Essays on the Dietary Pattern and Consumer Preference for Sustainable Food

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Abbreviation

FAO: Food and Agricultural Organization

CDG: Chinese Dietary Guidelines

NHFPC: National Health and Family Planning Commission of the People's Republic of China

CHNS: China Health and Nutrition Survey

CFP: China Food Pagoda

3SLS: Three-stage Least Square Estimation Model

CDC: Chinese Center for Disease Control and Prevention

CFPS: Chinese Food Pagoda Score

IV: Instrumental Variable

FE: Fixed Effect

RE: Random Effect

DKI: Dietary Knowledge Index

Lasso: Least absolute shrinkage and selection operator

CV: Cross-validation

MSE: Mean Squared Error

WTP: Willingness to Pay

CVM: Contingent Valuation Methods

OLS: Ordinary Least Square Estimation Model

IVM: In-Vitro Meat

VIF: Variance Inflation Factor

Acknowledgement

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Executive Summary

With the rapid economic growth, the dietary pattern has undergone great changes in China. The traditional dietary structure high in staple food and vegetables is evolving into Western food diet containing a lot of fat (Guo et al., 2000; Popkin et al., 2001; Tian and Yu, 2013; 2015; Huang et al., 2017; Wang et al., 2017). Changes in dietary patterns have resulted in the co-existence of under-nutrition and over-nutrition and the prevalence of obesity and diabetes. These issues deserve more attention from policy makers. Actually, many factors could influence the changing diet in China, such as dietary knowledge, food accessibility and preference. One objective of this dissertation is to study the impacts of dietary knowledge, food accessibility and preference on diet quality. The findings may provide valuable implications for nutrition security in China. Additionally, consumers start to value sustainable food because of their increasing awareness of environmental protection or other reasons. Eliciting consumer preference for sustainable food such as organic food and meat alternatives is important to develop sales markets. Therefore, another objective of this dissertation is to explore consumers' willingness to pay (WTP) for organic food and meat alternatives.

Concerning the research methodology, the first topic employs three-stage least square estimation models (3SLS) to explore how food accessibility and diversity of agricultural production affect real food consumption, the deviation of real food consumption from the China Food Pagoda (CFP) 2016, and diet quality among Chinese farmers. In the second topic, we estimate the impact of dietary knowledge on Chinese diet patterns by adopting the random effects model as the main strategy and employing pooled OLS model in robustness tests. Moreover, this topic employs the mediation test to empirically evaluate the mediated effect of dietary knowledge on the diet pattern. For the topic three and four, we use the payment card

approach to elicit the WTP for organic food and meat alternatives, and then a generalized Tobit model is employed to estimate interval regression models to capture the factors of WTP for sustainable food. In order to check for the robustness of the results, a simple OLS is used as an alternative method for these two topics.

Generally, we observe that food accessibility and dietary knowledge have effects on the diet pattern. In chapter two, we confirm that food accessibility contributes to improvements in diet quality for Chinese farmers, especially for those not engaged in agricultural production. Living close to local food markets reduces farmers' cost of accessing more diversified food, which could increase the consumption of food not produced at home, decrease the overconsumed own produced food, and finally lead to a higher level of diet quality. Families not engaged in agricultural activity do not produce food, so their food consumption is highly dependent on food accessibility; therefore, food accessibility has a significantly strong influence on their diet quality. For chapter three, our findings suggest that dietary knowledge can significantly improve Chinese adults' diet quality and this impact is mediated by unhealthy food preference. Moreover, increasing availability of unhealthy food could weaken the influence of dietary knowledge on diet quality.

Additionally, the fourth chapter' results show that political party support could affect the consumers' WTP for organic food in Germany. Consumers supporting the Green Party in comparison with other consumers have a lower WTP for organic vegetables after controlling other socioeconomic factors, since they wish organic food should not be a privilege for individuals but inclusive to the general public.

For chapter five, we suggest that consumer perception has a significantly effect on the WTP for meat alternatives. Specifically, environmental awareness only has a positive impact on the WTP for plant-based meat, while the satisfaction with food safety and the degree of liking gym positively influence the WTP for both plant-based and cultured meat. Additionally,

risk preference, trust, positive and negative reciprocity could also have vital roles in the Chinese consumers' WTP for meat alternatives. First, residents with more preference for risk would like to pay more for meat alternatives. Then, the preference for trust could reduce the consumers' WTP for plant-based meat. Moreover, positive reciprocity has a significantly positive effect on the WTP for plant-based meat, while negative reciprocity significantly and negatively influences the WTP for cultured meat. Lastly, the public is just willing to pay lower price for meat alternatives than traditional meat.

These findings can provide general policy implications. First, promoting dietary knowledge (e.g., popularizing the Chinese Food Pagoda 2016 to the general public) is still an effective way to improve Chinese diet quality. In addition, creating a fair and sustainable food environment is an innovative and effective solution. Second, the policy to promote organic food should offer farmers more subsidies to offset their high production costs. Third, policy interventions should lay stress on advertising the environmental-friendly attribute of meat alternatives, and it is beneficial for producers to target consumers with a high level of risk preference or more reciprocity. Last but not the least, it is necessary to make reasonable prices for both plant-based and cultured meat.

Chapter 1 Executive Introduction

1.1 Background

Along with the increasing economic development, dietary patterns have changed remarkably in developing countries, especially in China. Such significant change can be attributed to many factors such as food accessibility and dietary knowledge. However, to the best of our knowledge, only few literature has focused on effects of food accessibility and dietary knowledge on Chinese dietary patterns. Therefore, this thesis further explores the roles of food accessibility and dietary knowledge in diet patterns in China and aims to provide new insights into promoting diet quality in developing countries.

Sustainable food consumption may have an essential influence on food policies aiming at improving the quality and sustainability of diet (Azzurra et al., 2019). Therefore, it can expand above studies on effects of food accessibility and dietary knowledge on diet quality. A worldwide public health goal is to achieve healthy and nutritious diet patterns from sustainable food consumption (Drewnowski et al., 2020). Additionally, studying the consumption of sustainable food could also provide important insights into the sustainability of food supply (Verain et al., 2016), contributing to the relevant literature and policy making. The broad definition of sustainable food consumption made by the UK Sustainable Development Commission (2005; 2009)[1] is based on the contribution of food and nutrition security; healthy and nutritious diets for everyone; feasible livelihood for farmers, processors and retailers; animal welfare; environmental protection; biodiversity safeguard; energy saving; and minimum waste.

However, sustainable food consumption is under-developed all over the world, which becomes a challenging political task (Fuchs and Loreck, 2005; Dagevos and Voordouw, 2013; Gorgitano and Sodano, 2014). Consumer preference for sustainable food in daily food choice is still marginal although people have the increasing consciousness of food sustainability (Verain et al., 2012; Azzurra et al., 2019). Price is the main determinant of food consumption

[1]Source: Sustainability Implications of the Little Red Tractor Scheme, 2005, https://www.sd-commission.org.uk/data/files/publications/050119%20Sustainability%20implications%20of%20the%20Little%20Red%20Tractor%20scheme.pdf
Setting the Table: Advice to Government on Priority Elements of Sustainable Diet, 2009, https://www.sd-commission.org.uk/data/files/publications/Setting_the_Table.pdf

choices, especially for poor net food buyers (Drewnowski et al., 2020). Exploring the WTP for sustainable food could capture consumer preference and give insights into the development of sustainable food systems. Therefore, this thesis studies factors of the WTP for sustainable food in both industrialized (i.e., Germany) and developing economies (i.e., China) to reach more general conclusions: First, organic food belonging to sustainable food has been promoted in European countries (Aschemann Witzel and Zielke, 2017; Azzurra et al., 2019). Germany is the largest organic food market in Europe, and organic food has been increasingly popular among consumers and gaining importance in policy making. Thus the third research topic is about the WTP for organic food in Germany. Second, China has an emerging and potentially powerful market for meat alternatives (another example of sustainable food) since many Chinese have been familiar with plant-based meat such as food mainly made from pea protein. Therefore, another topic following from that would be the WTP for meat alternatives in China.

1.1.1 The Dietary Change in China

Since the commencement of reform and opening-up in 1978, the Chinese economy has developed remarkably. Meanwhile, the agricultural sector has undergone tremendous changes in China over the forty years. According to Table 1.1, the total production of major agricultural products has experienced dramatic increases from 1978 to 2020.

[Insert Table 1.1 here]

Along with the increasing food supply, the dietary pattern among the Chinese has also evolved accordingly. Table 1.2 demonstrates the consumption per capita of different food among Chinese over years. We find that residents tend to consume less grains, potatoes and beans, while the consumption of meat, poultry and aquatic products has increased. Previous literature also finds that the Chinese have gradually shifted from a diet structure containing lots of staple food and vegetables to a Western food diet high in fat (Guo et al., 2000; Popkin et al., 2001; Tian and Yu, 2013, 2015; Huang et al., 2017; Wang et al., 2017). In addition, urban residents consume more milk and fruit than rural residents.

[Insert Table 1.2 here]

It has been confirmed that many factors could affect the changing diet in China or other developing countries, such as economic growth (Guo et al., 2000; Du et al., 2004; Tian and Yu, 2013, 2015; Zheng et al., 2016; Zhou et al., 2015), urbanization (Popkin and Bisgrove, 1988;

Solomons and Rainer, 1995; Zhai et al., 2014; Tian et al., 2017), culture and technical change (Popkin, 2003), globalization (Drewnowski and Popkin, 1997), and income (Behrman and Doelalikar, 1987; Jensen and Miller, 2010). Strikingly, food accessibility has a leading impact on residents' dietary patterns in rural areas. Additionally, dietary knowledge can shape diet patterns and influence health outcomes (Block, 2004; Variyam, 2008; Shimokawa, 2013). However, only a few studies have studied the influences of food accessibility and dietary knowledge on diet quality in China.

1.1.2 Organic Food

Organic food as a category of sustainable food has become increasingly popular all over the world. Developing organic production is environmentally friendly without the use of fossil energy, fertilizers and pesticides. From Figure 1.1, we can find that the area of organic agricultural land increased dramatically from 1999 to 2019 in the whole world.

[Insert Figure 1.1 here]

There has been significant progress in the organic food market among developed countries. Germany has the largest organic food market among European countries. Moreover, German organic market has grown as fast as the general food market in 2020. Figure 1.2 shows the market value for organic food and beverages has increased a lot from 2000 to 2020 in Germany.

[Insert Figure 1.2 here]

1.1.3 Meat Alternatives

Along with the increasing economic development, the diet pattern among the Chinese has changed remarkably. Table 1.2 also shows that meat consumption per capita and poultry consumption per capita have increased a lot. The huge meat demand not only puts pressure on meat production, but also has an adverse impact on the environment. In this case, meat substitutes could be a solution.

Based on the survey by consultancy Euromonitor, China has more than 70 percent of the market size of meat substitutes in the Asia Pacific region, thus becoming a huge potential market in the future[2].

[2]Source: https://www.gfi-apac.org

1.2 Research Topics

Given the fact that the structure of food consumption has changed in China, will food accessibility, diversity of agricultural production and dietary knowledge have influences on residents' diet status? In addition, many factors could affect the WTP for sustainable food, but what is the relationship between political party support and consumer preference for organic food? Moreover, what are the impacts of consumers' perceptions and economic preferences on the WTP for meat alternatives? To answer these questions, this dissertation will focus on four research topics: Food accessibility, diversity of agricultural production, and dietary pattern in rural China; The impact of dietary knowledge on the diet pattern of Chinese adults; Political party support and consumer preference for organic food in Germany: the perspective of social identity and social movements; The impacts of consumers' perceptions and economic preferences on the willingness to pay for meat alternatives in China.

1.2.1 Research Topic 1

Research topic 1 is 'Food accessibility, diversity of agricultural production, and dietary pattern in rural China'. This research topic is discussed in Chapter two. The market-oriented reform in China in the past 4 decades has greatly reshaped the consumption pattern in rural areas. In particular, farmers' diets are more likely to depend on food market development such as food accessibility. We investigate the role of food accessibility in the transition of dietary patterns in rural China by using the China Health and Nutrition Survey data (1997-2011) and whether food accessibility helps alleviate the deviation between farmers' dietary pattern and the recommended dietary pattern according to China Food Pagoda 2016.

1.2.2 Research Topic 2

Research topic 2 is 'the Impact of dietary knowledge on the diet pattern of Chinese adults'. Chapter three presents the study of this research topic. It aims to explore the influence of dietary knowledge on the diet pattern among Chinese adults. We first set up a theoretical framework to identify the possible channels from dietary knowledge to dietary outcomes. Then, using the China Health and Nutrition Survey (CHNS) data from 2004 to 2011, this study employs the mediation test to empirically evaluate the mediated effect of dietary knowledge on the diet pattern.

1.2.3 Research Topic 3

Research topic 3 is ‘Political party support and consumer preference for organic food in Germany: the perspective of social identity and social movements’, and it is presented in chapter four. Consumers nowadays are increasingly inclined to pay for environmentally friendly products such as organic food with the attribute of environmental sustainability (Paul et al., 2016; Rana and Paul, 2017). Although ample studies have concentrated on the WTP for organic food, few of them studied the relation between political party support and the WTP for organic vegetables. However, it is widely believed that social identity and social movements will change consumer preference and thus affect individual consumption behavior through a political process. This topic sheds light on the linkage between political party support and consumer preference for organic food in Germany where organic food has been increasingly popular.

1.2.4 Research Topic 4

Research topic 4 is ‘the Impacts of consumers’ perceptions and economic preferences on the willingness to pay for meat alternatives in China’ and it is presented in chapter five. In recent years, much attention has been attached to meat alternatives which are becoming an attractive substitute for traditional meat. However, only a few studies have been conducted on effects of consumers’ perceptions and economic preferences on the WTP for meat alternatives in China. Consequently, this chapter investigates how consumers’ perceptions (the attitudes towards the environment, food safety and gym) and six economic preferences (risk, trust, positive reciprocity, negative reciprocity, patience and altruism) influence the WTP for meat alternatives in China based on a dataset from an online survey and interval regressions. It may provide valuable insights into the meat alternatives market in China in the future.

1.3 Author Contributions

The second chapter - ‘Food accessibility, diversity of agricultural production, and dietary pattern in rural China’ has been published in *Food Policy*, Volume 84 in 2019. Prof. Tian is the corresponding author. He was responsible for the following tasks: conceptualization; methodology; Supervision; visualization; validation; writing - review & editing. I contributed to data curation, methodology, investigation, formal analysis, resources, visualization, validation and writing-original draft.

(1) Huang, Y., & Tian, X. (2019). Food accessibility, diversity of agricultural production and dietary pattern in rural China. *Food Policy*, 84, 92-102.

The third chapter - ‘the Impact of dietary knowledge on the diet pattern of Chinese adults’ is a conference paper. Prof. Tian is the corresponding author. I conceived of the presented idea, conducted data analysis and designed the model. Additionally, I completed the manuscript with inputs from all authors. Prof. Yu developed the theoretical formalism, performed methodology and supervision. Prof. Tian contributed to conceptualization, visualization, validation and writing - review & editing.

(2) Huang, Y., Yu, X., & Tian, X. (2021). The impact of dietary knowledge on the diet pattern of Chinese adults. Paper prepared for presentation at the 2021 CAER-IFPRI Annual Conference, 28-30 October, 2021, Beijing, P.R. China.

The fourth chapter - ‘Political party support and consumer preference for organic food in Germany: the perspective of social identity and social movements’ is a working paper at present. Prof. Yu is the corresponding author. I assisted Professor Yu to conduct the conceptual framework. In addition, I collected and processed the data. I wrote the manuscript in consultation with all authors.

(3) Huang, Y., Feil, J. H., & Yu, X. (2021). Political party support and consumer preference for organic food in Germany: the perspective of social identity and social movements.

The fifth chapter - ‘the Impacts of consumers’ perceptions and economic preferences on the willingness to pay for meat alternatives in China’ is a conference paper. Prof. Yu is the corresponding author. I, together with Professor Yu, designed the analytic model and conducted the conceptual framework. Also, I processed the data and took the lead in drafting the manuscript under Professor Yu’s supervision. Xiaoping Zhong was responsible to collect the data. All authors were involved in the discussion of results and comments about this chapter.

(4) Huang, Y., Zhong, X., & Yu, X. (2021). The impacts of consumers’ perceptions and economic preferences on the willingness to pay for meat alternatives in China. Paper prepared for presentation at the international conference on “Sustainable Resource Management for Adequate, Safe and Nutritious Food Provision”, 16 October, 2021, Nanjing, P.R. China.

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Tables and Figures

Table 1.1 the Production of main agricultural products in China

Food category (10,000 tons)	1978	1996	2000	2005	2008	2011	2014	2017	2020
Grains, potatoes and beans	30476.5	50454.0	46217.5	48402.2	53434.3	58849.3	63964.8	66160.7	66949.2
Meat and poultry	/	4584.0	6013.9	6938.9	7370.9	8023.0	8817.9	8654.4	7748.4
Aquatic products	465.4	3288.1	3706.2	4419.9	4895.6	5603.2	6001.9	6445.3	6549.0
Eggs	/	1965.2	2182.0	2438.1	2699.6	2830.4	2930.3	3096.3	3467.8
Milk	/	735.8	919.1	2864.8	3236.2	3262.8	3276.5	3148.6	3529.6
Fruit	657.0	4652.8	6225.1	16120.1	18279.1	21018.6	23302.6	25241.9	28692.4

Data source: National Bureau of Statistics of China (NBSC)

Table 1.2 the Dietary change of Chinese residents

Food category (kg)	1985	1990	1995	2000	2005	2010	2015	2020
Nationwide areas								
Grains, potatoes and beans	228.36	227.39	211.90	189.41	152.16	131.53	134.50	141.20
Meat and poultry	14.36	15.92	16.18	20.91	26.90	28.43	34.60	37.50
Aquatic products	2.93	3.60	4.84	6.08	8.21	10.17	11.20	13.90
Vegetables	134.27	135.24	108.06	109.64	109.29	104.68	97.80	103.70
Eggs	3.19	3.69	5.11	7.10	7.16	7.56	9.50	12.80
Milk	/	/	/	4.28	9.33	8.76	12.10	13.00
Fruit	/	/	/	32.50	34.17	36.92	40.50	51.30
Nuts	/	/	/	1.67	1.74	/	3.10	3.70
Edible oil	4.45	5.49	6.18	7.46	7.40	7.57	10.60	10.40
Urban areas								
Grains, potatoes and beans	134.76	130.72	97.00	82.31	76.98	81.53	112.6	120.20
Meat and poultry	21.96	25.16	23.65	25.5	32.83	34.72	38.30	40.40
Aquatic products	7.08	7.69	9.20	9.87	12.55	15.21	14.70	16.60
Vegetables	144.36	138.70	116.47	114.74	118.58	116.11	104.40	109.80
Eggs	6.84	7.25	9.74	11.21	10.40	10.00	10.50	13.50
Milk	/	4.63	4.62	9.94	17.92	13.98	17.10	17.30
Fruit	/	41.11	44.96	57.48	56.69	54.23	49.90	60.10
Nuts	/	3.21	3.04	3.30	2.97	/	4.00	4.20
Edible oil	5.76	6.40	7.11	8.16	9.25	8.84	11.10	9.90
Rural areas								
Grains, potatoes and beans	257.45	262.08	258.92	250.23	208.85	181.44	159.50	168.40
Meat and poultry	12.00	12.60	13.12	18.30	22.42	22.15	30.20	33.80
Aquatic products	1.64	2.13	3.06	3.92	4.94	5.15	7.20	10.30
Vegetables	131.13	134.00	104.62	106.74	102.28	93.28	90.30	95.80
Eggs	2.05	2.41	3.22	4.77	4.71	5.12	8.30	11.80
Milk	/	/	/	1.06	2.86	3.55	6.30	7.40
Fruit	/	/	/	18.31	17.18	19.64	29.70	39.90
Nuts	/	/	/	0.74	0.81	0.96	2.10	3.10
Edible oil	4.04	5.17	5.80	7.06	6.01	6.31	10.10	11.00

Data source: National Bureau of Statistics of China (NBSC)

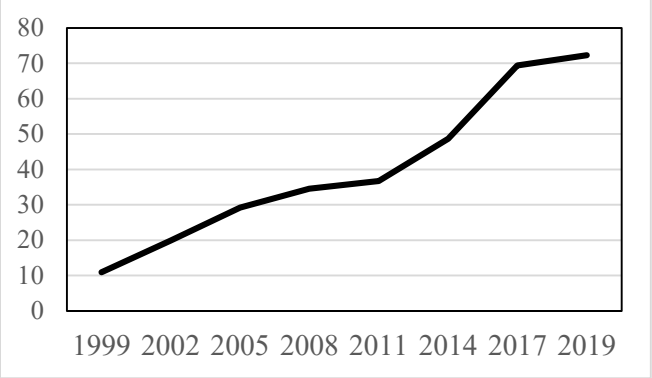

Figure 1.1 the Area of organic agricultural land from 1999 to 2019 (million hectares)
Data source: a report from www.organic-world.net - The World of Organic Agriculture 2021.

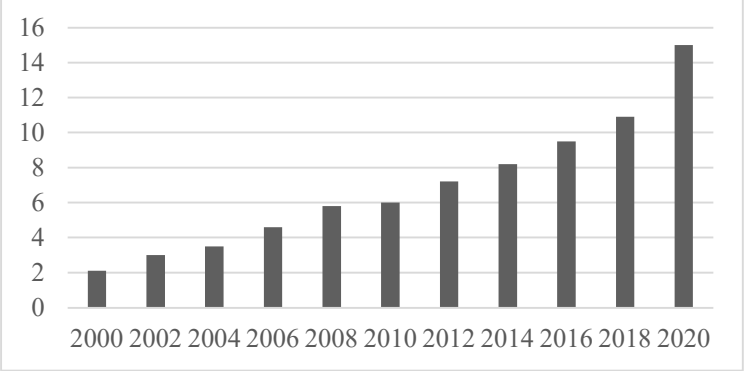

Figure 1.2 Market value for organic food and beverages in Germany (billion EUR)
Data source: a report from www.organic-world.net - The World of Organic Agriculture 2021.

Chapter 2 Food Accessibility, Diversity of Agricultural Production, and Dietary Pattern in Rural China[3]

2.1 Introduction

In the past 4 decades, China has made profound progress in its agricultural sector. The total grain production increased from 305 million tons in 1978 to more than 600 million tons in recent years, with an annual growth of 2% (NBSC, 2018). Additionally, the total production of meat and poultry experienced a greater increase than total grain production, increasing from 10 million tons in the early 1980s, to more than 84 million tons in 2017 (Chao et al., 2017; NBSC, 2018).

