionable to simply assume the reference price is formed from the previous price, especially for households who consume self-produced food. A behavior pattern called endowment effect, which means that people often demand much more to give up an object than they would be willing to pay to acquire it (Thaler, 1980). Therefore there is the tendency to place a larger value on an item when it is in one's possession than when it is not in one´s possession (Brenner et al., 2007). An analogous IKEA effect might be suitable for the case of agricultural households. Norton, Mochon, and Ariely (2012) documented the IKEA effect as the increased valuation that people have for self-assembled products compared to objectively similar products which they did not assemble themselves. Troye and Supphellen (2012) did a similar experiment finding that participants who prepared the food liked the food better than those who did not prepare it, even though both groups tasted the same dish. Applying the theory to agricultural households, it might be possible that the farmers' subjective value of the same products is higher than that of the consumers, leading to a higher reservation price or reference price of the self-produced food. Thus, for farmers who consume self-produced food, 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 which is influenced by the endowment effects. Moreover, it is uncertain whether and how agricultural households perceive a price increase as a profitable or an unfavourable situation for their self-produced food, and how it is varied by the commercialized level of food products. We leave these questions for future research.

7.4.2 Boundaries of mental accounting

Although we found some evidence of mental accounting in consuming self-produced food, we are not clear about the boundaries of mental accounting. The created hypothetical scenarios may not fully reflect reality. People's mental accounting of their own produce might be weak or even disappear when the market price is high enough and when transaction costs are low enough. Also, in our hypothetical questions, we created a condition of food reserve being 20% higher than the food needed to consume, and then we observed people tracking their consumption against the food reserve budget. However, we expect that, if the food reserve is high enough to exceed a certain level, people may not track against it anymore. Thus, future research may focus on the boundaries of the effect of mental accounting of consuming self-produced food.

7.4.3 The utility of the TPB

The study of social-psychological factors is different from other studies in the dissertation that the data used is cross-sectional, prohibiting conclusions concerning causal effects. Although habits and perceived needs contributed to the explanation of food consumption intentions, the processes of habit formation and need development could not be traced in the cross-section.

There is a branch of criticism about the utility of the TPB; that is, whether the designed interventions based on the TPB results are useful and really lead to behavior change (Sniehotta et al., 2014). Some experimental studies showed failure of the TPB in causing behavior change (Chatzisarantis & Hagger, 2005; Sniehotta, 2009). However, more studies seem to support the utility of the TPB (Hardeman et al., 2002; Hackman & Knowlden, 2014). Hence, the utility of the interventions proposed from the results remains to be tested either by more rigorous experiments or by panel data.

7.5 Conclusion

To conclude, some insights from behavioral economics has been found applicable and helpful to explain the food consumption behavior of rural households in China in this dissertation. Our findings confirm that loss aversion effects exist for food demand responses to price changes in different directions for rural households. However, the loss aversion effects differed by type of households (pure consumers versus farmers), food categories, and model specifications with different ways to incorporate reference price. Mental accounting theory was first applied to explain the allocation and consumption of self-produced food of rural households, and we found more than half of the subjects showed mental accounting behavior at some level. Moreover, more subjects using "more- than-needed-food reserve" than "food-needed-to-consume" as their mental budget, and tracking consumption against the budget, consequently indicating overconsumption of own-produced food, which is usually storable staple food, thus may sacrifice an opportunity to achieve a more diversified diet. Also, when food reserve was lower than consumption needs, mental accounting seemed less obvious, instead, households purchase more food from the market to compensate the shortage of the available food, consequently rendering underconsumption less likely. As for social-psychological factors, we found incorporation of perceived need and habit substantially increased the explanatory power of the TPB, and perceived need and habit are stronger predictors of intention than attitudes, subjective norms, and perceived behavioural control for consumption of eggs, dairy, fish, and fruits, which are food items contain rich nutrients but with far-below-recommended consumption level for the rural households.

Additionally, this dissertation presented several theoretical and practical implications as well as avenues for future research. The previous studies of behaviour economics in food consumption were almost exclusively focused on pure consumers in developed countries. This dissertation is a fresh attempt to switch the focus, making behavioral economic contributions to explain food

consumption of rural residents in a developing country, who face more challenges of undernutrition. The ideas, results, and implications in this dissertation may also apply to rural residents of other developing counties where smallholder agriculture is prevenient.