Along with the increasing food supply, the dietary pattern of Chinese residents changed significantly. Numerous examples in the literature have shown that Chinese consumers are switching from a traditional Chinese diet, characterized by complex carbohydrates and fiber, to a refined food and Western food diet, which is high in fat, saturated fat, and sugar (Guo et al., 2000; Popkin et al., 2001; Tian and Yu, 2013; 2015; Huang et al., 2017; Wang et al., 2017). These changes in the dietary pattern have led to two remarkable effects on nutrition and health. First, the increasing food consumption and changing dietary structure contribute to an improving nutrition status of Chinese residents. The Food and Agricultural Organization (FAO) estimates that the prevalence of undernourishment in China has decreased from 24% in the early 1990s to less than 10% in recent years (FAO et al., 2017). Second, overconsumption of high-calorie density food has been associated with an increasing prevalence of non-communicable diseases like diabetes and obesity (Huang et al., 2017; Tian et al., 2017). The co-existence of under-nutrition and over-nutrition has attracted increasing concern from the public and academia in China. To provide a guideline for a healthy diet, the Chinese Dietary

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Guidelines 2016 (CDG 2016) was released at the end of 2016 by the National Health and Family Planning Commission of the People's Republic of China (NHFPC). The guideline was formulated based on basic nutrition demands and health conditions.

Studies in the literature have found that the changing diet in China and other developing countries could be attributed to economic growth (Guo et al., 2000; Du et al., 2004; Tian and Yu, 2013, 2015; Zheng et al., 2016; Zhou and Yu, 2015), urbanization (Popkin and Bisgrove, 1988; Solomons and Rainer, 1995; Zhai et al., 2014; Tian et al., 2017), culture and technical change (Popkin, 2003), globalization (Drewnowski and Popkin, 1997), and shifting preferences from nutrients to non-nutritional attributes like tastes (Jensen and Miller, 2010). Most of these studies have concluded that increasing household income plays a central role in reshaping consumers' dietary pattern because the income elasticities of animal products (meat and poultry, milk and its products, and aquatic products) are substantial and statistically significant, and that of staple foods such as coarse grain and starches is very small and even negative (Huang and Gale, 2009; Burggraf et al., 2015; Chen et al., 2016; Zhou et al., 2017). Therefore, the diet of people with income levels considered poor is often dominated by staple food because it is the cheapest calorie source. As income increases, consumers tend to care more about other attributes of food other than nutrition such as taste, appearance, odor, status value, and degree of processing (Behrman and Doelalikar, 1987; Jensen and Miller, 2010). As a result, staple food is gradually replaced by more delicious animal food and healthy food (Tian and Yu, 2015).

Notably, consumers' diet is affected by household income (affordability) and other factors, such as food accessibility, choice, nutritional knowledge, and motivation to consider health (Wrigley et al., 2003). In particular, food accessibility plays a central role in shaping the dietary pattern of consumers living in rural areas, because poor food market development constrains the availability and variety of food. According to the food desert hypothesis, the availability of healthful foods in low-income neighborhoods is lower than that in high-income neighborhoods, which might further lead to a less healthful diet for people at the poor income level (Wrigley et al., 2003; Allcott et al., 2017).

Strikingly, few examples in the literature have analyzed the impact of food accessibility on the dietary pattern and nutrition status (Popkin, 2014). Chege et al. (2015) investigated the impact of supermarkets on farm household nutrition in Kenya. They observe that participation in supermarket channels is associated with a significantly higher intake of calories, vitamin A, iron, and zinc. They also provide three possible impact pathways and argue that supermarket participation might increase farmers' income, agricultural specialization, and the likelihood of

male control of revenues. Using household survey data, they observe that increasing income and agricultural specialization have positive impacts, and male control of revenues has negative impacts on dietary quality. In addition, Sibhatu et al. (2015) and Koppmair et al. (2016) observe evidence that market access has a positive impact on farmers' dietary diversity in several Africa and Asia countries. Zhang (2002) also argues that rural market development has a significant impact on farmers' food consumption in China. In particular, expenditure on grain will decrease as market develops, and expenditure on edible oil, vegetable, and pork will increase.

In this article, we investigate the impact of food accessibility on the dietary pattern of rural residents in China by using the most recent six waves (1997, 2000, 2004, 2006, 2009, and 2011) of the China Health and Nutrition Survey (CHNS) data. In particular, we estimate deviation of the real dietary pattern from the recommended dietary pattern in CDG 2016 and the China Food Pagoda (CFP) 2016 and analyze whether increasing food accessibility can help alleviate the deviation. The goal of our study is threefold: to evaluate the dietary quality of Chinese rural residents between 1997 and 2011 using the CFP 2016, test whether food accessibility contributes to better dietary quality in rural China, and estimate the heterogeneous impact of food accessibility on the dietary pattern across farmers with different diversity of agricultural production.

In the past 4 decades, Chinese farmers have been transforming from subsistence agriculture to specialized, market-oriented agriculture. This transformation has led to a high dependence of farmers' dietary pattern on local food accessibility. Therefore, dietary patterns of rural residents are more likely to be constrained by the accessibility of food in the local food market due to the relatively poor market access, and it is of more interest to address this research gap by using a large-scale sample over a long time period. This agricultural transformation is underway in many other developing countries, for example, countries in Africa. Our study thus provides valuable implications for rural development and nutrition security in the developing world.

The remainder of this article is organized as follows. Section 2 presents a simple framework to explain the possible pathway and an empirical model to investigate the impact of food accessibility on the dietary pattern. Section 3 briefly discusses the data and measurement of key variables. Section 4 presents the empirical results and various robustness tests. The last section discusses the results and provides a simple conclusion and implication for other developing countries.

2.2 Theoretical Framework and Empirical Model

2.2.1 Theoretical Framework

In the traditional agriculture sector, most rural residents are subsistent farmers. These farmers are highly self-sufficient; neither sell nor buy much food from markets; and have a dietary pattern that depends mainly on their production of food. However, because the agriculture sector tends to be more specialized and market-oriented, farmers focus on several products that have comparative advantages. The change from polyculture to monoculture increases farmers' productivity and agricultural income (Kurosaki, 2003; Klasen et al., 2016), but might decrease their dietary quality due to the strong link between own production and food consumption (World Bank, 2007; Jones et al., 2014).

Recent literature has already found evidence that production diversity is positively associated with dietary diversity in several developing countries (Herforth, 2010; Jones et al., 2014; Koppmair et al., 2015; Sibhatu et al., 2015). However, if food accessibility is high, such that a farmer can easily access a market where food can be bought, the impact of production diversity on dietary quality will weaken and tend to be insignificant (Sibhatu et al., 2015; Ng'endo et al., 2016). Therefore, we expect that food accessibility will improve the dietary quality of rural residents and the effect of food accessibility on dietary quality depends on on-farm own production. For farmers with very diverse farm production, their diet depends mainly on their production and might not be affected too much by the market access. By contrast, for rural families highly specialized in a few agricultural products and those not engaged in the agriculture sector, their diet patterns will be strongly affected by the accessibility of food in a local market.

2.2.2 Empirical Model

The impact of food accessibility on dietary pattern can be modeled as follows:

$$y_{it} = \beta_0 + \beta_1 MDI_{jt} + X\delta + u_{it} \qquad 2.1$$

Where y_{it} refers to dietary pattern indices of individual i in year t; MDI_{jt} refers to various indices used to measure food accessibility in village j at year t; and X refers to all other covariates, including respondents' individual and family characteristics (e.g. education, age, gender, and physical activity level) and household characteristics (household net per capita income; household size; ratios of children and elderly people; and ownership of typically fixed

assets, e.g., a refrigerator, motorcycle, and car).

To control unobserved regional heterogeneity, we control the village fixed effect in the estimation. Individual characteristics are used to control heterogeneous individual preference for diet, and household structure (household size and demographic structures) is controlled to make the food consumption comparable across different households, which is similar to dividing the total household consumption by the number of adult equivalent, recommended by Chege et al. (2015).

Refrigerators are mainly used to store fresh food; motorcycles and cars can significantly increase the accessibility to food sold in markets far from home; and all of these assets can affect food consumption. Village dummies are adopted to control regional heterogeneity, such as various cuisines in China. In addition, heterogeneity of agricultural production across different regions is correlated with the food supply within the region and might further affect the food consumption of residents. These regional heterogeneities can also be controlled by village dummies and yearly dummies.

Finally, individuals from the same family might have a similar dietary pattern; thus, we further adjust the standard error by using the household cluster effect. Moreover, farmers' dietary patterns might also depend on their food production; thus, we adopt a simple index to measure the diversity of agricultural production for each family and control it as an additional covariant.

In addition, the heterogeneous impact of market development on family diet is also investigated across several subgroups, including families with highly diverse agricultural production, families with low agricultural production, and families that only participate in off-farm work.

The literature has also shown that food accessibility measures based on the environment might be endogenous (Dunn, 2010) because markets may prefer to locate in densely populated areas where the demand is high, and farmers may tend to reside in the area with well-developed infrastructure including supermarkets to reduce the cost of access to food; thus, the reasons for farmers' sorting on neighborhoods are likely to be correlated with the underlying determinants of their nutrition and health outcomes (Kling et al., 2007). To manage the possible endogeneity of the food accessibility variable, we find an additional IV and integrate it into each model. In addition, the error terms in different food equations might correlate with each other, and we must estimate multiple food equations simultaneously. Therefore, we adopted a three-stage

least square estimation model (3SLS), which is a combination of a IV and the seeming unrelated regression model, to estimate the impact of food accessibility on the consumption of each food item. Furthermore, the impact of food accessibility on the deviation of real food consumption from CFP 2016 is also estimated using a 3SLS model.

2.3 Data

2.3.1 CHNS Dataset

The CHNS is an ongoing cohort survey of approximately 4,400 families per year in urban and rural areas in nine provinces of China (i.e., Guangxi, Guizhou, Henan, Heilongjiang, Hubei, Hunan, Jiangsu, Liaoning, and Shandong; three municipalities of Beijing, Chongqing, and Shanghai were included in 2011). The nine provinces include the north and south area, the well-developed east-coastal region, and the poor remote region; and vary substantially in geography, economic development, public resources, and health indicators. The survey is jointly conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention. Samples were selected by using a multi-stage, random cluster strategy, and can be treated as a representative of the Chinese population. Detailed information is available in the literature (Zhang et al., 2014).

The survey provides sufficient data for our research. In particular, the household and individual surveys collect detailed information on residents' socioeconomic conditions, residents' diet structures, and the nutritional status of each individual and household. In addition, the village questionnaire collects information on village infrastructure (e.g., water, transport, electricity, communications), services (family planning, health facilities, and retail outlets), population, prevailing wages, and prices of representative foods.

We focus on adults aged 20-59 because the CFP is set mainly for healthy adults. In addition, individuals who are pregnant, breastfeeding, or ill during the survey period are removed because their diet might be un-comparable with others. To remove measurement error, we follow the suggestion of Tian and Yu (2013) and drop observations with a total calorie intake less than 520 kilocalories (the estimated energy requirement for a female newborn younger than 0.5 years old) or greater than 8,000 (approximately three times the average calorie intake of Chinese residents in the sample). Finally, 11,721 samples were obtained from the recent six-wave data after combing data from different questionnaires collected from 6,775

individuals. Detailed information about the sample is presented in the next section.

2.3.2 Measurement of Key Variables

(1) Dietary Pattern

The CHNS provides two sets of food consumption data: 24-hour individual dietary intake data and household food inventory change data. The 24-hour individual dietary intake data is adopted in our research because it records all food consumed at home and away from home by individuals. In addition, family food inventory change data is used to measure individual consumption of oil and salt, which is not available in individual dietary recall data. To control the bias caused by eating-away-from-home, the number of meals eaten at home during the survey days is collected for all family members; this data is used to generate the food consumption per person per day (Popkin et al., 2010; Tian and Yu, 2013; Zhai et al., 2014) and further used to measure per capita salt and oil consumption from the household food inventory change data (Tian et al., 2017).

Individual consumption of each food item is further summed up into ten food groups to be consistent with CFP 2016. CDG 2016 was jointly created by the Chinese Center for Disease Control and Prevention (CDC), National Health and Family Planning Commission of the People's Republic of China, and the Chinese Nutrition Society (CNS, 2016; Tian et al., 2017). The CFP demonstrates the main principles of CDG 2016 in a figure and transforms the principle into recommended daily consumption quantities for healthy adults for five food groups: (1) grains, potatoes and beans; (2) fruit and vegetables; (3) animal products (eggs, aquatic products, meat and poultry); (4) legumes and nuts, milk and its products; and (5) oil and salt. Specific lower and upper bounds are set for ten food items as a reference level (see the last column of Table 2.1).

[Insert Table 2.1 here]

Under-consumption and overconsumption are defined by considering that the real consumption was lower than the lower bound and higher than the upper bound of CFP 2016, respectively. In addition, Xu et al. (2015) developed the Chinese Food Pagoda Score (CFPS) to measure the overall dietary quality for each family on the basis of the key principles of CDG 2007 and the recommended consumption quantity of the CFP 2007. We update the CFPS according to the new principles in CFP 2016 and adopt the result to measure dietary quality in our study. Specifically, each food group receives score '1' if the real consumption is within the

recommended consumption interval. If the real consumption is 50% higher than the upper bound or 50% lower than the lower bound, the score is '0.5'. If the deviation between real consumption and recommendation is too large, the score is '0'. Furthermore, to encourage a healthy diet, the score is '1' if the real consumption of fruit and vegetables is greater than the lower bound. Finally, the score of ten food groups is summed up to calculate the CFPS for each individual. Therefore, a greater CFPS indicates a more balanced diet that adheres to the CFP 2016. The detailed assignment method is presented in Table 2.1.

(2) Food Accessibility

Market development can be measured in many different ways. In this research, we mainly focus on accessibility of food. Therefore, we develop two methods to measure the accessibility of food in local markets. First, the distance to the free market where residents go most often to buy food is adapted to proxy the access to a food market. The free market is a traditional market that sells fresh foods and other products; is open-air or enclosed; and vendors and consumers can negotiate and decide the final price. One difference between free markets and modern markets, such as a supermarket or hypermarket, is that prices are fixed in modern market.

In particular, we record the distance to various free markets where residents go most often to buy grains, cooking oil, vegetables, fruits, meat (poultry, egg), fresh milk, preserved milk, fish, and bean curd. We next take the average of these nine distances to a free market as the measure of access to a local food market, which we expect to affect the dietary quality of rural residents because living far away from food markets could increase the cost of obtaining access to food that cannot be produced at home. Second, the number of fruit and vegetable stores and vendors (stall peddlers) currently operating in the village is used to capture the availability of food in the region. Many stores and vendors in a market indicate a higher availability of the food supply, which could contribute to a high-quality diet. This measure is adopted as a robustness check and uses the 2004-2011 data because it is only recorded after 2004.

(3) Diversity of Agricultural Production

CHNS records family income from nine sources, and four are related to agriculture (farming, fishing, gardening, and livestock). Because the recorded income is profits from each source, we cannot directly use these figures to calculate a specialization index, such as the Herfindahl index. Regarding the data availability, we count the number of agricultural productions that families are engaged in and use the number as a measure of the diversity of agricultural

production in this research. Farmers engaged in one or two agricultural productions are defined as specialized; farmers engaged in more than two productions are defined as diversified; and respondents not engaged in agricultural productions are defined as non-farmers.

(4) Other Covariates

We use the generated per capita net income in the survey to measure household income, which is the sum of all sources of income and revenue minus expenditures. The income and revenue include business, farming, fishing, gardening, livestock, non-retirement wages, retirement income, subsidies, and other income (Du et al., 2004). We also control individual and household characteristics (education; age; gender; physical activity level; household size; demographic ratios of children and elderly people; and ownership of a refrigerator, car, or motorcycle) to account for individual and household heterogeneity.

Physical activity in the CHNS is based on occupation type (1=very light physical activity, working in a sitting position like office worker or watch repairer; 2=light physical activity, working in a standing position such as sales person or teacher; 3=moderate physical activity like student or driver; 4=heavy physical activity such as farmer or dancer; and 5=very heavy physical activity such as loader, logger, or miner). We classify 1 and 2 as light activity, 3 as moderate activity, 4 and 5 as heavy activity.

In addition, village and yearly fixed effects are controlled in the model to control for regional heterogeneity and time trend, and several exogenous variables are adopted as the instrumental variable (IV) of food accessibility indicators. The first IV is a dummy variable identifying whether an open trade area, open city, or special economic zone is proximal to this village, that is, within 2 hours by bus. This location variable is determined by the Chinese government and should not directly affect individual diet. Thus, this location variable can be treated as exogenous in our model. In addition, the good location of village is often related to policy priority and better access to capital. Therefore, a village located proximal to an open trade area, an open city, or a special economic zone could have a well-developed food market.

The second group of IVs includes four variables to measure the transportation system in the village: a dummy to identify whether the village is proximal to a navigable river, whether a bus stop is in the village, whether a train station is proximal to the village, and the distance to the nearest train station. These variables measure the geographic feature and local transportation condition for each village. Villages with better transportation condition have better access to food and other products produced outside of the village. Thus they should be

related to the development of free market. In addition, public transportation and geographic condition can be treated as exogenous in the individual food consumption function, and they are also widely used in previous literature to measure market access (Emran and Hou, 2013). In practice, to make sure that all chosen IVs are valid, we will select IVs from these five variables for each function according to the over-identification test (Sargan statistic) and the under-identification test (Kleibergen-Paap test).

Another challenge to measure the distance to food markets is that the distance depends both on the location of food markets and households. It is possible that households might choose to live in larger villages and towns which are closer to food markets if there is no restriction on geographic mobility. However, in rural China, the institutional constraints (the Hukou system) on geographic mobility of rural households make it very unlikely for rural households to migrate to other villages, because they have very high risks to lose all the benefits associated with the legal residents. Therefore, there is less concern over endogeneity caused by geographic spacing of households in rural China (Emran and Hou, 2013). Table 2.2 provides a brief summary and definition of all variables.

[Insert Table 2.2 here]

2.4 Results

2.4.1 Dietary Pattern of Chinese Rural Residents

We first present the dietary pattern of Chinese rural residents in each year and compare the real consumption with the CFP 2016. Results are presented in Figure 2.1. Our data indicates that fruits, meat and poultry, and milk and its products undergo a rapid increase over years, but fruits, and milk and its products are still severely under-consumed in rural China. Additionally, Chinese rural residents have a deficient intake of eggs and aquatic products; even an increasing trend is detected. By contrast, we observe a slight overconsumption of cereal, potato, and beans; meat and poultry (in recent two waves); and legumes and nuts. Additionally, we observe that the consumption of vegetables has decreased slightly below the lower bound in recent years. The consumption of oil and salt is much higher than the recommended level.

[Insert Figure 2.1 here]

2.4.2 Changing CFPS in China over Time

Table 2.3 presents the mean CFPS for rural Chinese residents at each year. We observe a

constant increase in CFPS for all groups after 2000, except for farmers who are engaged in very diversified agricultural activities (more than two agricultural activities). Moreover, we also observe that residents from a high-income family have higher CFPS, indicating a more balanced diet according to CFP 2016. In addition, the CFPS varies across individuals from families with different production diversity. In particular, families not engaged in agricultural production have the highest CFPS; while those specialized in 1 or 2 agricultural activities have the lowest CFPS.

[Insert Table 2.3 here]

2.4.3 Impact of Food Accessibility on the Dietary Pattern of Chinese Rural Residents

The impact of food accessibility on the CFPS of Chinese rural residents is presented in Table 2.4. In this paper, we adopt four models: the OLS model, the IV model, the fixed effect (FE) model and the random effect (RE) model. The endogeneity test (the difference of two Sargan-Hansen statistics, is numerically equal to a Hausman test but is more robust to various violations of conditional homoscedasticity, see Hayashi, 2000), rejects the null hypothesis, indicating that the distance to food market is endogenous in this model and the IV model should be preferred. The Kleibergen-Paap underidentification test rejects the null hypothesis at 1% significance level, which indicates the chosen IV is strongly related to the endogenous regressor (Kleibergen and Paap, 2006), so that the additional exogenous variables are strong IVs. We also conduct the FE and RE regressions with IV, but the panel is strongly unbalanced and 53.87% (3650 in 6775) of individuals only have one observation. In addition, the unobserved individual effect is very small and the share of variance caused by unobserved individual effects is negligible, so that the RE model approaches the pooled IV. In fact, results estimated from IV, FE, and RE are very similar. Therefore, our discussion will focus on results estimated from the IV model. Our results indicate that the distance to food market does have a negative impact on CFPS, and it is statistically significant at 5% significance level. Specifically, 1 km closer to the free market can increase the CFPS by 0.133, which is roughly 8% of the mean value. Moreover, we also observe that individuals who are engaged in more agricultural activities have better dietary quality as expected.

[Insert Table 2.4 here]

In addition, characteristics of the individual, family, regional, and yearly dummies also affect CFPS. For instance, males and people with heavy physical activity have lower CFPS. In addition, respondents from a family with an income level considered high, many members, and

a large share of children have better dietary quality. Families who own a refrigerator and motorcycle also have better dietary quality. Furthermore, the dietary quality significantly improved after 2004, and significant regional heterogeneity is also detected.

To investigate the mechanism of the positive impact of food accessibility on CFPS, we further take the real consumption of each food group as the dependent variable and estimate the impact of food accessibility on the consumption of each food group separately using a 3SLS model. Results are presented in Table 2.5. We observe that the distance to food market has a significant impact on several food groups. In particular, individuals who live far away from the food market will have a higher consumption of cereal, potatoes, and beans; vegetables; and salt; surprisingly, they also have a higher consumption of fruit and aquatic products. By contrast, living proximal to a free market can increase the consumption of oil. Bear in mind that all food groups are measured in gram, so that the real impact is very small for most food items, except for edible oil and salt.

[Insert Table 2.5 here]

2.4.4 Impact of Food Accessibility on the Deviation of Food Consumption from CFP

In this section, we will test whether food accessibility contributes to smaller deviation of real food consumption from the CFP 2016. We take a dummy variable to identify whether individuals' real consumption is in the recommended interval by CFP 2016 (0 refers to within the interval and 1 refers to beyond), and adopt a multi-equation linear probability model with IV to control the correlation across different functions and endogeneity bias. We present the results in Table 2.6. Results indicate that a larger distance leads to bigger deviation of legumes and nuts, and edible oil, but smaller deviation of fruit.

[Insert Table 2.6]

2.4.5 Robustness Check

(1) Various Diversity of Agricultural Production

To test the robustness of our results, we further divide the total sample into three groups according to the diversity of agricultural production, and estimate the impact of food accessibility on CFPS for different individuals. Results are shown in Table 2.7. We observe that higher accessibility of food can increase the CFPS for individuals whose family is not engaged in agricultural production. For specialized farmers and diversified farmers, we do not observe

strong evidence that food market development has a significant impact on CFPS of individuals, even though coefficients are negative as expected.

[Insert Table 2.7 here]

(2) Alternative Food Accessibility Measure

To test the robustness of our results, we further use the number of food stores selling fruits and vegetables in the village as an alternative measure of food accessibility in rural areas. Because this data is only collected after 2004, we thus use the recent 4-wave survey data. Results are presented in Table 2.8. We observe that the results are similar to before. In particular, higher accessibility of food in local market contributes to a higher CFPS, and this phenomenon is particularly true for non-farmers.