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Summary

Summary

Behavioral economics is useful to capture the characteristics of bounded rationality of people when making food decisions, which may help to explain and predict food behaviors in actual life better. However, the majority of related studies were conducted in developed countries and on pure consumers living in urban areas. In contrast, little research applying behavioral economics in food consumption has been found in developing countries, where a considerable number of people, especially poor rural households who are both food consumers and producers, are still suffering from hunger and micronutrient deficiency.

Noticing the research gaps of behavioral economics in food consumption for rural residents in developing countries, and the practical interest in behavioral economics being helpful in designing a broader array of policies or strategies to improve diets and nutrition of rural residents, this dissertation aims to bring behavioral economic insights to provide additional explanations of food consumption of rural households in underdeveloped areas of China. More specifically, this dissertation examines loss aversion and asymmetric price effects on food demand (Chapter 3); explores mental accounting applications in dealing with self-produced food and its dietary outcome (Chapters 4 and 5); and tests how attitudes, subjective norms, perceived behavioral control, perceived need, and habit influence food consumption of rural households (Chapter 6).

In Chapter 1, we first introduce the scientific motivation and societal context that underlies the topic. Key aspects of food consumption of rural households and their relations to behavioural economics are discussed. Before we empirically examined these relations, we first started from a standard economics framework to explore how food and nutrient demand were influenced by income and prices when considering the household consumption of own-produced food in Chapter 2. We find that income changes have a greater nutritional effect on agricultural households than on other households. As for simulations of price changes, a price reduction and a price increase are not having symmetric effects, as doubling the prices would hurt the group of other households far more than agricultural households while a reduction of prices would not that clearly bring a benefit to them compared to agricultural households. We therefore see simulations as a valuable addition to the report of nutrient elasticities.

In Chapter 3, we examine the loss aversion and asymmetric price effects on food demand. We extended prior studies by incorporating asymmetric price effects in demand models to explore possible asymmetric food demand patterns of rural households, by applying different ways of modeling reference prices in demand models and comparing the results, by further comparing asymmetric food demand patterns of pure consumers and farmers (who are both food producers and consumers) and comparing asymmetric effects for different food items. We found that the phenomenon of loss aversion on food demand was also partly applicable to rural households in

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). We interpret this phenomenon by reasoning that a price increase is a profitable and favorable situation for farmers who would sell pork to the markets for cash income and thus consume less of their production. 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. We further found that asymmetric price effects were easier detected by the segmented price model, but not detected by the price increase and price decrease model, which places the actual price together with price increase and price decrease terms in the model. The latter result may occur because the coefficient of actual price had already captured and absorbed the effects of loss and gain terms, thus weakening their effects.

To our knowledge, we are the first to apply insights from mental accounting theory to explain the consumption of own-produced food of agricultural households, particularly addressing the insensitivity to price change in Chapter 4, and the dietary outcome of applying mental accounting in Chapter 5. In Chapter 4, we assumed that agricultural households reserve a certain quantity of self-produced food for own consumption and overlook the opportunity cost of the quantity of planned consumption of self-produced food. Therefore, the consumption 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. We found that the hypothesis of no significant effect of price holds for some products, and 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.

Findings in Chapter 4 partly support our assumption of mental accounting of self-produced food but could not fully explain and testify the process of budget setting and tracking. Therefore, in Chapter 5, we first used hypothetical scenarios for a further exploration aiming to answer the questions of whether households use the "food-needed-to-consume" or the "food reserve" as their mental budget, and whether the budget is guiding household consumption of own-produced food. We found that more than half of the subjects showed mental accounting behavior at some level, and more subjects using "food reserve" than "food-needed-to-consume" as their mental budget. Also, we found evidence for tracking consumption against the budget, consequently indicating overconsumption of own-produced food. In addition to the hypothetical scenarios, we further selected actual rice and potato producers with either greater or smaller food reserve than the amount of food needed, as in a natural field experiment. We found that, when the food reserve is greater than consumption needs, the excess reserve is to some extent guiding people's consumption and leading to overconsumption. When the reserve is lower than consumption needs, consumption needs may serve as the mental budget, and people will compensate the shortage from market purchases when the food reserve is depleted. Who are more likely to practice mental accounting

was also examined in Chapter 5. We found that mental accounting is associated with specific experience and general cognitive ability.

Chapter 6 aims to examine the effects of social-psychological factors in food consumption of rural households. It is complementary to existing literature by adding evidence of the theory of planned behavior (TPB) applied to food consumption of rural residents in a developing country, and by examining the roles of perceived need and habit together with the TPB in predicting food consumption intentions and behaviors. Results showed that incorporation of perceived need and habit substantially increased the explanatory power of the TPB, but these factors only had significant direct effects on intention rather than behavior. Perceived need and habit are stronger predictors of intention than any other TPB construct for consumption of all food items except for meat. We found indirect effects of the constructs in the extended TPB model on consumption to be different across food items.