[Insert Table 2.8 here]

2.5 Discussion and Conclusion

The food consumption pattern in rural China has experienced a remarkable change along with the rapid economic and social development of the past 4 decades. In particular, as an increasing number of farmers specialize in a few agricultural activities and migrate to urban areas for non-farm jobs, the dietary pattern of rural residents should depend more on accessibility of food in local market. In this paper, we investigate the role of access to food markets on the dietary pattern of rural residents in China. The CHNS data (1997-2011) is adopted, and the real consumption is compared with the recommended dietary pattern according to CFP 2016. In general, the main findings can be summarized as follows:

First, the dietary quality of Chinese people in rural areas has been improving since 2000. In particular, people from families with a high income level not engaged in agricultural production have higher dietary quality than the other groups. The improvement in CFPS could be partly attributed to the increasing accessibility of food in local markets. Living 1 km closer to the free market could increase the CFPS by 8%. Living close to the free food market decreases the cost of accessing more diversified food, which could increase the consumption of food not produced at home, decrease the overconsumed own produced food, and finally lead to a diet with higher quality.

Second, individuals with better access to food markets have a higher consumption of oil and a lower consumption of cereal, potatoes, and beans; vegetables; fruits; and salt than

individuals with worse access to food. In rural areas, cereal, potatoes, and beans are usually produced at home, and salt is usually used to store animal products such as meat. Because these foods are already overconsumed (Figure 2.1), moving closer to the market will reduce their consumption and contribute to a higher CFPS.

Similarly, most rural families cultivate vegetables in their backyard for self-consumption. Famers living proximal to markets can find a greater number of substitutes for vegetables; thus, this group of farmers might replace vegetables with other food, in particular, processed food like deep oiled food sold in modern food markets. Notably, the consumption of vegetables in rural China decreased to slightly less than the lower recommended level in 2011, and oil was overconsumed in all waves. We posit that substituting vegetables with deep oiled food could deteriorate dietary quality and result in a lower CFPS. The higher consumption of fruit in individuals who live far from the market could be attributed to fruit trees planted in backyards in rural remote areas, that is, families who live in remote mountainous areas may have more land to plant fruit trees. However, we use caution when explaining these results, because the real impact of reduction in distance to a free market on food consumption is very small. In particular, a 1 km reduction in distance to a free market (approximately 56% of the mean distance in our sample) results in a less than 1% change for nine of the ten food groups. The only exception is salt: consumption reduced by 7.49% of the average real consumption in 2011. The small impact might also explain the controversial evidence that farmers' dietary patterns are converging with the recommended dietary pattern in CFP 2016 along with the increasing food accessibility. In particular, higher food accessibility decreases the deviation of fruits and increases the deviation of legumes and nuts, and oil.

Finally, the impact of food accessibility on dietary quality is much stronger for those not engaged in agricultural production. Families not engaged in agricultural activity do not produce food, and their food consumption is highly dependent on food markets; thus, food accessibility has a significantly strong impact on their diet quality. By contrast, families engaged in diverse agricultural production can depend on their production, and their diet is not affected by food accessibility in local markets. Our results indicate that food accessibility has a significant impact on improving the dietary quality of rural residents, particularly those not engaged in agriculture.

Compared with the literature that observed positive impacts of market development on household nutrition (e.g., Zhang, 2002; Chege et al., 2015; Sibhatu et al., 2015; Koppmair et al., 2016), we highlight the interaction role of agricultural specialization on shaping the

association between these two variables. We observe that market access has a significant impact on only the dietary quality of rural residents who do not work in the agriculture sector anymore, and no significant impact is detected for people engaged in agriculture. Moreover, increased food consumption and dietary diversity do not necessarily lead to higher dietary quality. A possibility is that increasing food accessibility might enlarge the deviation between real consumption and recommended consumption if some food is already overconsumed. These topics, however, are not well addressed in the literature.

Our finding also provides several implications for rural development in developing countries other than China: first, highly specialized agricultural production might deteriorate dietary quality of rural residents if the food accessibility is poor in local markets; second, increasing food accessibility might also increase the consumption of some food already overconsumed in rural areas; thus, other policies such as promoting dietary knowledge in rural areas should be implemented along with rural development. In addition, complementary polices and interventions such as food shopping and cooking skill programs, price promotions, in-store stocking policies, food and drink taxes and subsidies, and increasing the availability of healthy food in markets can bridge the gap between consumers' perceptions of food and their real food consumption behavior, which might also contribute to higher dietary quality (Cummins et al., 2014).

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Tables and Figures

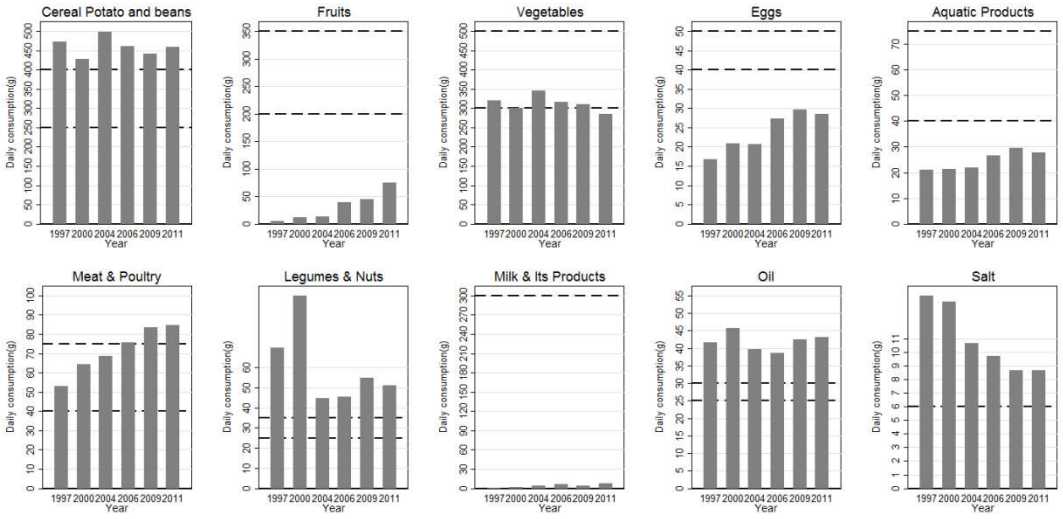

Figure 2.1 Dietary pattern of Chinese rural adults during 1997-2011

Notes: 1. Horizontal dashed line refers to the recommended consumption level. The upper line refers to the upper bound. The lower line refers to the lower bound.

2. One standard was set for milk and its products, and salt, in the China dietary guideline.

Table 2.1 Chinese Food Pagoda Score (CFPS) at various energy levels

Food group	1600 kcal	1800 kcal	2000 kcal	2200 kcal	2400 kcal	2600 kcal	2800 kcal	Dietary guidelines
Grains, potatoes and beans (g)								250-400
Score as “1”	175-225	200-250	225-275	250-300	275-325	325-375	350-400	
Score as “0.5”	88-175	100-200	113-225	125-250	138-275	163-325	175-350	
Score as “0.5”	225-338	250-375	275-413	300-450	325-488	375-563	400-600	
Vegetables (g)								300-500
Score as “1”	≥300	≥400	≥450	≥450	≥500	≥500	≥500	
Score as “0.5”	150-300	200-400	225-450	225-450	250-500	250-500	250-500	
Fruit (g)								200-350
Score as “1”	≥200	≥200	≥300	≥300	≥350	≥350	≥400	
Score as “0.5”	100-200	100-200	150-300	150-300	175-350	175-350	200-400	
Meat and poultry (g)								40-75
Score as “1”	15-65	25-75	25-75	50-100	50-100	50-100	75-125	
Score as “0.5”	8-15	13-25	13-25	25-50	25-50	25-50	38-75	
Score as “0.5”	65-98	75-113	75-113	100-150	100-150	100-150	125-188	
Eggs (g)								40-50
Score as “1”				40-50				
Score as “0.5”				20-40				
Score as “0.5”				50-75				
Aquatic products (g)								40-75
Score as “1”	≥40	≥50	≥50	≥75	≥75	≥75	≥100	
Score as “0.5”	20-40	25-50	25-50	38-75	38-75	38-75	50-100	
Milk and its products (g)								300
Score as “1”				≥300				
Score as “0.5”				150-300				
Legumes and nuts(g)								25-35
Score as “1”	15-25	15-25	15-25	25-35	25-35	25-35	25-35	
Score as “0.5”	8-15	8-15	8-15	13-25	13-25	13-25	13-25	
Score as “0.5”	25-38	25-38	25-38	35-53	35-53	35-53	35-53	
Edible oil (g)								25-30
Score as “1”			≤25			≤30		
Score as “0.5”			25-38			30-45		
Salt (g)								<6
Score as “1”				≤6				
Score as “0.5”				6-9				

Note: The energy level is the upper bound for each interval except for the level of 2800 kcal. For instance, individuals with energy intake lower than or equal to 1600 kcal are classified into the group ‘1600’. Individuals with energy intake more than 2600 kcal are classified into the group ‘2800 kcal’.

Table 2.2 Descriptive analysis and definition of variables

Variables	Mean	SD	Min	Max	Definition
CFPS	2.79	1.13	0.00	9.00	China Food Pagoda Score
Production diversity	1.36	1.22	0.00	4.00	Families' number of agricultural production (farming, fishing, gardening, and livestock)
Individual characteristics					
Physical activity	2.16	0.90	1.00	3.00	Physical activity level, 1 = light, 2 = moderate, 3 = heavy
Education	1.84	0.77	1.00	3.00	Highest education completed: 1 = primary, 2 = secondary, 3 = tertiary
Age	41.87	10.34	20.00	59.00	Years of age
Gender	0.50	0.50	0.00	1.00	1 if male and 0 if female
Family characteristics					
Ln(income)	8.18	1.10	0.69	12.96	Per capita household income deflated to 1997 price
Household size	4.34	1.70	1.00	15.00	Number of household members
Children ratio	0.18	0.18	0.00	0.83	Children ratio of household members
Elderly people ratio	0.06	0.12	0.00	0.75	Elderly people ratio of household members
Refrigerator	0.50	0.50	0.00	1.00	Does the household own a refrigerator? 1 if yes and 0 if no
Car	0.07	0.26	0.00	1.00	Does the household a own car? 1 if yes and 0 if no
Motorcycle	0.36	0.48	0.00	1.00	Does the household own a motorcycle? 1 if yes and 0 if no
Village characteristics					
Location	0.37	0.48	0.00	1.00	Near open trade area or city (< 2 hours by bus), 1 if yes and 0 if no
Train	0.16	0.36	0.00	1.00	Is train station proximal to the village? 1 if yes and 0 if no
Train distance	44.22	59.37	0.00	300.00	Distance to the nearest train station in km
Bus stop	0.63	0.48	0.00	1.00	Bus stop in the village? 1 if yes and 0 if no
River	0.14	0.34	0.00	1.00	Is navigable river proximal to the village? 1 if yes and 0 if no
Food accessibility indices					
Distance	1.77	2.84	0.00	23.89	Average distance (km) to free market where residents go most often to buy grains, cooking oil, vegetables, fruits, meat (poultry, egg), fresh milk, preserved milk, fish and bean curd
Number	4.84	14.56	0.00	200.00	Number of food stores selling fruits and vegetables in the village
Village dummy variables	\	\	\	\	Dummy for each village
Year dummy variables	\	\	\	\	Dummy for each year

Note: Physical activity (CHNS records the physical activity based on occupation type: 1=very light physical activity, working in a sitting position like office worker or watch repairer; 2=light physical activity, working in a standing position such as sales person or teacher; 3=moderate physical activity like student or driver; 4=heavy physical activity such as farmer or dancer; and 5=very heavy physical activity such as loader, logger, or miner. We classify 1 and 2 as light activity, 3 as moderate activity, 4 and 5 as heavy activity).

Table 2.3 CFPS of rural Chinese residents 1997-2011

Group	1997	2000	2004	2006	2009	2011
No. obs.	1774	1750	1803	1886	2019	2489
Total people	2.524	2.529	2.650	2.866	2.977	3.044
Income groups						
Low income	2.255	2.374	2.489	2.673	2.834	2.832
Middle income	2.539	2.475	2.617	2.865	2.974	3.018
High income	2.778	2.738	2.844	3.058	3.124	3.282
Diversity of production						
No agricultural activity	2.669	2.712	2.847	3.078	3.144	3.194
Specialized farmers	2.410	2.399	2.486	2.712	2.805	2.963
Diversified farmers	2.533	2.496	2.645	2.808	3.035	2.799

Notes: 1. Low-, middle-, and high-income groups refer to the lowest, middle, and highest tertiles of income in each year.

2. No agricultural production refers to families not engaged in agricultural activity. Specialized and diversified farmers are engaged in one or two and more than two agricultural activities.

Table 2.4 Impact of food accessibility on CFPS

Models	OLS_cluster	IV_cluster	IV_FE	IV_RE
Distance	0.0424	-0.1330	-0.1721	-0.1330
	(6.99)***	(-2.21)**	(-2.24)**	(-2.77)***
Production diversity	0.0113	0.0193	0.0394	0.0193
	(0.67)	(1.04)	(1.53)	(1.32)
Individual characteristics				
Physical activity	-0.0458	-0.0488	-0.0488	-0.0488
	(-2.75)***	(-2.78)***	(-1.70)*	(-3.08)***
Education	0.0282	0.0281	0.0411	0.0281
	(1.66)*	(1.58)	(0.82)	(1.71)*
Age	0.0005	0.0009	0.0086	0.0009
	(0.48)	(0.82)	(0.11)	(0.85)
Male	-0.0788	-0.0749	-	-0.0749
	(-4.85)***	(-4.43)***	-	(-3.67)***
Family characteristics				
Ln(income)	0.0524	0.0602	0.0625	0.0602
	(4.06)***	(4.32)***	(3.15)***	(5.13)***
Hhsize	0.0276	0.0273	0.0059	0.0273
	(3.33)***	(3.20)***	(0.32)	(3.78)***
Child_ratio	0.2892	0.2926	0.3073	0.2926
	(4.26)***	(4.06)***	(2.60)***	(4.82)***
Old_ratio	0.0939	0.1472	-0.2214	0.1472
	(0.92)	(1.37)	(-0.99)	(1.57)
Refrigerator	0.0613	0.0852	0.0283	0.0852
	(1.91)*	(2.44)**	(0.58)	(3.06)***
Car	-0.0037	-0.0032	-0.0256	-0.0032
	(-0.07)	(-0.06)	(-0.32)	(-0.08)
Motorcycle	0.0390	0.0514	0.0233	0.0514
	(1.38)	(1.70)*	(0.55)	(2.12)**
Year dummy				
y2000	-0.0731	-0.0031	-0.0199	-0.0031
	(-1.81)*	(-0.06)	(-0.08)	(-0.07)
y2004	0.0248	0.1702	0.1246	0.1702
	(0.56)	(2.49)**	(0.22)	(3.09)***
y2006	0.1974	0.4256	0.4039	0.4256
	(4.46)***	(4.65)***	(0.57)	(5.80)***
y2009	0.2680	0.4724	0.4016	0.4724
	(5.59)***	(5.52)***	(0.42)	(6.86)***
y2011	0.2481	0.5691	0.5462	0.5691
	(4.90)***	(4.76)***	(0.50)	(5.85)***
Constant	2.0347	2.0404	1.8429	2.0404
	(3.91)***	(3.93)***	(0.67)	(7.03)***
Village dummy	Yes	Yes	No	Yes
Observations	11721	11721	11721	11721
F/Wald test	14.58***	13.96***	2817.05***	75745.71***
R^2	0.22	0.13		
Kleibergen-Paap underidentification test		94.56***		
Sargan statistic		0.81		
Endogeneity test of endogenous regressor		9.87***		

Notes: 1. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.
2. Value in brackets is t statistics.
3. Within variation is very small, and the fraction of variance due to u_i is close to 0, so that rho is almost 0 in the RE model.
4. Endogeneity test is robust to various violations of conditional homoscedasticity.

Table 2.5 Impact of food accessibility on the consumption of each food group

	Cereal, potato, and beans	Fruit	Vegetables	Eggs	Aquatic products	Meat and poultry	Legumes and nuts	Milk and its products	Oil	Salt
Distance	0.6657	0.6615	0.2039	0.0108	0.1867	0.1457	-0.1087	0.0133	-0.2150	0.6487
	(5.67)***	(5.53)***	(1.74)*	(0.09)	(1.66)*	(1.42)	(-0.95)	(0.11)	(-1.72)*	(4.83)***
Production diversity	0.0198	-0.0314	0.0649	0.0018	0.0131	-0.0358	0.0015	-0.0184	-0.0418	-0.0448
	(1.30)	(-2.02)**	(4.26)***	(0.11)	(0.89)	(-2.68)***	(0.10)	(-1.15)	(-2.57)**	(-2.57)**
Individual characteristics										
Physical activity	0.1153	-0.0076	0.0643	-0.0481	-0.0305	-0.0297	0.0105	-0.0186	-0.0157	0.0053
	(9.42)***	(-0.61)	(5.27)***	(-3.89)***	(-2.60)***	(-2.78)***	(0.88)	(-1.46)	(-1.20)	(0.38)
Education	-0.0183	0.0159	-0.0112	0.0066	0.0236	0.0337	0.0003	0.0111	0.0134	0.0099
	(-1.68)*	(1.44)	(-1.03)	(0.60)	(2.28)**	(3.55)***	(0.03)	(0.98)	(1.15)	(0.80)
Age	-0.0021	-0.0117	0.0365	0.0131	0.0116	-0.0196	0.0188	-0.0020	0.0132	-0.0041
	(-0.22)	(-1.17)	(3.74)***	(1.32)	(1.24)	(-2.29)**	(1.98)**	(-0.20)	(1.26)	(-0.36)
Male	0.1792	-0.0333	0.0679	0.0262	0.0438	0.0956	0.0494	-0.0126	0.0029	-0.0072
	(20.40)***	(-3.71)***	(7.75)***	(2.95)***	(5.21)***	(12.45)***	(5.78)***	(-1.37)	(0.31)	(-0.72)
Family characteristics										
Ln(income)	-0.0236	0.0040	0.0235	0.0534	0.0353	0.0959	0.0412	0.0196	0.0390	0.0152
	(-2.14)**	(0.35)	(2.13)**	(4.78)***	(3.34)***	(9.91)***	(3.83)***	(1.70)*	(3.31)***	(1.21)
Hhsize	-0.0082	0.0021	-0.0156	-0.0159	-0.0013	-0.0060	0.0089	-0.0200	-0.0541	-0.0310
	(-0.78)	(0.20)	(-1.49)	(-1.49)	(-0.13)	(-0.66)	(0.87)	(-1.82)*	(-4.82)***	(-2.57)**
Child_ratio	0.0386	0.0048	0.0032	-0.0081	0.0025	0.0091	-0.0159	0.0084	-0.0462	-0.0436
	(4.06)***	(0.49)	(0.34)	(-0.84)	(0.28)	(1.10)	(-1.72)*	(0.84)	(-4.56)***	(-4.02)***
Old_ratio	-0.0006	-0.0300	0.0035	0.0014	-0.0024	-0.0130	0.0045	0.0177	0.0038	-0.0128
	(-0.07)	(-3.13)***	(0.37)	(0.15)	(-0.27)	(-1.58)	(0.49)	(1.81)*	(0.38)	(-1.19)
Refrigerator	-0.0436	0.0043	-0.0063	0.0527	0.0139	0.1087	-0.0019	0.0068	0.0337	-0.0338
	(-3.63)***	(0.35)	(-0.53)	(4.36)***	(1.21)	(10.37)***	(-0.17)	(0.54)	(2.64)***	(-2.47)**
Car	-0.0039	0.0280	-0.0031	0.0028	0.0213	0.0457	0.0176	0.0219	0.0143	-0.0037
	(-0.41)	(2.89)***	(-0.32)	(0.29)	(2.34)**	(5.49)***	(1.90)*	(2.20)**	(1.41)	(-0.34)
Motorcycle	-0.0141	-0.0106	-0.0124	-0.0016	0.0236	0.0424	-0.0119	-0.0033	-0.0076	-0.0282
	(-1.41)	(-1.04)	(-1.25)	(-0.16)	(2.46)**	(4.84)***	(-1.22)	(-0.31)	(-0.71)	(-2.46)**
Year dummy										
y2000	-0.1091	-0.0394	-0.0313	0.0317	-0.0105	0.0479	0.1066	-0.0109	0.0421	-0.0431
	(-8.48)***	(-3.01)***	(-2.44)**	(2.44)**	(-0.85)	(4.26)***	(8.51)***	(-0.81)	(3.07)***	(-2.93)***
y2004	0.0052	-0.0738	0.0578	0.0100	-0.0060	0.0287	-0.1096	0.0178	0.0043	-0.1762

	(0.30)	(-4.23)***	(3.39)***	(0.58)	(-0.37)	(1.92)*	(-6.58)***	(1.00)	(0.24)	(-9.02)***
y2006	-0.0855	-0.0099	-0.0065	0.0858	-0.0050	0.0326	-0.0960	0.0440	0.0051	-0.2487
	(-3.69)***	(-0.42)	(-0.28)	(3.66)***	(-0.23)	(1.61)	(-4.25)***	(1.82)*	(0.21)	(-9.38)***
y2009	-0.0997	0.0086	-0.0186	0.0945	0.0126	0.0437	-0.0651	0.0147	0.0170	-0.2831
	(-4.45)***	(0.38)	(-0.83)	(4.18)***	(0.59)	(2.23)**	(-2.99)***	(0.63)	(0.71)	(-11.06)***
y2011	-0.0736	0.0877	-0.0612	0.0795	-0.0355	-0.0112	-0.0677	0.0193	0.0394	-0.3648
	(-2.15)**	(2.51)**	(-1.79)*	(2.30)**	(-1.08)	(-0.37)	(-2.03)**	(0.54)	(1.08)	(-9.32)***
Village dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
df_m	192	192	192	192	192	192	192	192	192	192
rmse	180.80	91.48	161.60	30.07	42.96	62.49	70.04	32.66	48.67	12.53
chi^2 test	4358.50***	2521.40***	2574.20***	2063.60***	3779.00***	6806.40***	3133.30***	1174.80***	926.90***	1084.60***
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.
2. Value in brackets is t statistics.

Table 2.6 Impact of food accessibility on the deviation of food consumption from CFPS

	Cereal, potato, and beans	Fruit	Vegetables	Eggs	Aquatic products	Meat and poultry	Legumes and nuts	Milk and its products	Oil	Salt
Distance	0.1593	-0.4975	0.1400	-0.0391	0.1188	0.1339	0.3920	-0.0609	0.2552	-0.1671
	(1.33)	(-4.02)***	(1.12)	(-0.31)	(0.97)	(1.06)	(2.98)***	(-0.48)	(2.01)**	(-1.35)
Production diversity	0.0371	0.0117	-0.0374	-0.0267	-0.0063	0.0184	-0.0113	-0.0092	-0.0244	0.0085
	(2.39)**	(0.73)	(-2.31)**	(-1.64)	(-0.39)	(1.12)	(-0.66)	(-0.56)	(-1.48)	(0.53)
Individual characteristics										
Physical activity	0.0811	0.0224	-0.0336	0.0434	0.0342	0.0079	0.0008	0.0041	-0.0248	-0.0323
	(6.52)***	(1.74)*	(-2.59)***	(3.31)***	(2.67)***	(0.60)	(0.06)	(0.31)	(-1.88)*	(-2.50)**
Education	0.0104	-0.0217	0.0046	0.0002	-0.0206	0.0324	-0.0077	-0.0126	-0.0073	-0.0236
	(0.94)	(-1.89)*	(0.40)	(0.01)	(-1.82)*	(2.77)***	(-0.63)	(-1.08)	(-0.62)	(-2.06)**
Age	-0.0135	0.0027	-0.0383	-0.0123	-0.0057	0.0035	0.0036	0.0147	0.0139	-0.0152
	(-1.36)	(0.26)	(-3.69)***	(-1.17)	(-0.56)	(0.34)	(0.32)	(1.40)	(1.32)	(-1.47)
Male	0.1025	0.0189	-0.0270	-0.0079	0.0055	0.0212	0.0282	0.0181	-0.0028	0.0123
	(11.49)***	(2.05)**	(-2.89)***	(-0.85)	(0.60)	(2.25)**	(2.87)***	(1.92)*	(-0.30)	(1.33)
Family characteristics										
Ln(income)	-0.0174	0.0045	-0.0210	-0.0053	-0.0275	-0.0189	-0.0078	0.0232	-0.0151	-0.0189
	(-1.55)	(0.38)	(-1.79)*	(-0.45)	(-2.38)**	(-1.59)	(-0.63)	(1.95)*	(-1.26)	(-1.62)
Hhsize	-0.0188	-0.0009	-0.0027	0.0160	-0.0051	-0.0409	-0.0187	-0.0208	-0.0215	-0.0017
	(-1.75)*	(-0.08)	(-0.24)	(1.42)	(-0.46)	(-3.61)***	(-1.59)	(-1.84)*	(-1.89)*	(-0.15)
Child_ratio	0.0080	0.0049	-0.0224	0.0020	-0.0250	-0.0050	-0.0032	0.0202	-0.0174	0.0450
	(0.82)	(0.49)	(-2.21)**	(0.20)	(-2.51)**	(-0.49)	(-0.30)	(1.98)**	(-1.69)*	(4.49)***
Old_ratio	-0.0124	0.0177	-0.0065	-0.0179	-0.0140	-0.0104	-0.0122	0.0442	-0.0266	0.0114
	(-1.30)	(1.78)*	(-0.65)	(-1.78)*	(-1.42)	(-1.02)	(-1.16)	(4.37)***	(-2.62)***	(1.14)
Refrigerator	-0.0218	-0.0016	-0.0147	-0.0221	-0.0380	-0.0124	-0.0455	-0.0167	-0.0132	-0.0052
	(-1.79)*	(-0.13)	(-1.16)	(-1.72)*	(-3.03)***	(-0.96)	(-3.39)***	(-1.30)	(-1.02)	(-0.41)
Car	0.0050	-0.0213	-0.0052	-0.0093	0.0041	0.0073	0.0162	0.0040	0.0266	-0.0066
	(0.51)	(-2.12)**	(-0.51)	(-0.91)	(0.41)	(0.71)	(1.52)	(0.39)	(2.59)***	(-0.66)
Motorcycle	-0.0009	0.0134	-0.0133	0.0055	0.0065	-0.0072	-0.0149	0.0046	-0.0055	0.0158
	(-0.09)	(1.27)	(-1.25)	(0.51)	(0.62)	(-0.67)	(-1.33)	(0.43)	(-0.51)	(1.49)
Year dummy										
y2000	-0.0675	0.0429	0.0536	-0.0161	-0.0045	0.0159	0.0319	-0.0106	-0.0331	-0.0423
	(-5.16)***	(3.16)***	(3.92)***	(-1.17)	(-0.34)	(1.15)	(2.22)**	(-0.76)	(-2.38)**	(-3.12)***
y2004	0.0014	0.0701	0.0088	-0.0104	-0.0072	-0.0066	0.0085	0.0071	-0.0435	0.0248
	(0.08)	(3.89)***	(0.48)	(-0.57)	(-0.40)	(-0.36)	(0.44)	(0.39)	(-2.35)**	(1.37)
y2006	-0.0157	0.0430	-0.0162	-0.0540	-0.0059	-0.0089	0.0060	0.0215	-0.0643	0.0615

	(-0.66)	(1.76)*	(-0.66)	(-2.17)**	(-0.24)	(-0.36)	(0.23)	(0.86)	(-2.56)**	(2.51)**
y2009	-0.0428	0.0009	-0.0081	-0.0437	-0.0154	-0.0112	-0.0158	0.0218	-0.0844	0.0985
	(-1.88)*	(0.04)	(-0.34)	(-1.82)*	(-0.66)	(-0.47)	(-0.63)	(0.90)	(-3.49)***	(4.17)***
y2011	-0.0153	-0.0237	0.0114	-0.0486	-0.0431	-0.0486	-0.0774	0.0421	-0.1146	0.0849
	(-0.44)	(-0.66)	(0.31)	(-1.33)	(-1.20)	(-1.32)	(-2.02)**	(1.15)	(-3.10)***	(2.35)**
Village dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
df_m	192	192	192	192	192	192	192	192	192	192
rmse	0.45	0.20	0.46	0.30	0.30	0.39	0.31	0.04	0.33	0.44
chi^2 test	1928.00***	1354.20***	854.90***	539.00***	1265.20***	600.60***	423.10***	479.70***	701.70***	1077.00***
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.
2. Value in brackets is t statistics.

Table 2.7 Heterogeneous impact of food accessibility on CFPS at different diversities of agricultural production

	Production diversity		
	No	Specialized	Diversified
Distance	-0.5002	-0.0430	-0.2281
	(-1.85)*	(-0.60)	(-1.17)
Individual characteristics			
Physical activity	-0.0702	-0.0387	-0.0264
	(-2.03)**	(-1.59)	(-0.68)
Education	0.0313	0.0042	0.0456
	(0.99)	(0.15)	(1.20)
Age	0.0019	0.0009	-0.0013
	(0.91)	(0.50)	(-0.62)
Male	-0.0970	-0.0998	0.0003
	(-3.34)***	(-3.92)***	(0.01)
Family characteristics			
Lnincome	0.0359	0.0828	0.0849
	(1.23)	(3.58)***	(2.28)**
Hhsize	0.0445	0.0205	0.0209
	(3.04)***	(1.48)	(1.22)
Child_ratio	0.1506	0.4057	0.2412
	(1.11)	(3.60)***	(1.59)
Old_ratio	0.0459	0.0008	0.5937
	(0.28)	0.00	(2.19)**
Refrigerator	0.2064	0.1018	-0.0862
	(3.35)***	(2.03)**	(-1.03)
Car	-0.0055	-0.0420	0.1809
	(-0.07)	(-0.47)	(0.93)
Motorcycle	0.0327	0.0456	0.0334
	(0.59)	(1.04)	(0.41)
Year dummy			
y2000	0.0422	0.0132	0.0100
	(0.40)	(0.16)	(0.09)
y2004	0.3011	0.0810	0.3485
	(1.99)**	(0.76)	(1.51)
y2006	0.6533	0.2998	0.5618
	(3.04)***	(2.13)**	(2.01)**
y2009	0.7035	0.3462	0.7088
	(3.33)***	(2.65)***	(2.39)**
y2011	0.7352	0.5010	0.7607
	(3.08)***	(2.59)***	(1.55)
Constant	2.8728	1.5361	2.3499
	(4.22)***	(3.63)***	(4.78)***
Village dummy	Yes	Yes	Yes

Obs	4147	4641	2933
F	50.07***	672.76***	60.60***
R^2	0.08	0.21	0.02
Kleibergen-Paap	40.49	46.92	12.22

Notes: 1. *, **, and *** indicate significance at 10%, 5%, and 1% levels respectively.
2. 'No', 'Specialized', and 'Diversified' refer to families who are not engaged, engaged in one or two agricultural activities, and engaged in more than two agricultural activities respectively.
3. Value in brackets is t statistics.

Table 2.8 Impact of food accessibility on CFPS by using the number of food vendors in the market to measure food accessibility

	Agricultural Specialization			
	IV	No	Specialized	Diversified
Number of food stores	0.0190	0.0150	0.0048	0.0010
	(1.88)*	(1.89)*	-0.2400	-0.0200
Agricultural activity	-0.0012			
	(-0.06)			
Individual characteristics				
Physical activity	-0.0473	-0.0854	-0.0351	-0.0299
	(-2.37)**	(-2.32)**	(-1.39)	(-0.71)
Education	0.0313	0.0369	-0.0134	0.0771
	-1.5000	-1.0200	(-0.48)	(1.84)*
Age	0.0015	0.0028	-0.0005	0.0021
	-1.1000	-1.1900	(-0.27)	-0.7500
Male	-0.1050	-0.1012	-0.1211	-0.0654
	(-5.14)***	(-2.95)***	(-3.38)***	(-1.25)
Family characteristics				
Lnincome	0.0425	-0.0180	0.0938	0.1261
	(2.52)**	(-0.75)	(4.17)***	(3.21)***
Hhsize	0.0254	0.0504	0.0246	0.0136
	(2.30)**	(2.82)***	(1.79)*	-0.7700
Child_ratio	0.3259	0.3261	0.3120	0.4781
	(3.64)***	(2.07)**	(2.76)***	(2.81)***
Old_ratio	0.0654	-0.0221	-0.0319	0.3915
	-0.5000	(-0.11)	(-0.18)	-1.5600
Refrigerator	0.0457	0.1353	0.0721	-0.0900
	-1.1800	(1.84)*	(1.65)*	(-0.96)
Car	0.0333	0.0576	-0.0080	0.0341
	-0.5600	-0.7000	(-0.11)	-0.2600
Motorcycle	0.0559	0.0357	0.0129	0.1023
	(1.65)*	-0.6000	-0.3300	(1.68)*
Year dummy				
y2006	0.2627	0.3908	0.1892	0.1374
	(4.67)***	(3.71)***	(3.57)***	-1.5300
y2009	0.3247	0.4202	0.2457	0.2545
	(5.73)***	(4.32)***	(4.47)***	(1.94)*
y2011	0.2920	0.3222	0.3462	0.0702
	(5.85)***	(3.73)***	(6.04)***	-0.5400
Constant	2.1332	2.4858	1.6409	2.2590
	(4.07)***	(4.30)***	(4.19)***	(3.05)***
Village dummy	Yes	Yes	Yes	Yes
Observations	8197	3145	3406	1646
F	9.97***	112.44***	6.81***	3.93***

R^2	0.16	0.16	0.24	0.23
Kleibergen-Paap	23.75***	13.89***	56.70***	8.50**

Notes: 1. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.
2. 'No', 'Specialized', and 'Diversified' refer to families not engaged, engaged in one or two agricultural activities, and engaged in more than two agricultural activities, respectively.
3. Value in brackets is t statistics.

Chapter 3 The Impact of Dietary Knowledge on the Diet Pattern of Chinese Adults[4]

3.1 Introduction

The co-existence of under- and over-nutrition and the increasing prevalence of obesity have gained widespread attention in China (Huang et al., 2017; Tian et al., 2017; Huang and Tian, 2019). The latest findings from the Chinese Residents Nutrition and Chronic Disease Status Report (2020)[5] show that unhealthy lifestyles are still common in China and more than 50% of Chinese adults are overweight or obese. The report reveals that the share of energy drawn from fat continues to rise, and surpasses the recommended upper limit (30%) in rural areas for the first time. In addition, per capita daily intake of oil and salt is still more than the recommended value. Generally, consuming more energy-dense foods which contain considerable amounts of sugar and saturated fats drives people to gain weight, particularly for those who have low physical activity (Qin and Pan, 2016). The prevalence of obesity can be reduced by achieving a balanced diet (Shimokawa, 2013). To guide people to form a balanced and healthy diet, National Health and Family Planning Commission of the People's Republic of China (NHFPC) published the Chinese Dietary Guidelines (CDG) 2016 and the China Food Pagoda (CFP) 2016, which were constructed according to basic nutrition demands and health conditions. Moreover, the Chinese government has been promoting the healthy diet pattern by releasing an outline for the 'Healthy China 2030' initiative[6]. The action plan points out that comprehensively popularizing dietary nutrition knowledge plays an important role in the process of forming scientific dietary habits and healthy diet

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[5]Source: From the official website of The Central People's Government of the People's Republic of China: http://www.gov.cn/xinwen/2020-12/24/content_5572983.htm
[6]Source: china_2018_annex-8_healthy_china_2030_strategy_2015.pdf (in Chinese), https://untobaccocontrol.org/impldb/wp-content/uploads/china_2018_annex-8_healthy_china_2030_strategy_2015.pdf

patterns.

Previous research has demonstrated that unhealthy eating habits and poor health outcomes can be caused by the low level of dietary knowledge (Asakura et al., 2017; Sun et al., 2021). Scientific dietary knowledge can shape healthy diet patterns and influence health outcomes (Block, 2004; Variyam, 2008; Shimokawa, 2013). Most importantly, improving the general public's level of dietary knowledge may reduce the prevalence of obesity and diet-related chronic diseases (Clement and Bonnefond, 2015).

Several studies have shown that Chinese residents' diet knowledge has improved in recent years (Zhou et al., 2017; Min et al., 2020), but the deviation of their diet patterns from CFP 2016 still exists and dietary quality is still poor (Huang et al., 2017; Huang and Tian, 2019). Preference for and increasing accessibility of unhealthy food could be reasons for the coexistence of improving diet knowledge and poor diet quality. Even though diet knowledge makes a big difference, it could be difficult for many residents to achieve a balanced diet pattern, because the affective evaluation of a food and food choices can be determined by food preference (Drewnowski, 1997; Mela, 2001). From this point of view, residents who prefer the taste of healthy food may consume healthy food such as vegetables and fruits frequently (Drewnowski et al., 2000). On the other hand, Beck et al. (2015) has found that preference for less healthy food could meddle in the adoption of healthy eating. Even though the association between preference for specific food and consumption of certain food has been confirmed (Drewnowski et al., 2000; Raynor et al., 2004; Beck et al., 2015; Pinho et al., 2018), whether the promoting effect of dietary knowledge on diet quality is mediated by the preference for unhealthy food in China has not been explored. In addition, food accessibility also plays a central role in the dietary quality of consumers. In particular, people who live in low-income neighborhoods are more likely to have poor access to healthy and diversified food, and rural residents who have low self-production are more vulnerable to food market fluctuations (Sibhatu et al., 2015; Koppmair et al., 2017; Huang and Tian, 2019). Unfortunately, current literature on the impact of dietary knowledge on diet outcomes does not include the availability of unhealthy food in the analytical framework. However, whether dietary knowledge can

be transformed into healthy food choices is often affected by the social environment where residents live (Min et al., 2021). Therefore, we incorporate an interaction term between unhealthy food accessibility and dietary knowledge into the regression model to further investigate how dietary knowledge influences the diet pattern.

The purpose of this paper is to investigate the influence of dietary knowledge on diet quality, which is measured by deviation of the real dietary pattern from the recommended dietary pattern in CDG 2016 and CFP 2016 among Chinese adults. Moreover, the mediating effect of preference for unhealthy food is examined, and the indirect effect and direct effect of dietary knowledge on diet quality are both tested and estimated. We further explore whether the availability of unhealthy food could interfere with the effect of dietary knowledge. Additionally, we study whether effects of dietary knowledge, unhealthy food preference and accessibility on diet quality vary among different subgroups of the population. Our research findings may provide new insights on the aspect of effective policies to promote healthy eating and reduce the prevalence of obesity in China.

The remaining sections of this paper are organized as follows. The second section presents a brief review of current literature and conducts a conceptual framework. Section three introduces the data. The fourth section describes the estimation strategy. Results and discussions are reported in section five. Section six concludes and gives policy implications.

3.2 Literature Review and Conceptual Framework

3.2.1 Literature Review

It has been confirmed that a high level of dietary knowledge could contribute to good diet outcomes (Shimokawa, 2013). Consumers employ nutrition knowledge to choose food products to some extent (Block, 2004), and thus diet outcomes are affected (Gould and Lin, 1994). The higher level of dietary knowledge significantly increases individuals' consumption of healthy food, such as fruit and vegetables, which further contributes to better health (Spillmann and Siegrist, 2010; Hsiao et al., 2020; Yang et

al., 2020). One study has found that nutrition knowledge would significantly improve the adherence to a Mediterranean dietary pattern (Bonaccio et al., 2013). In addition, Shimokawa (2013) has found heterogeneous impacts of dietary knowledge on diet for different Chinese people. In particular, dietary knowledge can significantly decrease the quantity of diet for overweight adults at the time food availability is increasing; but it influences primarily the quality of diet for non-overweight adults when food availability declines. Moreover, bad eating habits caused by poor dietary knowledge significantly affect the prevalence of obesity and diet-related diseases (Bonaccio et al., 2013; Popkin and Hawkes, 2016; Sun et al., 2021).

At the same time, preference is an essential driver of food consumption (Divert et al., 2017). Food preference has a significant effect on the composition of food demand and diet quality for both rural and urban households in a rapidly growing economy (Paul, 2011). For example, several studies have shown that alcohol preference could lead to increasing alcohol intake which is associated with low consumption of dairy products, fruit and vegetables, and thus worsens diet quality (McCann et al., 2003; Sluik et al., 2016). However, some studies have also proved that the preference for wine shows a strong relation with healthier dietary patterns in Western countries (Barefoot et al., 2002; Forshee and Storey, 2006). Additionally, previous studies have found a significantly positive association between the taste preference and food consumption (Biloukha and Utermohlen, 2000; Divert et al., 2017). A greater liking for food containing high fat could bring a higher intake of dietary fat (Raynor et al., 2004), and the preference for food high in salt is confirmed to be connected with lower diet quality (Carbonneau et al., 2021).

Previous studies recognize that individual characteristics and other relevant factors should also be considered when we investigate the effect of dietary knowledge on diet status. For example, income not only influences consumers' dietary patterns (Huang and Tian, 2019), but also plays an important role in the process of transforming dietary knowledge into actions (Sekabira and Qaim, 2017; Ren et al., 2019). People with high income may have more access to high quality food, while low-income residents are less likely to adjust their dietary patterns due to budget constraints and poor availability of

healthy food, even if they acquire reasonable nutrition knowledge. A large body of studies have proved that individual characteristics can affect residents' dietary patterns (e.g. Petrovici and Ritson, 2006; Huang et al., 2017; Tian et al., 2017; Huang and Tian, 2019; Mader et al., 2020). Additionally, individual food preference and eating habits can be changed by families or friends (Yakusheva et al., 2014; Sun et al., 2021). Furthermore, some studies have demonstrated that food accessibility plays a central role in influencing consumers' dietary patterns and nutrition status (Huang and Tian, 2019).

3.2.2 Conceptual Framework

Recent literature has already found evidence that dietary knowledge and food preference have leading roles in residents' diet quality (Shimokawa, 2013; Wang et al., 2019; Sun et al., 2021). However, no empirical studies investigate how dietary knowledge and unhealthy food preference influence Chinese real diet patterns to adhere to CFP 2016, and whether the availability of unhealthy food inhibits dietary knowledge from improving diet quality. To fill in the gap in current literature, we test whether the impact of diet knowledge on diet quality is mediated by unhealthy food preference. Moreover, this study incorporates the interaction term between dietary knowledge and unhealthy food accessibility into the food consumption framework.

Thus, food consumption behavior could be expressed as:

$$\mathrm{y} = f\left(P, K, Z\right) \tag{3.1}$$

Where y, P and K denote dietary outcome, preference, and dietary knowledge index, respectively. Z is a vector of exogenous variables. Clearly, P is a function of K as dietary knowledge could affect preference.

Take total difference in both sides of Equation 3.1, we have

$$\mathrm{dy}/dK = \partial \mathrm{y} / \partial K + \left(\partial \mathrm{y} / \partial P\right) \cdot \left(\partial P / \partial K\right) \tag{3.2}$$

Equation 3.2 shows that there are two channels that dietary knowledge could affect dietary outcomes: a direct channel $\frac{\partial \mathrm{y}}{\partial K}$, and an indirect channel through changing food

preferences $\frac{\partial y}{\partial P} \cdot \frac{\partial P}{\partial K}$ (it mainly reduces unhealthy food consumption). The conceptual framework can be depicted in Figure 3.1.

[Insert Figure 3.1]

From an empirical perspective, we hypothesize that a high level of dietary knowledge will alleviate the deviation between residents' real food consumption and the recommended dietary pattern. After separating samples into two groups with different dietary knowledge, we find that consumers with more dietary knowledge are less likely to prefer unhealthy food. We thus hypothesize that unhealthy food preference may mediate the relationship between diet knowledge and diet quality.

Furthermore, the influence of dietary knowledge on diet quality may be weakened by the availability of unhealthy food. When the availability of unhealthy food increases, residents' motivation to transform dietary knowledge into healthy eating behaviors will be weakened, thus leading to a smaller effect of dietary knowledge on improving diet quality.

3.3 Data Description

3.3.1 Samples

The China Health and Nutrition Survey (CHNS) is an ongoing survey jointly conducted by two institutions (The National Institute of Nutrition and Food Safety at China Centers for Disease Control and Prevention and the Carolina Population Center, University of North Carolina at Chapel Hill). The survey employs a multi-stage and random cluster strategy to pick samples which can represent most Chinese populations. The CHNS records detailed consumption of above 1500 food items consumed at home and away from home during a period of three consecutive days. Zhang et al. (2014) presents more detailed information about the CHNS.

CHNS started to collect information on dietary knowledge among residents aged over 12 since 2004. We thus employ the recent four waves of dataset (2004, 2006, 2009 and 2011) in this study. We only focus on adults aged from 20 to 59 since the CFP 2016

is built mainly for healthy adults. Therefore, we delete individuals who are pregnant, breastfeeding, or ill during the survey period. In addition, individuals with a total daily calorie intake less than 520 or greater than 8000 kcal are also removed to reduce measurement error (Tian and Yu, 2015). The final dataset includes 12183 adults aged from 20 to 59. Characteristics of relevant variables are presented in Table 3.1.

[Insert Table 3.1]

3.3.2 Chinese Food Pagoda Score

We use the Chinese Food Pagoda Score (CFPS) as the dependent variable. CFPS is an indicator measuring the deviation between the real dietary pattern and the recommended dietary pattern in CDG 2016 and CFP 2016, which is employed to proxy diet quality in this study. The calculation method of CFPS is the same as that in the study of Huang and Tian (2019), and detailed assignment methods of various foods in CFP 2016 are shown in Table A1. By summing up scores of ten food groups, the CFPS is calculated for each individual. According to the method of calculating CFPS, it ranges from 0 to 10. A greater CFPS indicates that an individual has a more balanced diet converging to the CDG 2016 and CFP 2016.

3.3.3 Dietary Knowledge, Unhealthy Food Preference and the Interaction Term between Dietary Knowledge and Unhealthy Food Accessibility

Dietary knowledge, unhealthy food preference and the interaction term between dietary knowledge and unhealthy food accessibility are three main explanatory variables of interest in our study.