In Chapter 7, the general discussion, we provide a synthesis of the main findings and discuss the theoretical and practical implications, as well as limitations and further research. Theoretically, this dissertation contributes to the literature by: a) examining whether some applications of behavioral economic theories such as loss aversion, mental accounting, and the theory of planned behaviour in food consumption that are relevant for urban residents and pure consumers also hold for rural residents; b) exploring how farmers behave differently than pure consumers with respect to asymmetric price effects on food demand, how farmers deal with self-produced food under the mental accounting hypothesis, how consumption of self-produced food influences nutrient intake and diets; and c) investigating social-psychological factors of food consumption which are often overlooked in food consumption studies of rural residents in developing countries. Future research was suggested for the topics of: a) formation of actual reference price of agricultural households, especially the role of endowment effects; b) boundaries of mental accounting of self-produced food regarding market price, transaction cost, and quantity of food reserve; and c) the utility of the TPB.

In conclusion, this dissertation is a fresh attempt in making behavioral economic contributions to explain food consumption of rural residents in a developing country, who face challenges of undernutrition. The findings confirm that behavioral economic theories such as loss aversion, mental accounting, and the theory of planned behaviour were also applicable to explain food consumption behaviour of rural households, and additionally to explain the behavior of allocation and consumption of self-produced food. The ideas, results, and implications in this dissertation may also apply to rural residents of other developing counties where smallholder agriculture is prevalent.

Acknowledgments

Acknowledgments

This thesis would have remained a dream had it not been for the support, help, and contribution from many important people. The PhD journey showed me that scientific work requires both "hard" and "soft" parts. Intellectual and emotional support from many helpful people made this thesis possible.

First and foremost, I acknowledge the supervision and support of my promotors Prof. Gerrit Antonides, Prof. Eveline van Leeuwen, and Prof. Fengying Nie. Gerrit, thank you for your intensive guidance and supervision from the very beginning to the end. You were devoted to my project from the conceptual design to the pilot survey on to very detailed textual changes. Your rigorous work attitude and rich academic reserves have set high standards for me and encouraged me to be more professional. In addition, your personality is so nice. You always reply to my email and discuss with me promptly and you are always willing to comfort me and cheer me up when I feel upset or frustrated. The mental support from you means a lot to me, it supports my PhD life and will have lasting positive effects on my future life. Eveline, thank you for being my official promotor in the middle of the project. You are always being considerate and kind to me. Thank you for reading my loss aversion chapter and giving constructive comments, and caring about me especially after the outbreak of Covid-19. Prof. Nie, thank you for giving me the opportunity to pursue my PhD. Without the valuable panel datasets obtained from the laborious field surveys, I could never have finished this thesis. Thank you for making me understand how important it is to be aware and sensitive about the context and society I am studying.

I would also like to express my gratitude to my committee members, Prof. Nico Heerink, Prof. Hans van Trijp, Prof. Eric van Dijk, and Dr. Koos Gardebroek for spending the time and effort to read my dissertation and attending the defence ceremony.

I would like to extend my sincere thanks to several other people who helped shaping this thesis. Prof. Justus Wesseler, thank you for being my official promotor in the beginning and commenting on my proposal. Prof. Jack Knetsch, thank you for reviewing my proposal and giving very constructive comments, we have been inspired by your ideas in the subsequent work. Dr. Christian H. Kuhlgatz, thank you for being my co-author in Chapters 2 and 4, your knowledge on demand systems is very helpful to me and discussions with you are always helpful and enjoyable. I thank Dr. Reza Kheirandish, Dr. Xiaohua Yu, and Dr. Yuqing Zheng for their constructive comments on an earlier version of Chapter 3, and Dr. Wei Zhang for her helpful comments on Chapter 4.

I acknowledge the generous support of my employer the Agricultural Information Institute of Chinese Academy of Agricultural Sciences (AII, CAAS) for funding my research. Many thanks to my Directors Prof. Fengying Nie and Dr. Xuebiao Zhang for allowing me study leave.

I am indebted to Dr. Claudius van de Vijver. Your hard work on the WUR–CAAS joint PhD program made this project run smoothly. Your training on academic writing and presenting, and efficient and effective academic development, is vital to me and made me feel prepared and less panicked when I just arrived in Wageningen. Thank you for your hospitality and genuine friendship.