First, the dietary knowledge index (DKI), a summary index generated from all twelve diet-related questions in the CHNS (see Table A2), is used to measure the level of dietary knowledge. DKI has been widely adopted by scholars (e.g. Shimokawa, 2013; Ren et al., 2019; Min et al., 2021; Sun et al., 2021). Individual awareness about each statement is measured by a 5-point Likert scale (1=strongly disagree, 2=somewhat disagree, 3=be neutral, 4=somewhat agree, 5=strongly agree) with an additional choice

(9=unknown). We further classify the statements into 'true' and 'false' according to the WHO criteria (1995): if the statement is 'true', we will record '1' point for options of 'somewhat agree' or 'strongly agree' for an individual, and '-1' point represents answers of 'somewhat disagree' or 'strongly disagree', and '0' point is given for other answers; for 'false' statements, respondents receive '1' point for options of 'somewhat disagree' or 'strongly disagree', and '-1' point means that respondents choose 'somewhat agree' or 'strongly agree', and '0' point represents other answers. Finally, we compute dietary knowledge score as DKI by summing up scores for 12 items. The final DKI index ranges from -12 to 12, and a larger number means a higher level of dietary knowledge. Figure 3.2 reports the annual mean value of DKI and we find a rising trend over years. Especially, the average DKI of residents went up significantly between 2004 and 2006, but it increased slowly from 2006 to 2011.

[Insert Figure 3.2]

Second, we employ the score of unhealthy food preference as the indicator to capture the level of preference for unhealthy food, and name the variable as 'preference'. CHNS employs five questions to record preference for fast food, salty snack foods, fruit, vegetables, soft drinks and sugared fruit drinks (see Table A3). Respondents can only choose one answer among 'like very much, like, be neutral, dislike, dislike very much and does not eat this food'. We divide food items into 'healthy' and 'unhealthy' according to the study of Min et al. (2021): for each respondent, we assign '-1' point for liking very much or liking healthy food, and for disliking very much or disliking unhealthy food; '1' point is assigned for liking very much or liking unhealthy food, and for disliking very much or disliking healthy food; '0' point is assigned for other answers. Then we compute the summary index of these responses, with a higher score meaning stronger preference for unhealthy food. According to the right panel of Figure 3.2, Chinese adults' preference for unhealthy food decreased continuously from 2004 to 2011, which might be attributable to the increasing level of dietary knowledge over years.

Third, to judge the availability of unhealthy food, we calculate the sum of numbers of fast food restaurants, the bars or shops selling alcoholic beverages and ice-cream

parlors in the community where the respondent lives, and take the logarithm of the total number and name it ‘unhealthy food’. The ‘Unhealthy*DKI’ variable is the interaction term between dietary knowledge and the availability of unhealthy food.

3.3.4 Other Potential Control Variables

The current studies have highlighted that many other variables such as social demographic characteristics and geographical distribution also affect the diet pattern (Shimokawa, 2013; Huang and Tian, 2019; Sun et al., 2021). Therefore, we also control the following potential variables in the empirical models. Table 3.1 presents descriptive statistics and definitions of all potential variables used in this paper. First, individual and family characteristics (physical activity; education; age group; gender; smoke; income; family size; demographic ratios of children and elderly people) are controlled to explain individual and household heterogeneity. In addition, individual characteristics of the householder (physical activity; education; age group; gender) and the food decision maker (physical activity; education; age group) are also included in regression models. Furthermore, yearly and regional (north or south) dummy variables are also controlled in this study. Finally, the urbanization index is employed to measure the level of development, which embraces various community characteristics for all communities in all survey waves (Xu et al., 2015).

3.4 Empirical Strategy

3.4.1 Basic Econometric Model

The dataset we used in this study is strongly unbalanced (there are 12183 individuals in our dataset, but only 92 individuals have been surveyed in all four waves, and more than 45 percent of individuals have only been surveyed in one wave). In this case, the fixed-effect model is not employed in the empirical analysis as it only uses the within variation in estimation. Therefore, the random effects model is adopted as the main estimation strategy and pooled OLS model is employed in robustness tests.

According to the conceptual framework, unhealthy food preference could mediate the effect of dietary knowledge on diet quality. A conventional three-step approach proposed by Baron and Kenny (1986) is used as the benchmark approach to testing whether the indirect (mediated) effect of unhealthy food preference on diet quality exists. Sobel-Goodman mediation test is a direct approach to estimate the indirect effect directly (Zhao et al., 2010), which is employed as a supplement in this study. We use the 'sgmediation' command in Stata 15 to detect the mediated effect. Thus, we build the following models to evaluate the mediating mechanism:

$$CFPS_{it} = \alpha_0 + \alpha_1 DKI_{it} + M\delta_1 + \mu_{1i} + \varepsilon_{1it} \quad 3.3$$

$$Preference_{\mathrm{it}} = \mathrm{c}_0 + c_1 DKI_{it} + M\delta_2 + \mu_{2i} + \varepsilon_{2it} \quad 3.4$$

$$CFPS_{it} = \gamma_0 + \gamma_1 DKI_{it} + \gamma_2 Preference_{\mathrm{it}} + M\delta_3 + \mu_{3i} + \varepsilon_{3it} \quad 3.5$$

Equation 3.3 indicates the total effect of dietary knowledge on diet quality. Equation 3.4 illustrates the mediating mechanism, where the coefficient c_1 of DKI_{it} indicates the impact of dietary knowledge on the mediator (unhealthy food preference). In Equation 3.5, the coefficient γ_1 of DKI_{it} is the direct effect of dietary knowledge on diet quality and the coefficient γ_2 of $Preference_{\mathrm{it}}$ indicates the impact of unhealthy food preference on diet quality. The existence of mediation effect depends on the magnitude and significance of three coefficients α_1 (in Equation 3.3), c_1 (in Equation 3.4) and γ_2 (in Equation 3.5). We can further decompose the total effect into direct effect and indirect effect using the decision tree proposed by Zhao et al. (2010).

Moreover, we incorporate accessibility of unhealthy food into Equation 3.5 to explore whether it could moderate the effect of dietary knowledge on diet quality. The model is as follows:

Equation 3.6:

$$CFPS_{it} = \omega_0 + \omega_1 DKI_{\mathrm{it}} + \omega_2 Preference_{it} + \omega_3 Unhealthy\ food_{it} + \omega_4 \left(Unhealth \times DKI\right)_{\mathrm{it}} + M\delta_4 + \mu_{4i} + \varepsilon_{4it}$$

For Equation 3.3-3.6, $CFPS_{it}$ is a score of the diet pattern of individual i at year t;

DKI_{it} refers to dietary knowledge of individual i in year t; $Preference_{it}$ is used to measure the preference for unhealthy food for individual i at year t; $Unhealthy\ food_{it}$ represents the availability of unhealthy food for individual i at year t; $Unhealth \times DKI$ is the interaction term between dietary knowledge and unhealthy food accessibility. M refers to a vector of other potential control variables. Finally, μ_{1i}-μ_{4i} refer to unobserved individual effects. If the unobserved individual effect is ignorable in our dataset, the static panel data models reduce to pooled cross-sectional data and we can employ the OLS to estimate models.

3.4.2 Machine Learning for Variable Selection

Least absolute shrinkage and selection operator (Lasso) was invented by Tibshirani (1996) and nowadays has been employed to build models for prediction or to select control variables (Buhlmann and Van De Geer, 2011; Hastie et al., 2015). When Lasso omits a potential covariate, it means that this covariate does not belong in the model or belongs but is correlated with selected covariates. Additionally, Lasso could avoid the danger of overfitting to some extent, particularly in the case of high-dimension data. Considering that there are many covariates potentially affecting the outcome in M vector, we do not know which variables should be correctly controlled for this research. Therefore, we use Lasso to select covariates from the M vector. When Lasso omits a potential covariate, it means that this covariate does not belong in the model or belongs but is correlated with selected covariates.

For the linear regression model: $y = X\beta + \varepsilon$, Lasso finds a solution obtained by minimizing the following estimator:

$$J = \frac{1}{2N}\left(y - X\beta'\right)'\left(y - X\beta'\right) + \lambda\sum_{j=1}^{p}\left|\beta_{\mathrm{j}}\right| \qquad 3.7$$

For Equation 3.7, $\left(y - X\beta'\right)'\left(y - X\beta'\right)$ is the in-sample prediction error and it is the same as the value minimized by OLS. N is the number of samples. $\lambda\sum_{j=1}^{p}\left|\beta_{\mathrm{j}}\right|$ is a

penalty and causes Lasso to omit variables. λ is the tuning parameter and it controls the intensity of the penalty. The larger the λ, the more variables are omitted, so the model will gradually become simple and efficient from complex and inefficient (λ = 0 would set the penalty to zero and corresponds to a model with maximum complexity). However, finding a suitable value of λ can make the model more reasonable. In Stata 16, Lasso provides three methods of confirming the value of λ: cross-validation (CV), adaptive Lasso and a plugin estimator.

CV is widely adopted if the goal of one study is prediction. Additionally, adaptive Lasso and a plugin estimator tend to select few covariates than CV, which may omit more covariates in this paper. Therefore, we use 10-fold CV to select a reasonable λ. The whole sample is randomly divided into ten folds. One fold is chosen, and then a linear regression is fit based on the other nine folds according to the variables in the model for that λ. Then, the prediction is calculated for the chosen fold using these new coefficient estimators and the mean squared error (MSE) of the prediction is calculated. Lasso will repeat the process for the other nine folds. Finally, 10 MSEs are averaged to compute the value of the CV function (mean prediction error). A reasonable λ is acquired when the minimum of the CV function is found, and now we can know the covariates selected by Lasso.

3.5 Results Discussion

In this section, we first compare observed dietary outcomes with dietary guidelines in China. Furthermore, we demonstrate how diet quality is influenced by dietary knowledge. Then the heterogeneity of these effects among different groups is analyzed. Lastly, we conduct the robustness test.

3.5.1 Dietary Outcomes of Chinese Adults

CHNS has calculated the total intake of three macronutrients (carbohydrate, fat and protein) and energy for every individual. We estimate the share of energy drawn from three macronutrients and present results in Figure 3.3.

[Insert Figure 3.3]

Figure 3.3 shows that the share of energy supplied by carbohydrate kept declining from 2004 to 2011, while both fat and protein contributed to an increasing share in total energy over years. In contrast with the standards in the Chinese dietary reference intake-Part 1: Macronutrient[7], the proportion of energy provided by carbohydrate was always within the reasonable range and was approaching the low bound of 50% in 2011, while the proportion of energy from fat increased continuously and jumped above the recommended upper limit since 2009. Furthermore, the proportion of energy supplied by protein located within the recommendation range during the whole period and increased slowly over time. These findings reflect the rapid undergoing nutrition transition in China as shown in previous studies (Tian and Yu, 2015; Zhou et al., 2017; Huang et al., 2017).

We also calculate ratios of residents whose macronutrients meet the standards or not in Table 3.2. Although the average proportion of energy from carbohydrate and protein located within the recommended values for Chinese adults, there was still a large proportion of the population whose ratios of energy supplied by carbohydrate, fat, and protein were not within the recommended ranges. In particular, more than 2/3 of Chinese adults did not have a reasonable consumption of fat, of which 59.22% ate too much fat and 12.50% ate too less fat in 2011.

[Insert Table 3.2]

Moreover, Table 3.3 summarizes the means of CFPS among different groups in each year. Our data shows that CFPS underwent a continual increase for almost all groups over years, indicating that the diet pattern became more and more balanced in China. Moreover, dietary quality varied among different groups. Specifically, we observe that females had a higher diet quality compared with males; residents with higher education or more income had more balanced diet than less-educated or poor

[7]Source: the Chinese dietary reference intake-Part 1: Macronutrient (in Chinese), http://www.nhc.gov.cn/wjw/yingyang/201710/fdade20feb8144ba921b412944ffb779/files/0fa10dfb812a48b483d931972df1ccb8.pdf

people; residents tended to have a higher CFPS if they lived in the community with a higher level of urbanization.

[Insert Table 3.3]

3.5.2 The Impact of Dietary Knowledge on Diet Patterns and the Mediated Effect

We first select covariates of the M vector for Equation 3.5 using Lasso. The left part in Figure 3.4 shows the reasonable λ is 0.0037 and 16 variables are finally added in Equation 3.5 (Equations 3.3 and 3.4 use the same control variables as Equation 3.5). Moreover, Table 3.4 lists the selected variables.

[Insert Figure 3.4 and Table 3.4]

After confirming control variables, we then estimate Equations 3.3, 3.4 and 3.5 using the random effects regression to explore the impact of dietary knowledge on Chinese adults' dietary patterns and test the mediation effect of unhealthy food preference. Results are presented in Table 3.5. Model 1 and 3 indicate that dietary knowledge significantly contributes to the improvement in diet quality. Our results imply that the higher level of dietary knowledge residents have, the more balanced their diet patterns are. This may be explained by more consumption of fruit and milk and less consumption of grains, potatoes and beans for residents with better dietary knowledge (see Table A4).

[Insert Table 3.5]

We also find that unhealthy food preference has a significantly negative effect on diet quality (in model 3). Residents preferring unhealthy food may consume more food that has been over-consumed, but less fruit and milk which are under-consumed in daily life, thus leading to a more unbalanced diet (see Table A4).

In model 3, the coefficient of dietary knowledge is positive and significant. Thus, dietary knowledge has a direct effect on diet quality, as expected. Model 1 shows dietary knowledge has the total effect on diet patterns, and in model 2, the effect of dietary knowledge on unhealthy food preference is negative and significant, while the effect of unhealthy food preference on diet patterns is negative and significant in model 3,

supporting the hypothesis that unhealthy food preference mediates the relationship between dietary knowledge and diet quality according to the three-step approach to test whether the indirect effect exists. The absolute value of coefficient of dietary knowledge slightly decreases from 0.017 (in model 1) to 0.016 (in model 3), while two coefficients are both statistically significant.

Moreover, the p value of the Sobel-Goodman mediation test is less than 0.05, so the null hypothesis is rejected, indicating the existence of mediating effect. The proportion of the total effect of dietary knowledge on diet quality mediated by unhealthy food preference is 6.22%, indicating direct impact plays the main role. Table 3.6 shows three effects in the Sobel-Goodman mediation test. The conclusion is consistent with findings of the three-step approach above, which confirm that the mediating effect of unhealthy food preference on diet quality exists.

[Insert Table 3.6]

3.5.3 The Impact of Dietary Knowledge on Diet Quality Moderated by Unhealthy Food Accessibility

Similarly, we use Lasso to select covariates of the M vector for Equation 3.6. The right part in Figure 3.4 shows the reasonable λ is 0.0033 and the number of variables that Equation 3.6 should control is 18. Additionally, we list the selected variables in Table 3.7.

[Insert Table 3.7]

Then, we employ the random effects regression to estimate Equation 3.6 and study whether unhealthy food accessibility could moderate the influence of dietary knowledge on the dietary balance. Table 3.8 shows the estimation results. We find that the estimated coefficient of interaction term between dietary knowledge and unhealthy food accessibility in model 4 is -0.007, which is statistically significant at the 1% level. This confirms that there exists a significant interaction effect between dietary knowledge and unhealthy food accessibility, and that the marginal effect of dietary knowledge on the diet pattern diminishes along with the increasing availability of

unhealthy food. The result is in line with our expectation. The explanation might be that increasing availability of unhealthy food will induce residents to consume more unhealthy food, which impedes the translation of dietary knowledge into healthier food choices, especially when residents have greater preference for unhealthy food (see the last four columns of Table 3.8: the coefficient of interaction term is statistically significant only for residents with more preference for unhealthy food).

[Insert Table 3.8]

Additionally, the marginal effect of DKI on CFPS is very small (in Table 3.8: 0.027), which could be attributable to the small variation of CFPS in our sample. From 2004 to 2011, CFPS only increased by 0.502, while DKI increased by 5.630, so about 30% (5.630*0.027/0.502≈30%) of the increase in CFPS is due to the improvement of DKI. Therefore, we can conclude that DKI has a big impact on CFPS and our finding indicates that dietary knowledge plays an important role in the improvement of diet quality.

Other variables such as socio-economic characteristics of respondents and cooks also significantly affect the diet pattern whatever unhealthy food accessibility is included in the analysis. Table 3.8 shows that the coefficient of physical activity is negative and statistically significant. There are two possible reasons: first, residents with lower physical activity are more likely to be well-educated, and thus, they might learn more about nutrition knowledge (Tian et al., 2017); in addition, the work with lower physical activity does not require high-calorie density food like cereal and potatoes (He et al., 2016). Moreover, compared with women, men have less balanced diet pattern because males usually prefer more high-fat-density food such as meat. Smoking is found to reduce diet quality. Further, people living in affluent households are more likely to adhere to the CFP 2016, and thus have higher diet quality. This finding is consistent with the result detected by Huang and Tian (2019), who claim that higher income earners are less likely to be under strong budget constraints (Sekabira and Qaim, 2017; Ren et al., 2019), and thus are capable of buying healthy food which is usually more expensive (Huang and Tian, 2019). Another important finding is that a well-educated family meal provider contributes significantly to diet quality

improvement. Tian and Yu (2015) also demonstrate that family members' nutritional status is related to the characteristics of the individual preparing meals. Finally, we also observe the significant regional difference in CFPS in China as follows: first, southern Chinese have higher diet quality than their counterparts living in northern China; second, residents who live in the community with a higher level of urbanization have more balanced diet. These regional heterogeneities may be attributable to the higher availability of healthy food in southern and highly urbanized areas (Drewnowski et al., 2007; Liu et al., 2014).

3.5.4 Heterogeneity Analysis

Previous studies have found that the transformation from knowledge and preference to food choice is also affected by individual characteristics (Xu et al., 2020; Sun et al., 2021), thus the impacts of dietary knowledge, unhealthy food preference and availability on diet quality may vary in different cohorts. In order to test the existence of heterogeneous impacts, we estimate Equation 3.6 using the random effects regression for several subsamples which are defined by gender, income, and education attainment. Results are presented in Table 3.9. The main findings can be summarized as follows.

[Insert Table 3.9]

First, the influence of dietary knowledge on diet quality is slightly bigger for male groups than that for female groups, while the effect of the interaction term between dietary knowledge and unhealthy food availability is almost the same in two groups. Additionally, the impact of unhealthy food preference is just significantly negative for male groups.

Second, dietary knowledge has a stronger effect on the improvement in diet quality for poor residents. In addition, the impact of unhealthy food preference is not statistically significant in the low-income group, but is significantly negative for the high-income group. Moreover, availability of unhealthy food can only affect poor people's diet quality.

Third, dietary knowledge contributes to better diet quality for both poor- and well-educated groups, and the impact is slightly bigger for residents with low education, but preference for unhealthy food can only deteriorate diet quality for poorly educated people. Furthermore, the impact of dietary knowledge on diet quality is moderated by availability of unhealthy food only for poor people and people with low education.

3.5.5 Robustness Check

3.5.5.1 OLS Regression Model

To test the robustness of our results, we re-estimate Equations 3.5 and 3.6 by pooled OLS. Results are presented in Table 3.10. As we can see, the main results are also almost the same as those estimated by the random effects regression, indicating that our results are robust.

[Insert Table 3.10]

3.5.5.2 Changing the Sample

Residents who are overweight or obese may care more about dietary knowledge and eating habits, and thus the impact of dietary knowledge on diet quality may be stronger among them than among other people. Therefore, we separate individuals into two groups (adults with normal body weight and adults that are affected by overweight or obesity) to conduct the further robustness check. The definition of overweight or obesity is based on body mass index (BMI), which is computed by dividing the weight (kg) by the square of the height (m^2) of each respondent. According to the criteria recommended by the Working Group on Obesity in China (1995), the individual is overweight or obese if her or his BMI is equal to or greater than 24.

Table 3.11 shows the results using pooled OLS after separating individuals into two groups. Model 7 (11), 8 (12) and 9 (13) show the results by estimating Equations 3.3, 3.4 and 3.5 respectively to check the mediating effect of unhealthy food preference. The results indicate that dietary knowledge has a significantly positive effect on diet

quality, which is mediated by the effect of unhealthy food preference. We also find that the absolute values of relevant variables are slightly larger among adults with overweight or obesity. Moreover, 6.73% of the total effect of dietary knowledge on diet quality is mediated by unhealthy food preference among adults not affected by overweight and obesity according to the Sobel-Goodman mediation test (see Table 3.12). Therefore, we can conclude that these results among adults not affected by overweight and obesity are consistent with findings among the whole dataset above, implying that conclusions of this study are robust.

[Insert Table 3.11 and 3.12]

In addition, models 10 and 14 show the results by estimating Equation 3.6, and we also find that a higher level of dietary knowledge contributes to the improvement in diet quality, and this effect could be moderated by unhealthy food accessibility.

3.6 Conclusion and Policy Implications

Given the sparse literature on the effect of dietary knowledge on diet outcomes in China, we investigate how eating behaviors and dietary patterns are affected by dietary knowledge among Chinese adults by using the CHNS data from 2004 to 2011. Then we check whether or not the linkage between dietary knowledge and diet quality is mediated by unhealthy food preference. Moreover, we study whether the influence of dietary knowledge on diet quality could be weakened by increasing availability of unhealthy food.

Our results show that the average DKI of Chinese residents increased steadily over time and was close to 8 in 2011, indicating that Chinese adults have acquired more and more dietary knowledge over time; but the diet quality, which is measured by CFPS, is still very low (3.227 in 2011). This indicates that increasing dietary knowledge does not lead to high diet quality. We thus further investigate the impact of dietary knowledge on diet quality. Our findings suggest that dietary knowledge can significantly improve Chinese adults' diet quality and this impact is mediated by unhealthy food preference. Additionally, the effect of dietary knowledge on diet quality is significantly weakened

if residents live in a neighborhood with high availability of unhealthy food, particularly for low-educated and poor people.

Several policy implications can be drawn from our study: first, we find strong evidence that a higher level of dietary knowledge significantly contributes to a more reasonable food consumption structure, so promoting education of nutrition knowledge (such as popularizing the Chinese Food Pagoda 2016 to the general public) is still an effective way to increase diet quality, which could further reduce the dual burden caused by the co-existence of under- and over-nutrition in China. Second, preference for unhealthy food has a significantly negative impact on diet quality. Therefore, public-service advertising of how to distinguish between healthy food and unhealthy food can play an essential role in improving diet quality in China. In particular, advertising in primary and middle schools to target children and encourage consumption of healthy food from an early age has been recommended in a previous study (Tian and von Cramon-Taubadel, 2020). Third, high availability of unhealthy food is the main obstacle to improve diet quality. In this case, creating a fair and sustainable food environment is an innovative and more effective solution[8]. Food environment refers to the natural, economic, political, and socio-cultural background where consumers participate in the food system to make decisions about obtaining, preparing, and consuming food. A fair and sustainable food environment can support healthy living and sustainable social development, and benefit all of us. There are some measures that can help create a fair and sustainable food environment. For example, the government should take specific policies to control the increasing availability of food facilities providing unhealthy food, and increase the cost of accessing unhealthy food (for example, the implementation of a tax on unhealthy food like sugary drinks).

[8]Source: 'Politik für eine nachhaltigere Ernährung: Eine integrierte Ernährungspolitik entwickeln und faire Ernährungsumgebungen gestalten - WBAE-Gutachte' (in German), https://www.bmel.de/SharedDocs/Downloads/DE/_Ministerium/Beiraete/agrarpolitik/wbae-gutachten-nachhaltige-ernaehrung.html

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Tables and Figures

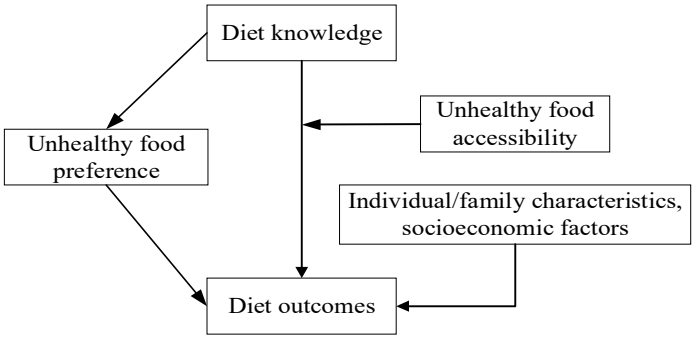

Figure 3.1 Conceptual framework

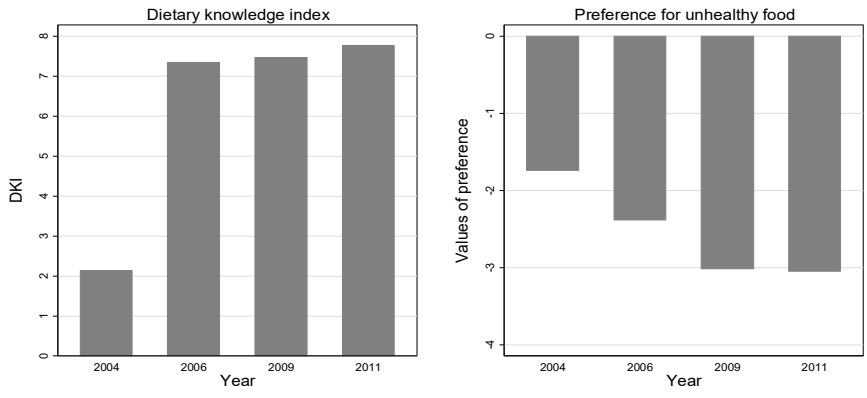

Figure 3.2 DKI and preference for unhealthy food over years

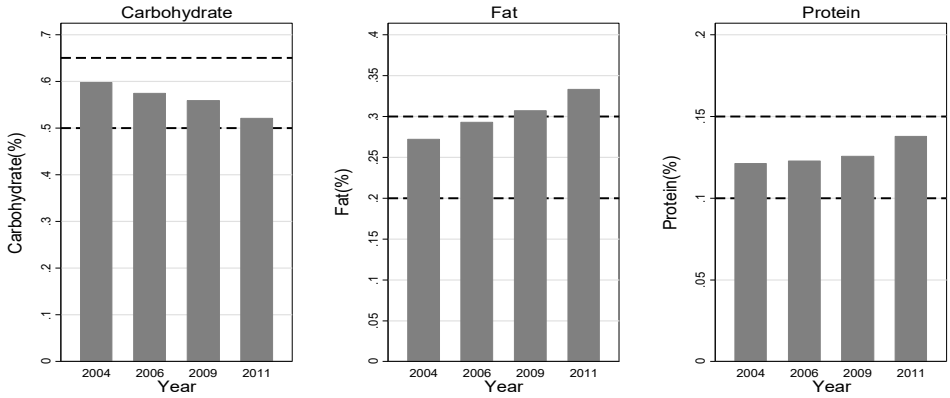

Figure 3.3 the Trend of per capita energy source structure in China

Notes: 1. The two dashed lines refer to the upper and lower bound recommended by China Dietary Guideline.
2. The bars are the yearly mean share of energy drawn from each macronutrient.

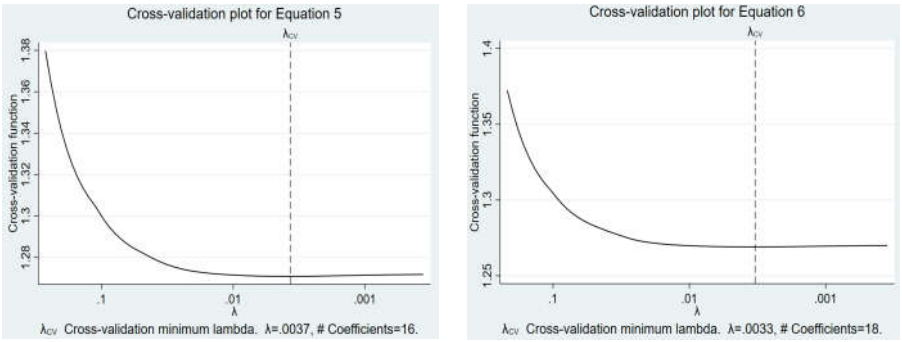

Figure 3.4 Cross-validation plots

Table 3.1 Descriptive statistics of variables

Variables	Description	Mean	Std. Dev.
CFPS	China food pagoda score	3.005	1.189
DKI	Score of dietary knowledge index	6.349	3.593
Preference	Score of unhealthy food preference	-2.599	1.796
Unhealthy food	the Logarithm of the total number of fast food restaurants, the bars or shops selling alcoholic beverages and ice-cream parlors in the neighborhood/village	1.533	1.286
Unhealth × DKI	the Interaction term between two variates of DKI and unhealthy food	9.848	11.025
Individual characteristics			
Physical activity	Physical activity level, light=1, moderate=2, heavy=3	1.910	0.902
Education	Highest education level completed, primary=1, secondary=2, tertiary=3	2.016	0.790
Age group	Respondents' age group=1 if age>40 and age<60, otherwise age group=0	0.599	0.490
Gender	Male=1, Female=0	0.484	0.500
Smoke	Smoking status: 1=yes, 0=no	0.291	0.454
Family characteristics			
Income	Per capita household income deflated to 2004, then take the logarithm of that to control for potential heteroscedasticity of the income variable	8.436	1.495
Family size	Number of members in the family	4.151	1.683
Children ratio	Ratio of children in the family	0.182	0.174
Elderly people ratio	Ratio of the elder in the family	0.063	0.126
Householder status			
Physical activity	Physical activity level, light=1, moderate=2, heavy=3	1.957	0.906
Education	Highest education level completed, primary=1, secondary=2, tertiary=3	1.991	0.789

Age group	Householder's age group=1 if age>40 and age<60, otherwise age group=0	0.731	0.443
Gender	Male=1, Female=0	0.687	0.464
Cook status			
Physical activity	Physical activity level, light=1, moderate=2, heavy=3	1.823	0.896
Education	Highest education level, primary=1, secondary=2, tertiary=3	1.854	0.791
Age group	Age group of the individual cooking meals=1 if age>40 and age<60, otherwise age group=0	0.691	0.462
Year	0 is the year 2004, 2 is the year 2006, 5 is the year 2009, 7 is the year 2011	3.819	2.731
Region	South (Jiangsu, Hunan, Hubei, Guangxi, Guizhou, Shanghai, Chongqing) =1, North (Liaoning, Shandong, Henan, Heilongjiang, Beijing)=0	0.544	0.498
Urbanization	The urbanization index is defined by a multidimensional 12-component capturing the population density, physical, social, cultural and economic environment, and a greater value means higher urbanization	66.792	20.132

Note: The physical activity is recorded according to job types in the CHNS: 1=very light physical activity, working in a sitting position like office worker or watch repairer; 2=light physical activity, working in a standing position such as sales person or teacher; 3=moderate physical activity like student or driver; 4=heavy physical activity such as farmer or dancer; and 5=very heavy physical activity such as loader, logger, or miner. Our paper defines 1 and 2 as light activity, 3 as moderate activity, 4 and 5 as heavy activity.

Table 3.2 Ratios of samples whose intake of macronutrients is within the recommended range, less and more than the reference

Nutrients	2004 (n=2843) (%)			2006 (n=2947) (%)			2009 (n=3063) (%)			2011 (n=3960) (%)		
	within	less	more	within	less	more	within	less	more	within	less	more
Carbohydrate	45.23	20.23	34.54	44.93	27.08	27.99	50.21	28.99	20.80	43.11	42.73	14.17
Fat	34.72	27.33	36.61	31.15	22.26	46.59	32.29	15.54	52.17	28.28	12.50	59.22
Protein	67.50	20.37	11.71	68.54	18.26	13.20	65.95	16.49	17.56	58.61	10.71	30.68

Table 3.3 Comparison of CFPS values of Chinese different groups

Groups	Means of CFPS				P[1]	Net change[2]
	2004	2006	2009	2011		
No. obs.	2843	2947	3063	3960	/	/
Total people	2.725	2.939	3.041	3.227	0.022	0.502
Female	2.748	2.973	3.089	3.342	0.023	0.594
Male	2.698	2.898	2.995	3.111	0.025	0.413
Age groups						
20-40 years	2.750	2.933	3.054	3.302	0.021	0.552
41-59 years	2.704	2.943	3.033	3.184	0.032	0.480
Education						
Primary education	2.595	2.734	2.893	2.941	0.014	0.346
Secondary education	2.698	2.908	3.038	3.092	0.037	0.394
Tertiary education	2.954	3.197	3.209	3.513	0.075	0.559
Income groups						
Low income	2.555	2.690	2.836	2.796	0.093	0.241
Middle income	2.819	3.073	3.038	3.069	0.274	0.250
High income	3.034	3.252	3.217	3.450	0.117	0.416
Urbanization level						
Low urbanization	2.495	2.614	2.716	2.798	0.007	0.303
Middle urbanization	2.724	3.008	3.043	3.041	0.192	0.317
High urbanization	3.186	3.329	3.335	3.570	0.088	0.384

Notes: 1. [1]P is the value of trend test.
2. [2]Net change between 2011 and 2004.
3. CFPS refers to China food pagoda score.

Table 3.4 the Process of selecting covariates by Lasso for Equation 3.5

ID	Lambda	Number[1]	Error[2]	Variables[3]
1	0.2664	2	1.3798	A: DKI; preference
2	0.2427	3	1.3648	A: urbanization
11	0.1051	5	1.3022	A: income; physical activity (individual characteristic)
15	0.0724	6	1.2893	A: education (cook status)
19	0.0499	7	1.2825	A: gender (individual characteristic)
21	0.0414	9	1.2798	A: year; smoke (individual characteristic)
24	0.0314	10	1.2764	A: region
27	0.0237	11	1.2742	A: education (individual characteristic)
30	0.0179	13	1.2729	A: age group (individual characteristic); elderly people ratio
35	0.0113	14	1.2717	A: family size
36	0.0103	15	1.2715	A: age group (cook status)
38	0.0085	16	1.2713	A: physical activity (cook status)
47	0.0037*	16	1.2708	U

Notes: 1. Number of observations=12813; Number of covariates=21; *Lambda (λ) is selected by cross-validation, the number of CV folds is 10.
2. [1]The number of non-zero coefficients.
3. [2]Mean prediction error (the CV function).
4. [3]Names of the variables added as models are fit for successive lambdas; A means added variables, U means unchanged variables.

Table 3.5 the Impact of dietary knowledge on diet quality and the mediated effect of unhealthy food preference

Variables	Model 1 CFPS		Model 2 Preference		Model 3 CFPS	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
DKI	0.017***	5.300	-0.073***	-15.290	0.016***	4.940
Preference	/	/	/	/	-0.014**	-2.360
Individual characteristics						
Physical activity	-0.046**	-2.140	-0.016	-0.510	-0.046**	-2.150
Education	0.025	1.270	0.057*	1.960	0.026	1.310
Age group	-0.006	-0.210	-0.842***	-21.050	-0.018	-0.640
Gender	-0.095***	-3.520	0.074*	1.840	-0.094***	-3.480
Smoke	-0.056*	-1.940	0.022	0.510	-0.055*	-1.930
Family characteristics						
Income	0.055***	7.470	-0.010	-0.900	0.055***	7.450
Family size	-0.010	-1.470	0.019*	1.860	-0.010	-1.430
Elderly people ratio	0.127	1.510	-0.062	-0.490	0.126	1.500
Cook status						
Physical activity	-0.013	-0.620	0.015	0.460	-0.013	-0.610
Education	0.051**	2.570	-0.042	-1.420	0.050**	2.540
Age group	-0.029	-1.030	0.242***	5.850	-0.025	-0.900
Year	0.022***	5.210	-0.129***	-20.420	0.021***	4.710
Region	0.078***	3.550	0.180***	5.490	0.081***	3.660
Urbanization	0.010***	13.400	-0.002*	-1.900	0.010***	13.360
Constant	1.698***	16.620	-1.321***	-8.750	1.680***	16.390
Observation	12813		12813		12813	
Wald test	1354.46***		2157.98***		1361.10***	

Notes: 1. ***, ** and * represent the significant levels 1%, 5% and 10%, respectively.
2. CFPS refers to China food pagoda score.
3. Preference refers to the score of unhealthy food preference.
4. DKI refers to the score of dietary knowledge index.

Table 3.6 Results of the Sobel-Goodman mediation test

Variable effect	Coef.	SE	P
Indirect effect	0.001	<0.001	0.010
Direct effect	0.017	0.003	<0.001
Total effect	0.018	0.003	<0.001

Table 3.7 the Process of selecting covariates by Lasso for Equation 3.6

ID	Lambda	Number[1]	Error[2]	Variables[3]
1	0.2167	4	1.3724	A: DKI; preference; unhealthy food; unhealth × DKI
2	0.1974	5	1.3583	A: urbanization
9	0.1029	6	1.3060	A: income
10	0.0938	7	1.3014	A: physical activity (individual characteristic)
14	0.0646	8	1.2882	A: education (cook status)
18	0.0446	9	1.2812	A: gender (individual characteristic)
19	0.0406	10	1.2798	A: smoke (individual characteristic)
21	0.0337	12	1.2772	A: year; region
26	0.0212	13	1.2724	A: education (individual characteristic)
28	0.0176	14	1.2714	A: age group (individual characteristic)
29	0.0160	15	1.2710	A: elderly people ratio
33	0.0110	16	1.2700	A: age group (cook status)
35	0.0092	17	1.2697	A: family size
42	0.0048	18	1.2691	A: physical activity (cook status)
46	0.0033*	18	1.2690	U

Notes: 1. Number of observations=12813; Number of covariates=23; *Lambda (λ) is selected by cross-validation, the number of CV folds is 10.

2. [1]The number of non-zero coefficients.
3. [2]Mean prediction error (the CV function).
4. [3]Names of the variables added as models are fit for successive lambdas; A means added variables, U means unchanged variables.

Table 3.8 Impacts of dietary knowledge and unhealthy food accessibility on diet quality by random effects regressions

Variables	Model 4		Preference for unhealthy food			
	CFPS		Low level		High level	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
DKI	0.027***	5.900	0.024***	2.880	0.030***	5.200
Preference	-0.014**	-2.300	0.048	1.400	-0.008	-0.780
Unhealthy food	0.019	1.190	-0.011	-0.310	0.030	1.590
Unhealth × DKI	-0.007***	-3.360	-0.003	-0.680	-0.009***	-3.530
Individual characteristics						
Physical activity	-0.045**	-2.120	-0.024	-0.650	-0.052**	-2.000
Education	0.027	1.360	0.016	0.470	0.033	1.350
Age group	-0.016	-0.590	-0.009	-0.180	-0.029	-0.880
Gender	-0.093***	-3.450	-0.117***	-2.670	-0.077**	-2.310
Smoke	-0.058**	-2.020	-0.051	-1.080	-0.063*	-1.780
Family characteristics						
Income	0.054***	7.300	0.056***	4.310	0.054***	6.030
Family size	-0.008	-1.160	-0.015	-1.330	-0.003	-0.380
Elderly people ratio	0.118	1.400	0.279**	1.980	0.049	0.470
Cook status						
Physical activity	-0.010	-0.480	-0.074*	-1.950	0.024	0.910
Education	0.049**	2.490	0.038	1.110	0.053**	2.210
Age group	-0.029	-1.040	-0.015	-0.280	-0.032	-0.980
Year	0.018***	4.200	0.020***	2.610	0.017***	3.200
Region	0.101***	4.450	0.081**	2.150	0.103***	3.730
Urbanization	0.011***	13.670	0.011***	7.560	0.012***	11.660
Constant	1.589***	15.140	2.050***	8.550	1.471***	11.520
Observation	12813		4431		8382	
Wald test	1385.89***		481.69***		862.91***	

Notes: 1. ***, ** and * represent the significant levels 1%, 5% and 10%, respectively.
2. CFPS refers to China food pagoda score.
3. Preference refers to the score of unhealthy food preference.
4. DKI refers to the score of dietary knowledge index.

Table 3.9 the Heterogeneity of impacts of dietary knowledge, unhealthy food preference and accessibility on Chinese adults' dietary patterns

Variables	Gender		Income		Education	
	Male	Female	Low	High	Low	High
DKI	0.030***	0.025***	0.033***	0.019***	0.028***	0.023**
Preference	-0.014*	-0.013	-0.012	-0.017*	-0.019**	-0.007
Unhealthy food	0.015	0.022	0.048**	-0.032	0.046**	-0.052
Unhealth × DKI	-0.006**	-0.008***	-0.010***	-0.002	-0.008***	-0.002
Other variables	Yes					
Observation	6199	6614	6408	6405	8707	4106
Wald test	541.37***	837.05***	509.20***	472.90***	720.53***	361.26***

Notes: 1. Reports of control variables are coefficients in random regressions.
2. ***, ** and * represent the significant levels 1%, 5% and 10%, respectively.
3. CFPS refers to China food pagoda score.
4. Preference refers to the score of unhealthy food preference.
5. DKI refers to the score of dietary knowledge index.

Table 3.10 Impacts of dietary knowledge, unhealthy food preference and accessibility on Chinese adults' dietary patterns by pooled OLS

Variables	Model 5 CFPS		Model 6 CFPS		Preference for unhealthy food			
					Low level		High level	
	Coef.	t-Ratio	Coef.	t-Ratio	Coef.	t-Ratio	Coef.	t-Ratio
DKI	0.017***	4.640	0.029***	5.580	0.025***	2.910	0.031***	4.920
Preference	-0.016**	-2.350	-0.015**	-2.290	0.048	1.310	-0.010	-0.930
Unhealthy food	/	/	0.021	1.110	-0.009	-0.250	0.032	1.460
Unhealth × DKI	/	/	-0.008***	-3.050	-0.003	-0.700	-0.010***	-3.190
Individual characteristics								
Physical activity	-0.050**	-2.480	-0.050**	-2.440	-0.026	-0.750	-0.059**	-2.320
Education	0.022	1.160	0.023	1.220	0.015	0.460	0.029	1.220
Age group	-0.028	-1.030	-0.026	-0.970	-0.012	-0.230	-0.036	-1.110
Gender	-0.089***	-3.670	-0.088***	-3.630	-0.117***	-2.940	-0.071**	-2.310
Smoke	-0.055*	-1.920	-0.059**	-2.040	-0.051	-1.080	-0.063*	-1.780
Family characteristics								
Income	0.056***	6.180	0.055***	6.040	0.056***	3.830	0.054***	4.940
Family size	-0.011	-1.320	-0.009	-1.080	-0.015	-1.210	-0.004	-0.460
Elderly people ratio	0.154	1.630	0.144	1.520	0.293**	2.020	0.053	0.460
Cook status								
Physical activity	-0.007	-0.280	-0.004	-0.150	-0.072*	-1.900	0.031	1.090
Education	0.047**	2.010	0.046*	1.960	0.039	1.060	0.050*	1.840
Age group	-0.025	-0.760	-0.029	-0.890	-0.011	-0.190	-0.035	-0.940
Year	0.020***	3.820	0.018***	3.390	0.020**	2.360	0.017***	2.650
Region	0.077***	2.860	0.098***	3.540	0.080*	1.890	0.104***	3.200
Urbanization	0.010***	10.950	0.011***	11.310	0.011***	6.800	0.012***	9.950
Constant	1.666***	13.420	1.570***	12.520	2.039***	7.430	1.472***	10.020
Observation	12813		12813		4431		8382	
F test	58.16***		54.00***		22.37***		36.24***	
R^2	0.103		0.105		0.100		0.099	
Root MSE	1.126		1.125		1.128		1.124	

Notes: 1. ***, ** and * represent the significant levels 1%, 5% and 10%, respectively.
2. CFPS refers to China food pagoda score.
3. Preference refers to the score of unhealthy food preference.
4. DKI refers to the score of dietary knowledge index.

Table 3.11 Robustness checks among different groups by pooled OLS

	Adults not affected by overweight and obesity				Adults affected by overweight and obesity			
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
DKI	0.017***	-0.073***	0.016***	0.030***	0.022***	-0.080***	0.021***	0.029***
Preference	/	/	-0.015*	-0.015*	/	/	-0.015	-0.015
Unhealthy food	/	/	/	0.023	/	/	/	0.004
Unhealth × DKI	/	/	/	-0.009***	/	/	/	-0.006
Other variables	Yes				Yes			
Observation	7157	7157	7157	7157	5021	5021	5021	5021
F test	54.85***	74.19***	51.67***	46.95***	40.41***	56.62***	38.04***	34.28***
R^2	0.103	0.135	0.104	0.106	0.108	0.145	0.108	0.110
Root MSE	1.128	1.690	1.128	1.127	1.130	1.622	1.130	1.129

Notes: 1. ***, ** and * represent the significant levels 1%, 5% and 10%, respectively.
2. CFPS refers to China food pagoda score.
3. Preference refers to the score of unhealthy food preference.
4. DKI refers to the score of dietary knowledge index.

Table 3.12 Results of the Sobel-Goodman mediation test among different groups

Variable effect	Adults not affected by overweight and obesity			Adults affected by overweight and obesity		
	Coef.	SE	P	Coef.	SE	P
Indirect effect	0.001	0.001	0.056	0.001	0.001	0.139
Direct effect	0.016	0.004	<0.001	0.021	0.005	<0.001
Total effect	0.017	0.004	<0.001	0.022	0.005	<0.001

Appendix A

Table A1 Chinese Food Pagoda Score (CFPS) at various energy levels

Food group	1600 kcal	1800 kcal	2000 kcal	2200 kcal	2400 kcal	2600 kcal	2800 kcal	Dietary guidelines
Grains, potatoes and beans (g)								250-400
Score as “1”	175-225	200-250	225-275	250-300	275-325	325-375	350-400	
Score as “0.5”	88-175	100-200	113-225	125-250	138-275	163-325	175-350	
Score as “0.5”	225-338	250-375	275-413	300-450	325-488	375-563	400-600	
Vegetables (g)								300-500
Score as “1”	≥300	≥400	≥450	≥450	≥500	≥500	≥500	
Score as “0.5”	150-300	200-400	225-450	225-450	250-500	250-500	250-500	
Fruit (g)								200-350
Score as “1”	≥200	≥200	≥300	≥300	≥350	≥350	≥400	
Score as “0.5”	100-200	100-200	150-300	150-300	175-350	175-350	200-400	
Meat and poultry (g)								40-75
Score as “1”	15-65	25-75	25-75	50-100	50-100	50-100	75-125	
Score as “0.5”	8-15	13-25	13-25	25-50	25-50	25-50	38-75	
Score as “0.5”	65-98	75-113	75-113	100-150	100-150	100-150	125-188	
Eggs (g)								40-50
Score as “1”				40-50				
Score as “0.5”				20-40				
Score as “0.5”				50-75				
Aquatic products (g)								40-75
Score as “1”	≥40	≥50	≥50	≥75	≥75	≥75	≥100	

Score as “0.5”	20-40	25-50	25-50	38-75	38-75	38-75	50-100	
Milk and its products (g)								300
Score as “1”				≥300				
Score as “0.5”				150-300				
Legumes and nuts(g)								25-35
Score as “1”	15-25	15-25	15-25	25-35	25-35	25-35	25-35	
Score as “0.5”	8-15	8-15	8-15	13-25	13-25	13-25	13-25	
Score as “0.5”	25-38	25-38	25-38	35-53	35-53	35-53	35-53	
Edible oil (g)								25-30
Score as “1”		≤25				≤30		
Score as “0.5”		25-38				30-45		
Salt (g)								<6
Score as “1”				≤6				
Score as “0.5”				6-9				

Note: The energy level is the upper bound for each interval except for the level of 2800 kcal. For instance, individuals with energy intake lower than or equal to 1600 kcal are classified into the group ‘1600’. Individuals with energy intake more than 2600 kcal are classified into the group ‘2800 kcal’.