I thank all my dear colleagues at the Urban Economics Group (UEC)/Economics of Consumers and Households Group (ECH): Michel, Johan, Pierre, Jannette, Ernst-Jan, Lieke, Anouk, Faith, Robert, Liesbeth, Sol Maria, Han, Erkinai, Kasia, for being kind and friendly to me. The coffee breaks, lunches, and group outings with you are definitely memorable to me. Michel, thank you for taking time on commenting on my powerpoint presentation regarding the loss aversion study. I appreciate your openness to me, the discussion about integrative negotiation with you has very much impressed me. My dear office mates Ernst-Jan and Lieke, we all started our PhD projects at about the same time, and we all have kids to take care of. Thank you for sharing your experience with me and cheering me on.

Thank you Karen, Dineke, Betty, Frank, and Gré for all your kind help and support throughout the past years, you helped me a lot on financial and educational issues.

The support and friendship of the Chinese community in WUR always gave me security while in the Netherlands. Liangzi, you are the first person who talked to me in Wageningen. Thank you for helping me settle down in Wageningen. Watching the football world cup match in your international corridor and Spring Festival dinner with you and Sijia is unforgettable. Shanshan Miao, thank you for helping me with Shaun's accidental injuries. Visiting museums with you was quite enjoyable. Jinghui, Jin Yan, Yujue, Li Fan, Yu Tian, Minjie, I enjoy the drinks and conversations with you a lot. Chen and Fanrong, thank you for helping me move in the cold winter of Wageningen. Xiaoqian and Honghui, thank you for sharing your experience of personal growth in PhD life with me frankly, I appreciated it very much. Qiuhong and Siyuan, thank you for helping me in the Covid-19 period.

My colleagues and friends at the International Information Division of AII, CAAS, thank you for your support and encouragement in the past years. Special thanks go to Haibo, Yue, Shanshan, Xiaomeng, and Jinlu for your tacit cooperation in daily work and in the field survey.

My friends in the little culture salon: Yanna, Yiyi, Tuo, and Cheng, every discussion with you is shedding light in my life. Debates and sharing of art, music, history, current news, and academic life with you help me broaden my vision and reduce prejudice. Thank you Tequila, for always mentally supporting me when I had a tough time.

I preserve special thanks to my family. My mama Huijuan and baba Ligeng, thank you for loving me unconditionally, trusting me, and helping to take care of Shaun when I was working. My dear husband Xiao, thank you for taking care of Shaun when I was in the Netherlands, and thank you for your company in all the moments of cheers and tears. My precious son Shaun, thank you for your patience, your optimism, and your innocence.

About the Author

Biography

Jiaqi Huang was born on the 20th of April, 1989 in Wuhan, China. She studied Engineering Management at Hubei University of Technology, China (2007–2011). After obtaining her BSc degree, Jiaqi started with the Research Master Agricultural Economics and Management: Research in Food Security and Nutrition at the Chinese Academy of Agricultural Sciences (CAAS) (2011–2014). In addition, she was also trained at ETH Zurich in Switzerland on Sustainable Agriculture and the World Food System (2013).

Jiaqi started to work at the Agricultural Information Institute of the Chinese Academy of Agricultural Sciences (AII, CAAS) as an assistant research fellow in 2014. In her role of working at AII, CAAS, she has participated in 14 international and domestic research projects cooperating with IFPRI, FAO, UNDP, IFAD, and WFP, or funded by the National Natural Science Foundation of China. These projects were focused on food security, nutrition, poverty reduction, food value chains, and women empowerment.

Jiaqi conducted her PhD research at the Urban Economics Group at Wageningen University & Research in the Netherlands (2016–2021). Her PhD research aims to bring insights from behavioral economics to explain food consumption behavior of rural households in under-developed areas of China. During her PhD research, she was also trained at the University of Bonn in Germany on Development Policy (2017). Her current research interests are food economics, behavioral economics, and development economics.

List of publications

Publications

Huang, J., Antonides, G., & Nie, F. (2020). Is mental accounting of farm produce associated with more consumption of own-produced food?. *Journal of Behavioral and Experimental Economics*, *88*, 101594.

Huang, J., Antonides, G., & Nie, F. (2020). Social-Psychological factors in food consumption of rural residents: The role of perceived need and habit within the theory of planned behavior. *Nutrients*, *12*(4), 1203.

Huang, J., Antonides, G., Kuhlgatz, C. H., & Nie, F. (2021). Mental accounting and consumption of self-produced food. *Journal of Integrative Agriculture*, *20*(9), 2569-2580.