Table A2 Questions about dietary knowledge in the CHNS

Do you strongly agree, agree, are neutral, disagree, or strongly disagree with the following statements? (Note: the question is not asking about your actual habits)	True/ False
Q1: Choosing a diet with a lot of fresh fruit and vegetables is good for health.	T
Q2: Eating a lot of sugar is good for health.	F
Q3: Eating a variety of foods is good for health.	T
Q4: Choosing a diet high in fat is good for health.	F
Q5: Choosing a diet with a lot of staple foods (rice and rice products and wheat and wheat products) is not good for health.	T
Q6: Consuming a lot of animal products daily (fish, poultry, eggs and lean meat) is good for health.	F
Q7: Reducing the amount of fatty meat and animal fat in the diet is good for health.	T
Q8: Consuming milk and dairy products is good for health.	T
Q9: Consuming beans and bean products is good for health.	T
Q10: Physical activities are good for health.	T
Q11: Sweaty sports or other intense physical activities are not good for health.	T
Q12: The heavier one's body is, the healthier he or she is.	F

Source: The dietary knowledge questionnaire is from the official website of the China Health and Nutrition Survey (CHNS) (http://www.cpc.unc.edu/projects/china).

Table A3 Questions about unhealthy food preference in the CHNS

How much do you like this food: Like very much, like, am neutral, dislike, or dislike very much?	Healthy (H)/ Unhealthy (U)
Q1: Fast food (KFC, pizza, hamburgers, etc.)	U
Q2: Salty snack foods (potato chips, pretzels, French fries, etc.)	U
Q3: Fruit	H
Q4: Vegetables	H
Q5: Soft drinks and sugared fruit drinks	U

Source: The dietary knowledge questionnaire is from the official website of the China Health and Nutrition Survey (CHNS) (http://www.cpc.unc.edu/projects/china).

Table A4 the Mean consumption of ten food groups listed in CFP 2016 among people with different preference for unhealthy food and different levels of dietary knowledge

Food category (g/day)	Total people	Preference for unhealthy food		the Level of dietary knowledge	
		Low	High	Low	High
Grains, potatoes and beans	435.515	426.177	446.344	458.001	414.727
Vegetables	308.510	302.470	315.514	319.357	298.481
Fruit	52.850	61.236	43.126	35.894	68.525
Meat and poultry	88.599	90.073	86.891	82.678	94.073
Eggs	28.086	30.932	24.787	25.151	30.800
Aquatic products	31.445	33.978	28.506	27.427	35.158
Milik and its products	14.279	16.152	12.108	10.801	17.495
Legumes and nuts	50.748	53.401	47.672	46.816	54.383
Oil	44.955	46.097	43.630	43.503	46.296
Salt	9.631	9.426	9.869	10.104	9.194
No. obs.	12813	6880	5933	6155	6658

Chapter 4 Political Party Support and Consumer Preference for Organic Food in Germany: the Perspective of Social Identity and Social Movements[9]

4.1 Introduction

After Lord Northbourne firstly proposed the concept of 'organic agriculture' in 1940, organic agriculture/food has been increasingly regarded as a global social movement for environmental and health protection. With the development and expansion of the intensive agricultural production system which is characterized by wide use of fossil energy, fertilizers and pesticides and monocultural production, many environmental and health problems emerged. People gradually start to pay more attention to the quality and safety of food, so that the organic food market has achieved relatively rapid development in recent years particularly in developed economies. The price of organic food is higher because of its high level of food safety and external social benefits such as ecological and environmental benefits (Adamtey et al., 2016; Rana and Paul, 2017). Compared with conventional food, organic food is more environmentally friendly and entails healthier attributes during its process of production, so consumers are willing to pay higher prices (Poveda, 2005; Magistris and Gracia, 2008). This social movement is reshaping global production of and demand for organic food, while consumers form different social identities towards organic food, and stand with their political parties to realize their political agenda. However, the linkage between consumer preference for organic food and political party support has not been well studied.

Social movements and the political agenda of a political party are often multifaceted. It could result in complicated implications for consumer preference for organic food. As organic food is widely regarded as being environmentally friendly, the

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Green Party in Germany is the main promoter of it. Consumers who support the Green Party could have two different thoughts. On the one hand, consumers who support the Green Party often pay more attention to environmental protection, and hence yield a higher WTP (Willingness to Pay) for organic food due to a higher value of the product itself. However, on the other hand, the Green Party supporters wish to expand the production of organic food, and believe organic food 'should not be an individual privilege', and should be more inclusive for the general public. The latter implies that consumers who support the Green Party might yield a lower WTP. The general conclusion for the linkage between political party support and consumer preference for organic food is inconclusive.

In order to fill in the gap in the literature, we conduct an online survey on organic food consumption in Germany, and empirically study the linkage between political party support and consumer preference for organic vegetables.

4.2 Literature and Background

4.2.1 Social Identity and Preference

Political parties could shape social preferences in a few channels. Supporters of a political party often have similar political beliefs, which is often defined as social identity. In 1972, Tajfel seminally published an article on social identity theory to explain the basic process of intergroup discrimination, as well as to explain social conflicts and social changes in the real world. By designing a minimal group paradigm research method, Tajfel and Turner (1986) study individuals' behaviour of treating members in different groups differently. The research results show that compared with outgroup members, individuals have ingroup bias towards ingroup members, and social identity is the main reason for this differential behaviour. Akerlof and Kranton (2000) not only incorporate different social categories and expected respective behaviour, i.e., a prescription or norm for behaviour, but also identity into a neoclassical utility function. Their findings indicate that disutility is caused by deviations from the prescription. Chen and Li (2009) then use an experimental design to find that social identity can

increase the level of individual social preference for ingroup members. People often make a more favourable evaluation of the group and the motive for such behaviour is the individual's need for self-esteem (Turner et al., 1979). It is out of the need for self-esteem that individuals tend to have ingroup preference and identify with the group they are in. Ashforth and Mael (1989) conclude that: (1) social identification is a perception of oneness with a group of people; (2) social identification stems from the categorization of individuals, the distinctiveness and prestige of the group, the salience of outgroups; and (3) social identification leads to activities that are congruent with the identity.

A large part of the research on social identity theory revolves around the inherent identity of individuals, such as racial identity (Hoff and Pandey, 2006), religious identity (Shariff and Norenzayan, 2007; Benjamin et al., 2016), criminal status (Cohn et al., 2015), household registration status (Afridi et al., 2015), Environmental concerns (Brieger, 2019), etc. Each individual has an inherent identity, which is equivalent to the identity of the group they belong to, and this identity is manifested in the individual's preference for the ingroup rules (Ashforth and Mael, 1989). When people's degree of identification with their inherent identity changes, their preference for ingroup rules will be inevitably lifted and reinforced (Bartels and Onwezen, 2014; Brieger, 2019).

4.2.2 Social Movements and Political Party Support

Social identity could well explain the social movement which mobilizes the resources to realize the political agenda in different contexts (Polletta and Jasper, 2001). First, Social identity is a strong motivation behind the resource mobilization of political process as it could capture better pleasures and obligations that actually encourage people to mobilize due to the ingroup obedience. Second, the strategic choices set is relatively homogeneous and the organisation cost is relatively low, as the participants of an ingroup with the same social identity are reflected by: what we believe, what we are comfortable with, what we like, and who we are. Third, social identity could be formed or reinforced by the cultural effects of social movements.

Organic food has gained significant momentum for social movements in the past decades. People who share the same environmental and health concern about modern intensive agriculture form the social identity, and support the Green Party to realize their political goals of sustainable agricultural production, while organic food could be regarded as an instrument for the social movement.

4.2.3 Political Party Support and Consumer Preference

We further argue that social identity and political party support can shape preference in two channels (Figure 4.1). First, social identity can enhance and change the individual's social preference directly for ingroup members in order to be submitted to the ingroup rules, culture or values, which often leads to ingroup bias, and makes the individual behaves more conducive to the ingroup. Any identity of an individual must correspond to a group, and the individual must subjectively form a sense of identity for the group, which is often called the collective identity, the basis for the identity to influence social preference (Ashforth and Mael, 1989; Polletta and Jasper, 2001). Second, social identity could change the social preference of consumers through political processes, such as social movements. The collective identity is an important force which drives social movements to realize the common goals or values of the group, as social movements are an important tool to mobilize resources to change political processes (Polletta and Jasper, 2001; Bhonagiri, 2016; Niederle et al. 2020).

[Insert Figure 4.1 here]

Social Movements can emerge when enough people feel alienated or excluded from the world around them or develop distrust of how political institutions governs society (Bhonagiri, 2016). The collective identity demands broader participation in the policy-making process, which makes the policy agenda more transparent, fairer and more accountable for the group. Nowadays, the imminent global environmental challenges form an immense and long-lasting social movement for organic food, to realize sustainable development.

Some literature already sheds light on the linkage between social identity & social movements and organic food consumption. Bartels and Onwezen (2014) find that social identity of the organic food consumers is positively related to the intention to buy products that make environmental and ethical claims. Niederle et al. (2020) shows how social movements produce institutional change and diversity in the organic food market.

Clearly, the linkage between political party support and consumers' willingness to pay for organic food is complicated, and unfortunately has not been well scrutinized in the current literature.

4.2.4 Organic Food and the Green Party Support in Germany

Germany is the largest organic food market in Europe, and organic food has been increasingly popular among consumers and gaining importance in policy making. The German government has made an ambitious plan to reach '20 percent organic farming in Germany by 2030'[10]. At the end of 2019, there were 32,100 operation entities (mainly farms) in Germany that produced organic production, and organic farming shared 9.7% of the total utilized agricultural land[11].

Organic agriculture has been an important policy agenda and hotly debated among different stakeholders in Germany. Particularly, Alliance 90/The Green Party (German: Bündnis 90/Die Grünen or Grüne), is a major supporter and promoter of organic food, or broadly speaking, sustainable agriculture. The formation of the Green Party happened in 1993 when the Green Party and Alliance 90, which was formed in West Germany in 1980 and in East Germany in 1990 respectively, were merged (Nordsieck, 2020). The 2019 European election result shows that 20.5% of votes cast was won by the Green Party and it became the second largest party in Germany that year[12]. In the 21st century, the typical classification of the Green Party is a political spectrum of the centre-left. The policies of the Green Party revolve around environmental protection

[10]Source: Federal Ministry of Food and Agriculture in Germany. https://www.bmel.de/EN/topics/farming/organic-farming/strategy-future-organic-farming.html;jsessionid=0B1BF87342EA1AF6318E040496FE869B.live832
[11]Source: Federal Ministry of Food and Agriculture in Germany. https://www.bmel.de/SharedDocs/Downloads/EN/Publications/Organic-Farming-in-Germany.pdf
[12]Source: https://www.dw.com/en/cdu-csu-spd-afd-fdp-left-greens/a-38085900

and social progress (Sloat, 2020), and put emphasis on aspects of mitigating the effects of climate change, cutting carbon emissions, and promoting sustainability and an ecologically sound production process[13]. In the 2021 German general election, the Green Party further detailed their organic agricultural policies in their election manifesto, including systematical reduction of pesticides, an immediate ban on glyphosate and 30% organic farming[14]. It particularly states that 'Organic food should not be a privilege'[15].

Because of fewer chemical residues and environmentally friendly features, organic food is becoming more popular all over the world (Huang, 1996; Sirieix et al., 2011; Yin et al., 2010; Yu et al., 2014a), and Germany is no exception. Research findings have underlined that developing the production and consumption of organic food has some benefits, such as increasing the environmental sustainability of agriculture, and reducing food-borne diseases though the production costs are relatively higher (Sanders, 2006; Yin et al., 2010; Sirieix et al., 2011; Yang et al., 2013; Yu et al., 2014a; Yu et al., 2014b). As organic agriculture is regarded as an alternative to intensive agriculture with negative environmental impacts, the Green Party calls for more regulation of agricultural production and is a strong supporter of organic agriculture in its political agenda. They propose a policy target of 30% organic farming in 2030 in the General Election in 2021.

If voters get to support a political party, a standard economic approach assumes rational and self-interested voting (Roos and Orland, 2014). Hence, people who support the Green Party shall fully understand the policies of the Party and voting for the policies would maximize their expected utility (Roos and Orland, 2014). People in favour of the Green Party are identified with the awareness of environmental protection, leading them to endorse organic food.

In the literature, the willingness to pay (WTP) has been widely used for eliciting consumer preference (Yu et al., 2014a). However, the literature has not offered a clear

[13]Source: https://www.dw.com/en/germanys-green-party-how-it-evolved/a-40586834
[14]Source: https://www.topagrar.com/management-und-politik/news/gruene-schaerfen-ihr-wahlprogramm-zur-landwirtschaft-nach-12594745.html?utm_campaign=search&utm_source=topagrar&utm_medium=referral
[15]Source: https://www.gruene.de/themen/ernaehrung

picture of the linkage between political party support and consumer preference (WTP is often used for measuring consumer preference) for organic food. On the one hand, the Green Party supporters clearly have a high concern for environmental protection, implying a higher WTP for organic food. On the other hand, consumers who support the Green Party wish to promote organic food through the social movement and the related political process. The Green Party also clearly states that 'organic food should not be a privilege' in their political manifesto. The expansion of organic food could reduce the inequality of organic food consumption, and make organic food more accessible to the general public with low prices. This is the political goal of the social movement which could be appealing for those who are identified as the supporters of the Green Party. From the perspective of social justice and inclusiveness, the Green Party supporters may wish to pay less or even no premium price for organic food, as they believe organic food is not an individual privilege, and should belong to the general public.

Hence, the general conclusion for the linkage between the Green Party support and consumer preference for organic food is inconclusive. If the first effect dominates, consumers who support the Green Party in Germany could yield a higher WTP for organic food; If the second effect dominates, consumers who support the Green Party however could yield a relatively lower WTP.

In the rest of the paper, we will empirically examine if the support of the Green Party is positively correlated with WTP for organic food in Germany.

4.3 Conceptual Framework and Empirical Strategy

4.3.1 Conceptual Framework

WTP is widely used as a measure of consumer preference. The current literature has intensively studied different factors on the WTP for organic food, including social demographic characteristics, cognition, consumption attitude, living environment, cultural difference and geographical distribution.

The influence of socioeconomic and demographic characteristics on the WTP for organic food is mainly reflected in two aspects. First are the individual-level factors, including gender, age, education, marital status, occupation, etc. (e.g. Hursti and Magnusson, 2003; Lockie et al., 2004; Lea, 2005; Stobbelaar et al., 2007; Ureña et al., 2008), and the second are the family level characteristics, including family size, family structure and family income (e.g. Michaelidou and Hassan, 2008; Loncaric et al., 2009; Yin et al., 2010; Yu et al., 2014a; Yazdanpanah et al., 2015).

Related, the literature has shed light on the impact of social movements on the organic market formation (Bartels and Onwezen, 2014; Gilding and Glezos, 2020) and institutional change (Niederle et al., 2020). However, it has not been linked to consumer preference for organic food which is a fundamental driving force behind organic food consumption. Though we know the social movement and political party support play important roles in consumer preference, it has not been well scrutinized particularly from the empirical perspective. It has been clear that people could form different social identities according to their social, cultural, environmental and economic backgrounds or beliefs. Self-concept is defined as the sense of who we are, including not only the personal identity (the awareness of an individual's characteristics and attitudes) but also a social identity (Turner et al., 1979; Chen and Chen, 2011). People tend to categorize, identify and compare between different identities and their corresponding groups. These collective identities lead to forming political parties.

Figure 4.1 shows that once social identity is categorized, it could change consumer preference through two channels. First, the ingroup people could form an ingroup culture which makes the members obey and reinforce the rules or the culture of the social identity. Consumers in an identity group could find more self-esteem and satisfaction. The promoters of organic food particularly care about environmental protection. Straightly speaking, consumers who support the Green Party have a social identity of higher environmental concern, and hence are willing to pay more for organic food per se.

The second channel could be promoting organic food through social movements and political processes. The social movement driven by social identity could be violent

or non-violent (Bhonagiri, 2016). As the environmental issues are imminent, touchy and long-lasting, the environmental groups could sustain the social movement for a long time. However, the goal of the social movement is clear: promoting organic agricultural production and reducing fertilizers and pesticides.

From the perspective of social justice, the social movement of organic food wishes to offer all people an equal chance to access to organic food by enforcing universal organic food production from the political process, and inequality aversion could be intrinsic to individuals (Bao and Yu, 2019). The Green Party supporters widely believe that 'organic food should not be a privilege'. In other words, the Green Party supporters might not be willing to pay a premium for organic food, and they wish organic food could be accessible to the general public, and the society pays the costs of organic production. Yu and Abler (2010) observe protest zeros of WTP values in evaluating environmental benefits when the respondents think the government should pay. In other words, the Green Party supporters might be willing to pay less for organic food in this scenario.

The two channels have different effects on individual WTP for organic food, and the final WTP values depend on the aggregate effect. When we consider the social identity and social movements in the framework of analyzing WTP for organic food, the WTP values may not be conclusive. It is possible that the Green Party supporter may be willing to pay less for organic food if the second effect dominates.

In the rest of the paper, we will use online survey data to empirically study the linkage between political party support and WTP for organic vegetables in Germany.

4.3.2 Empirical Strategy

There are a number of approaches to eliciting consumer preference for non-market goods: contingent valuation methods (CVM), choice experiments, and experimental auction methods. Each method has some advantages and also some disadvantages. For instance, the choice experiment could consider more attributes, but it could overshoot the WTP values (Yu et al., 2014a). We specifically use the payment card approach which

belongs to a CVM method. Compared with the open-ended approach and the discrete approach, the payment card is more flexible. It divides the WTP values into several intervals, and the survey respondents could pick an interval in which she/he thinks her/his WTP values fall. In practice, survey respondents may not know the exact number of her/his WTP values, such intervals could be more flexible for the respondents. In addition, it also yields more choices than the traditional single or double-bounded discrete method proposed by Hanemann (1984) and Carson et al. (1990).

We can specify the following regression model:

$$WTP_j = \beta_0 + \beta_1 G_j + Z_j\gamma + \varepsilon_j \quad 4.1$$

Where WTP_j is a continuous WTP value for organic vegetables for the jth observation - either observed or unobserved; G_j is a dummy variable denoting the Green Party support (e.g. Yes =1, No=0) and the corresponding coefficient is β_1; Then, Z_j is a vector of other socioeconomic variables and their corresponding coefficient vector is γ. The error term ε_j is assumed to be normally distributed $\varepsilon_j \sim N(0, \sigma_1^2)$.

If we can observe a specific number of WTP_j, it is a point data; If we only know WTP_j falls in an interval $[WTP_{1j}, WTP_{2j}]$, it is unobserved but $WTP_{1j} \leq WTP_j \leq WTP_{2j}$.

We are particularly interested in the coefficient of G_j. If it is positive, it indicates that the consumer supporting the Green Party has a higher WTP value for organic vegetables; otherwise, the individual has a lower WTP value.

There are a number of estimation methods for Equation 4.1 (Tian et al. 2011; Yu et al., 2014a). Amemiya (1973) proposes a generalized Tobit model known as the interval regression approach, to deal with such a data structure (Davidson and MacKinnon, 2004, Section 11.6; Yu et al., 2014a). However, in order to check for the robustness of the results, a simple OLS which regards the WTP value in an interval as the middle-point value could be an alternative method.

4.4 Data Description

4.4.1 Samples

The data used in this paper were obtained from a survey of WTP for organic food in Germany for the period from August to September of 2020, conducted by the way of online questionnaire with a survey company named 'respondi AG'. The online survey is a relatively common method nowadays with the expansion of the internet. It is relatively inexpensive and easy to control when collecting information by uniformly designed questions.

The survey includes 549 samples which randomly selected in Germany. In order to make the samples more representative, the survey company particularly controlled for gender and age structures, and made them close to the general population. Finally, respondents are aged from 18 to 80, and the whole dataset includes 277 women and 272 men. In addition, 182 samples come from rural areas, while the rest are from urban areas. Table 4.1 presents the descriptive statistics for main variables.

[Insert Table 4.1 here]

Particularly, we include a question of political party support which included all major political parties, and find that the support rates for the Green Party, CDU/CSU, SPD, Linke, FDP and AfD respectively are 17.5%, 17.5%, 14.2%, 15.5%, 2%, and 11.8%. Compared to general party supporting rates in Germany, it is less representative for CDU/CSU and FDP, slightly over representative for Linke (the Left Party). The supporting rate of 17.5% for the Green Party in this survey is close to 20.5% which was the supporting rate in the 2019 European Parliament Election.

4.4.2 Survey Design

In the survey, we use the payment card approach and set the question of WTP as follows: 'Compared with non-organic foods, what is the maximum percentage of the premium that you are willing to pay for the certified organic food (Vegetables)?'. Given that organic vegetables occupy a large proportion in organic food markets, this study particularly explores the linkage between political party support and consumer

preference for organic food, which is based on the consumers' WTP for organic vegetables.

The choices set of premium prices for organic vegetables in the payment card consists of six intervals: 0, (0,10%], (10%,30%], (30%,50%], (50%,100%], more than 100%. Compared with the continuous method (such as the open-ended method), the payment card intervals are more flexible for the respondents to make decisions. Intervals can let the answer close to the true values, thereby reducing the bias caused by measurement errors (Juster and Smith, 1997).

4.5 Results Discussion and Policy Implications

4.5.1 Estimation Results

Table 4.2 reports the estimation results for the interval regression for Equation 4.1. We report two estimation results: one including all political parties and comparing the effect of the Green Party Support with CDU/CSU, SPD, LINKE, FDP, AFD and others; and one only including the dummy variable of the Green Party and treating other parties as the reference. Comparing the two regressions, we find the results are very consistent. In terms of political party support, Model 1 shows that only the Green Party support is statistically significant, and the coefficient is very close to that in Model 2 which only includes the dummy variable of the Green Party.

[Insert Table 4.2 here]

The coefficients for all other parties are not statistically significant in Model 1, while the coefficient for the Green Party is -0.12 in two models, and statistically significant at 5%. It implies that the consumers who support the Green Party have a 12% lower WTP premium for organic vegetables in Germany. The consumers who support other parties are not significantly different in WTP values.