Anane, I., Nie, F., & **Huang, J.** (2021). Socioeconomic and geographic pattern of food consumption and dietary diversity among children aged 6–23 months old in Ghana. *Nutrients*, *13*(2), 603.

Conference papers / presentations

Huang, J., Antonides, G., Kuhlgatz, C. H., & Nie, F. (2018, August). Mental accounting, production scale, and consumption of self-produced food: Empirical evidence from rural China. No. 273986, 2018 AAEA (Agricultural & Applied Economics Association) Annual Meeting. Washington D. C., USA.

Kuhlgatz, C. H, **Huang, J.**, Antonides, G., & Nie, F. (2018, August). The effect of food prices and own-produced food on food security of Chinese rural households. No. 273988, 2018 AAEA (Agricultural & Applied Economics Association) Annual Meeting. Washington D. C., USA.

Huang, J., Antonides, G., & Nie, F. (2019, September). Is mental accounting of farm produce associated with more consumption of self-produced food? Paper presented at the 2019 IAREP/SABE Conference. Dublin, Ireland.

Huang, J., Antonides, G., & Nie, F. (2019, October). Loss aversion and asymmetric price effects on food demand of rural households: Panel evidence from China. *Proceedings of the 11th CAER-IFPRI Annual Conference*. pp. 249-286. Hangzhou, China.

Wu S., **Huang, J.**, Bi, J., Nie, F., Chen, K., & Liu, C. (2019, October). Production diversity and dietary diversity in poor rural China: Linkage and pathway. *Proceedings of the 11th CAER-IFPRI Annual Conference*. pp. 1009-1032. Hangzhou, China.

Huang, J., Antonides, G., & Nie, F. (2018, June). Loss aversion and irreversible food demand of agricultural households. Paper presented at the WASS PhD Day, Wageningen, The Netherlands.

Jiaqi Huang
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
YRM-50806 Quantitative Data Analysis: Multivariate Techniques	WUR	2017	6.0
ECH-51306 Behavioural & experimental Economics	WUR	2017	6.0
Writing PhD Research Proposal	WUR	2017	6.0
'Loss Aversion and Irreversible Food Demand of Agricultural Households'	WASS PhD Day, Wageningen, The Netherlands	2018	1.0
'Mental Accounting, Production Scale, and Consumption of Self-produced Food'	AAEA Annual Meeting, Washington D. C., USA	2018	1.0
'Is mental accounting of farm produce associated with more consumption of self-produced food?'	SABE/IAREP Conference, Dublin, Ireland	2019	1.0
'Loss Aversion and Asymmetric Price Effects on Food Demand of Rural Households: Panel Evidence from China'	CAER-IFPRI Annual Conference, Hangzhou, China	2019	1.0
B) General research related competences			
Research Methodology: From Topic to Proposal	WASS	2017	4.0
WASS Introduction Course	WASS	2017	1.0
C) Career related competences/personal development			
Academic Writing and Presenting in English	WGS	2016	1.75
Efficient and Effective Academic Development	WGS	2016	1.75
Summer School on Development Policy	University of Bonn	2017	2.0
Randomized Controlled Trials	J-PAL and AII of CAAS	2019	2.0
Total			**34.5**

*One credit according to ECTS is on average equivalent to 28 hours of study load

Note:
WUR=Wageningen University;
WASS=Wageningen School of Social Sciences;
SABE= Society for the Advancement of Behavioral Economics;
IAREP=International Association for Research in Economic Psychology;
CAER=China Agricultural Economics Review;
IFPRI=International Food Policy Research Institute;
WGS= Wageningen Graduate Schools;
AAEA=Agricultural & Applied Economics Association;
J-PAL=The Abdul Latif Jameel Poverty Action Lab;
AII of CAAS=Agricultural Information Institute of Chinese Academy of Agricultural Sciences.

Funding

The research described in this thesis was financially supported by the Agricultural Information Institute of Chinese Academy of Agricultural Sciences [grant number: CAAS-ASTIP-2016-AII], the National Natural Science Foundation of China [grant numbers: 71861147003, 71661147001], and the Chinese Academy of Agricultural Sciences - Wageningen University (CAAS - WU) Joint PhD Programme [MOE11NL1A20151701N].

Financial support from Urban Economics Group, Wageningen University for printing this thesis is gratefully acknowledged.

Cover design: Jiaqi Huang

Printing: Digiforce || ProefschriftMaken