Our conceptual framework in Section 4.3 indicates that the Green Party particularly pays attention to environmental protection, and actively promotes organic agriculture. On the one hand, the Green Party supporters shall have a higher WTP for

organic food if we only consider the environmental effects. On the other hand, the Green Party supporters also care much about social justice, and think organic food should not be an individual privilege. Organic food should be more inclusive to the general public. If the second factor dominates, the WTP premium for organic food should be lower for the supporters of the Green Party. It exactly explains the negative coefficient for the Green Party in the estimation.

Table 4.2 also shows that age, employment, and education levels are statistically significant as well. It is reasonable that senior and employed consumers are willing to pay more for organic vegetables, as these people are in better economic status. However, it seems puzzling that the coefficient for university education has a relatively lower WTP for organic food. One possible explanation is that people with more education may not think organic food is healthier in terms of nutrition. Some literature also finds that some consumers will immediately stop buying organic vegetables when they do not believe that organic vegetables represent absolute safety (Barrett, 2002; Krystallis and Chryssohoidis, 2005).

4.5.2 Robustness Test

Apart from the interval regression discussed above, the OLS treating the interval as the middle point value is an alternatively statistical method to estimate Equation 4.1 (Yang et al., 2013; Yu et al., 2014a). For the sake of the robustness check, we estimate Equation 4.1 with OLS. Specifically, we define the true WTP value as the middle point for a closed interval; for the left censored data, the lower boundary plus the half distance of the neighboring interval is taken to represent the true WTP value (Yu et al., 2014a). Other independent variables are defined in the same way as the interval regression.

Table 4.3 reports the estimation results of OLS. The results are consistent with the interval regression. Clearly, only the coefficient for ‘the Green Party’ is statistically significant among all political parties. The coefficient is around -0.15 for both Model 3 which includes all dummies for all major political parties and Model 4 which only includes the dummy for the Green Party, which is slightly larger in terms of absolute

value, but still consistent with the interval regression above. All other coefficients are also consistent with the interval regression. It evidences that our results are robust.

[Insert Table 4.3 here]

4.5.3 Policy Implications

In addition to the above regression results which shed light on the linkage between the Green Party supporters and WTP for organic food, we could also estimate the WTP for organic food in Germany as a by-product, which also has vital policy implications (Thompson, 1998; Yu et al., 2014a). Table 4.4 comparatively reports the means and medians of WTP for organic vegetables between the supporters of the Green Party and those of other political parties. We use t-tests to compare the differences between two groups.

[Insert Table 4.4 here]

For the raw data, we assume the true WTP ratios are at the middle point of the interval. Especially, the true WTP ratio for the up-open interval has the equivalent of the lower boundary plus the half distance of the adjacent interval (Yu et al., 2014a). Then, the Green Party supporters are willing to pay roughly 39.6% more for organic vegetables. In addition, the WTP for other political parties' supporters is significantly higher than that for the Green Party supporters. These results are consistent with our econometric estimation above.

We also report the mean and median ratios of WTP for organic vegetables from the predicted ratios gained from the above two different interval regressions. Compared with the raw data, some research underlines that the predicted values are more likely to indicate dependable information (Yu and Abler, 2010; Yu et al., 2014a). We hence discuss the results in the following section based on the predicted WTP ratios.

We can see the predicted values from two interval regressions are basically synonymous. On average, our findings indicate that supporters of the Green Party are willing to pay 32.6% more for organic vegetables in comparison with conventional vegetables. The number is relatively lower in contrast with the ratio of 46.8% given by

supporters of other political parties or no-party supporters. In addition, research findings highlight that the WTP in real markets is often slightly lower compared with that of in hypothetical markets (List and Shogren, 1998). It is possible that consumers in favour of the Green Party in the real world may have even a lower WTP for organic vegetables than the number in this study.

The Green Party is working to promote social movements and gain political power to ensure that everyone has equal access to organic food in the market, as they believe that organic food should not be a privilege for some individuals. For instance, the Green Party clearly stated that their goal for organic farming in Germany is 30% in 2030.

Though the Green Party actively promotes organic food in Germany, the high production costs could be an insurmountable trench. In order to reach the political goal of 30% organic farming in 2030, political slogans or pure regulations are not sufficient. As no chemical fertilizers or pesticides are allowed in organic farming, farmers have to increase labor or other expensive alternative inputs. In an aging society, the costs for organic food are expected to climb continuously, and farmers have to bear the increasing costs. Hence, more government subsidies to fill in the cost gap between organic and conventional food are necessary for promoting organic farming.

4.6 Conclusion

Many consumers nowadays increasingly pay attention to environmentally friendly products as environmental sustainability is being an imminent global challenge. The demand for organic food has been increasing all over the world (Paul et al., 2016; Rana and Paul, 2017). Although there has been a lot of research on WTP for organic food, few studies shed light on the linkage between political party support and WTP for organic vegetables. It is widely believed that social identity and social movements will change consumer preference and thus affect individual consumption behaviour through the political process. In light of this, based on the theory of social identity and social movements, this paper mainly studies the WTP for organic vegetables for the consumers who support the Green Party in Germany.

Environmental awareness is a vital motivating factor and a major reason to urge consumers to have a positive attitude towards organic vegetables (Makatouni, 2002; Valerian et al., 2011). The Green Party is a firm promoter of environmental protection. Based on the theory of social identity, consumers who support the Green Party shall have a higher WTP per se for organic vegetables due to their environmental protection awareness. However, on the other hand, the Green Party also pays attention to social justice, and believes that organic food should not be a privilege. In other words, the Green Party supporters also fight to make organic food more inclusive to the general public, and the Green Party supporters hence may have a lower WTP in this regard.

With use of the survey data from Germany in 2020, we find that the Green Party supporters have a significantly lower WTP for organic food (12% lower) in comparison with other political parties. This is consistent with our conceptual framework of social identity and social movements. The Green Party is actively promoting organic food production in Germany, and making organic food more inclusive in the future. However, the policy to promote organic food should offer farmers more subsidies to offset their high production costs.

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Tables and Figures

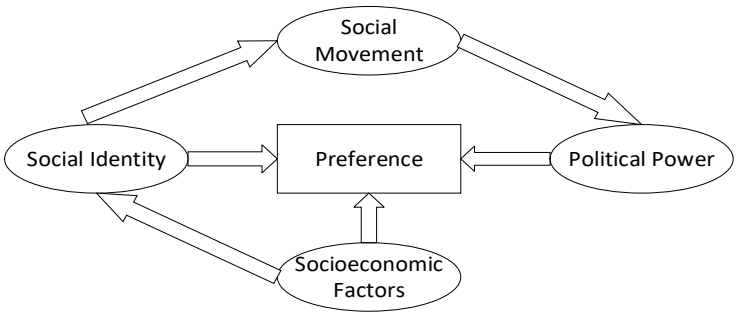

Figure 4.1 Social identity and consumer preference

Table 4.1 Descriptive statistics of main variables

Variables	Description	Mean	Std.Dev.
Gender	male=1, female=0	0.495	0.500
Marriage	married=1, unmarried=0	0.248	0.432
Area	live in urban areas=1, live in rural areas=0	0.668	0.471
Age	respondents' age	48.730	15.134
Family_size	the number of members in the family	2.188	1.839
Children	the number of children in the family	1.084	0.373
Employment	employed=1, unemployed or retirement =0	0.466	0.499
Income1	(monthly net family income≤1500 Euro)=1, otherwise=0	0.568	0.496
Income2	(1500 Euro<monthly net family income≤2500 Euro)=1, otherwise=0	0.306	0.461
Income3	(2500 Euro<monthly net family income)=1, otherwise=0	0.126	0.332
University	have a university education degree=1, otherwise=0	0.142	0.349
Liveplace	currently living in former east Germany=1, currently living in west Germany=0	0.658	0.475
German	native language is German=1, otherwise=0	0.954	0.209
the Green Party	the most supported political party is the Green Party=1, otherwise=0	0.175	0.380
CDU_CSU	the most supported political party is CDU/CSU=1, otherwise=0	0.175	0.380
SPD	the most supported political party is SPD =1, otherwise=0	0.142	0.349
Linke	the most supported political party is "Die Linke"=1, otherwise=0	0.155	0.362
FDP	the most supported political party is FDP=1, otherwise=0	0.020	0.140
AfD	the most supported political party is AfD=1, otherwise=0	0.118	0.323
Other	support other political party=1, otherwise=0	0.215	0.411

Table 4.2 Interval regression results

Variables	Model 1		Model 2	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
the Green Party	-0.120**	0.058	-0.122***	0.044
CDU_CSU	0.016	0.063	/	/
SPD	0.032	0.064	/	/
Linke	-0.001	0.065	/	/
FDP	-0.087	0.092	/	/
AfD	-0.029	0.069	/	/
Gender	0.038	0.038	0.033	0.037
Marriage	0.007	0.048	0.006	0.048
Area	0.062	0.038	0.064*	0.038
Age	0.002*	0.001	0.002*	0.001
Family_size	0.011	0.01	0.01	0.01
Children	0.021	0.045	0.021	0.046
Employment	0.085**	0.041	0.087**	0.041
Income1	0.06	0.061	0.06	0.06
Income2	0.025	0.06	0.026	0.059
University	-0.117**	0.048	-0.120***	0.047
Liveplace	0.016	0.039	0.018	0.039
German	-0.006	0.098	-0.007	0.097
Constant	0.172	0.143	0.168	0.141

Note: ***, **, and * denote 1%, 5%, and 10% statistical significance, respectively.

Table 4.3 Linear regression results

Variables	Model 3		Model 4	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
the Green Party	-0.154*	0.081	-0.149**	0.062
CDU_CSU	0.024	0.088	/	/
SPD	0.028	0.088	/	/
Linke	-0.01	0.091	/	/
FDP	-0.167	0.111	/	/
AfD	-0.052	0.097	/	/
Gender	0.049	0.053	0.04	0.051
Marriage	0.013	0.066	0.012	0.066
Area	0.087	0.054	0.090*	0.054
Age	0.003	0.002	0.003	0.002
Family_size	0.015	0.014	0.014	0.014
Children	0.015	0.062	0.016	0.062
Employment	0.105*	0.057	0.110*	0.056
Income1	0.079	0.085	0.08	0.083
Income2	0.027	0.083	0.028	0.082
University	-0.183***	0.063	-0.190***	0.061
Liveplace	0.014	0.054	0.017	0.054
German	-0.044	0.141	-0.045	0.138
Constant	0.25	0.199	0.237	0.196

Note: ***, **, and * denote 1%, 5%, and 10% statistical significance, respectively.

Table 4.4 Mean and median of WTP for organic vegetables

WTP	Obs	Mean		Median	t Test
		Ratio	Std. Dev.	Ratio	t
Raw data					
WTP-the Green Party	96	0.396	0.539	0.200	2.631***
WTP-other	453	0.572	0.605	0.400	
the Whole sample	549	0.541	0.597	0.400	/
Predicted values from interval regression only including the Green Party					
WTP-the Green Party	96	0.326	0.082	0.334	17.631***
WTP-other	453	0.468	0.069	0.473	
the Whole sample	549	0.443	0.090	0.460	/
Predicted values from interval regression including more political parties					
WTP-the Green Party	96	0.326	0.080	0.335	16.918***
WTP-other	453	0.468	0.074	0.472	
the Whole sample	549	0.443	0.092	0.454	/

Notes: 1. ***denotes 1% statistical significance, respectively.

2. Test for the different WTP of organic vegetables between the Green Party and other political parties. (H_0: the Mean of the Green Party's WTP < the Mean of other political parties' WTP).

Chapter 5 The Impacts of Consumers' Perceptions and Economic Preferences on the Willingness to Pay for Meat Alternatives in China[16]

5.1 Introduction

Traditional meat production is resource-intensive and environmentally harmful, and meat consumption could result in public health issues such as animal-transmitted pandemics, antibiotic resistance, heart diseases, and obesity (Bryant and Barnett, 2018; Bryant et al., 2019; Liu et al., 2021). It is expected that the demand for meat may keep increasing due to the rapid economic growth over the coming decades in China (Bryant et al., 2019). To meet the need while minimizing the negative effects from meat production and consumption, meat alternatives (so-called artificial meat) including plant-based meat and cultured meat can serve as a more sustainable choice to develop sustainable meat production and reduce the demand for meat from farm animals in the near future (Yuan et al., 2019; Zhang et al., 2020; Liu et al., 2021). Therefore, in contrast with conventional animal livestock systems, meat alternatives can protect environment, save energy, improve food safety and public health (Bonny et al., 2015; Zhang et al., 2020). Moreover, the developmental wave of meat alternatives is the change direction of the meat industry in the near future (Zhang et al., 2020).

Given the potential benefits that meat alternatives can bring to both meat consumers and industries, understanding the factors of the willingness to pay (WTP) for meat alternatives becomes necessary. Although there are many factors worth investigating, this paper focuses our research scope within consumers' perceptions and economic preferences which have been highlighted as the main drivers for consumers' decision making (Falk et al., 2018; Zhang et al., 2020; Lades et al., 2021; Malavalli et

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al., 2021). This paper has two main implications. First, it can help policy designs to effectively promote the development of meat alternatives market. Second, eliciting WTP could help us comprehend societal acceptance of those meat substitutes, capture potential public preferences, and even suggest more potential commercial opportunities (Meyer et al., 2018; Song and Lee, 2018; J. Kantor and B. Kantor, 2021).

Consumers may decide whether or not to buy meat substitutes based on their perceptions (Zhang et al., 2020). Additionally, the current literature has found that difference in economic preferences is linked to varied economic outcomes and behaviours because preferences such as risk and reciprocity tend to have a driving force for individual decision making (Falk et al., 2018). However, the effects of consumers' perceptions and economic preference on WTP have been under-investigated in China given their effects on the acceptance, purchase intension and commercial success of meat alternatives (Falk et al., 2018; Zhang et al., 2020; Lades et al., 2021; Liu et al., 2021; Malavalli et al., 2021). Therefore, our paper adds to literature by providing another empirical evidence of the effects of these two factors on WTP for meat alternatives in China. Based on an online survey, this study investigates how consumers' perceptions and economic preferences influence the Chinese consumers' WTP for meat alternatives, which may provide valuable insights into the Chinese meat alternatives market in the future, and fill in a gap in the literature on the WTP for plant-based meat and cultured meat in China.

The rest parts of this study are structured as follows. In the second section, a brief review of the current literature and the conceptual framework are described. Section three presents the survey design, data and empirical strategy. Results and policy implications are discussed in section four. Section five gives concluding remarks.

5.2 Literature Review and Conceptual Framework

5.2.1 Literature Review

Ample studies have explored the impacts of consumers' perceptions on meat alternatives but their research population has been mainly focused on USA or European

consumers (e.g. Hocquette et al., 2015; Verbeke et al., 2015a; Wilks and Phillips, 2017; Bryant and Dillard, 2019; Bryant et al., 2019). Since the first lab-grown burger was unveiled in London in 2013, European consumers have shown increasing interest in in-vitro meat (IVM) and their perceptions have been found to be positively related to the acceptance of IVM (Hocquette et al., 2015; Verbeke et al., 2015b; Mancini and Antonioli, 2019). Only a small number of American consumers are willing to purchase IVM regularly as an alternative to farmed meat due to their concerns over the limited taste and unnatural production (Wilks and Phillips, 2017). To the best of our knowledge, limited studies have conducted surveys of consumer perception of plant-based and cultured meat in China. Previous literature only focuses on the urban population, cross-country comparisons, and descriptive analysis of consumer's attitude towards cultured meat in China (Bekker et al., 2017; Bryant et al., 2019; Zhang et al., 2020; Liu et al., 2021). However, these findings are not representative of general conclusions on the influence of consumers' perceptions on the WTP for meat alternatives in China.

It is concluded that consumers' perceptions have strong influences on the purchase intention and consumption behaviours of meat alternatives (Zhang et al., 2020; Carlsson et al., 2021; Liu et al., 2021; Malavalli et al., 2021). On the one hand, the purchase decision is mainly affected by the concern over meat substitutes in terms of perceived health and safety risk from the technology involved in the production (Verbeke et al., 2015a; Liu et al., 2021; Malavalli et al., 2021). Some researchers suggest that strong health and safety concern are correlated with purchase intentions towards meat alternatives (Laestadius, 2015; Shaw and Iomaire, 2019; Carlsson et al., 2021). Also, the purchase is associated with consumers' perceptions such as environmental awareness and the protection of animal welfare (Laestadius, 2015; Wilks and Phillips, 2017; Bryant et al., 2019; Shaw and Iomaire, 2019; Carlsson et al., 2021). Consumers who consider plant-based or cultured meat to be beneficial for the environment and animal welfare, tend to have higher inclinations to meat alternatives, as opposed to those advocating for traditional meat (Wilks and Phillips, 2017; Liu et al., 2021). In general, consumers with higher levels of environmental awareness and animal welfare awareness are more possible to pay more or buy meat alternatives with the

environmental and animal-friendly nature (Bryant et al., 2019; Carlsson et al., 2021).

On the other hand, previous empirical studies have found that individual preference measures are related consumers' decisions and behaviours. For example, individuals' tendency to take risks is related to investment decisions and health outcomes (Anderson and Mellor, 2008; Dohmen et al., 2011). Other measures such as altruism, positive reciprocity, negative reciprocity, and trust are also found to affect economic performances such as the levels of charitable giving and subjective wellbeing (Dohmen et al., 2009; Guiso et al., 2009; DellaVigna et al., 2012; Franzen and Vogl, 2013; Ziegler, 2021). In addition, Lades et al. (2021) elicits seven different economic preferences including risk taking, patience, present bias, altruism, positive reciprocity, negative reciprocity and trust, to explore whether these preference measures predict everyday pro-environmental behaviours, and finds that only altruism works.

However, no study investigates how economic preferences influence the WTP for meat alternatives, though it is expected that individual preference measures could have effects on the consumers' WTP for plant-based meat and cultured meat. To be more specific, consuming meat alternatives may bring uncertain benefits such as reducing environmental pollution, which suggests the linkage with the preference for risk taking; In addition, developing the production of meat alternatives has positive externalities in the future, implying the link to time preference (patience); Altruism, trust and reciprocity have been proved to be associated with environmentally friendly behaviours (Clark et al., 2003; Kotchen and Moore, 2007; Tam and Chan, 2018; Ziegler, 2021), while consuming meat alternatives can be referred to as an environmentally friendly behaviour in a sense. Therefore, this study aims to systematically examine whether economic preferences influence the consumers' WTP for plant-based meat and cultured meat.

Lastly, empirical studies suggest that some demographic variables such as age, gender, education level, vegetarian and household income, are also associated with the WTP for meat alternatives (Carlsson et al., 2021; J. Kantor and B. Kantor, 2021; Liu et al., 2021).

5.2.2 Conceptual Framework

First, we employ three variables including environment, food safety and gym, to capture consumers' perceptions. In Table 5.1, we have shown no strong correlations among these three variables via the covariance matrix for consumers' perceptions. Additionally, we have used Variance Inflation Factor (VIF) as the indicator (the 'collin' command in Stata 15) to check collinearity among these three variables. Normally, there is no collinearity if VIF<10 and tolerance>0.1 simultaneously. Additionally, the study of Akinwande et al. (2015) indicates that the number of VIF should be lower than 5. Further, Yang et al. (2011) finds that the collinearity may be a problem if the condition number is more than 30[17]. The results are shown in Table 5.2 and no substantial collinearity has been found between these three variables. Therefore, these three variables can be incorporated into regressions jointly.

[Insert Table 5.1 and 5.2 here]

Based on the relevant studies on consumers' attitudes related to environmental awareness, safety and health perception, we have the following three hypotheses. First, consumers with more concern about environmental protection will pay more for meat alternatives because environmental awareness is positively related to the purchase intention of meat substitutes (Mancini and Antonioli, 2019; Carlsson et al., 2021; Liu et al., 2021; Malavalli et al., 2021). Second, consumers satisfied with food safety are more likely to believe in the safety of meat alternatives. Since concerning over artificial meat is negatively linked with declining purchase motivation (Malavalli et al., 2021), so greater satisfaction with the current status of food safety may result in a higher WTP for meat alternatives. Third, we use the degree of preferring fitness to capture consumers' health concern. Some studies have investigated that there is a positive linkage between health awareness and the WTP for meat alternatives (Bryant et al., 2019; Carlsson et al., 2021; Malavalli et al., 2021). Consequently, we assume that a higher level of preferring gym would make consumers pay more for meat alternatives.

[17]The 'coldiag2' command in Stata 15 is employed to confirm the results of collinearity diagnostics by calculating 'condition number using scaled variables'.

Moreover, researchers have proposed that focusing on a single preference measure may misrepresent the true relationship between economic preferences and consumer decisions which could be influenced by multiple preferences simultaneously (Dohmen et al., 2008, 2010; Albanese et al., 2017; Lades et al., 2021; Ziegler, 2021). To overcome this limitation, this paper incorporates all six preference measures (risk attitude, trust, positive reciprocity, negative reciprocity, patience and altruism) simultaneously into the framework of analyzing the consumers' WTP for meat alternatives to identify the impact of a single preference measure. Similarly, we show the covariance matrix for preference measures in Table 5.3, and also use the 'collin' and 'coldiag2' commands in Stata 15 to test the collinearity among six preference measures and present results in Table 5.2. We find that no strong correlations among these variables and that the multicollinearity problem can be ignored. Therefore, including all economic preferences in the one regression model can be feasible.

[Insert Table 5.3 here]

Several studies have found positive influences of risk-taking preference and time preference on pro-environmental decisions, trying new things or activities generating uncertain benefits in the long term (Epper et al., 2011; Brody et al., 2012; Qiu et al., 2014; Fischbacher et al., 2021), while meat alternatives regarded as novel goods have the characteristics of environmental protection, saving energy and uncertainty. Correspondingly, the WTP for meat alternatives is a manifestation of challenging new things or accepting the general uncertainty about consuming meat alternatives, which may be preferred by individuals with high preferences for risk and patience. Therefore, we would expect that higher levels of risk taking and patience would lead to a higher WTP for meat alternatives. Furthermore, since trust has been suggested to positively affect the WTP for environmental protection (Franzen and Vogl, 2013), it is possible that trust can be positively connected with higher WTP for meat alternatives. However, Ziegler (2021) has also found that environmental values could be negatively influenced by trust, while meat alternatives are good for the environment. Following this logic, consumers with a high level of trust would prefer traditional meat rather than artificial meat. Consequently, the directional effect of trust on the WTP for meat substitutes may

be ambiguous. With respect to higher levels of reciprocity and altruism, these measures are more likely to facilitate the protection of animal welfare (Ziegler, 2021) and promote food consumption that is environmentally friendly. Thus, we would anticipate that reciprocity and altruism can positively influence the WTP for meat alternatives.

Figure 5.1 presents a framework summarizing the hypotheses we have made above over the effects of consumers' perceptions and economic preferences on the WTP for meat alternatives.

[Insert Figure 5.1 here]

5.3 Data Description and Empirical Strategy

5.3.1 Samples

This paper relies on an online survey conducted via a Chinese website (https://www.wjx.cn/) in 2020. The online survey is a predominant research approach to conducting consumer science studies (Malavalli et al., 2021). At the beginning of the questionnaire, some introductory information displays as follows: 'In recent years, meat alternatives have gradually entered the Chinese food market. Starbucks, KFC and some other businesses have supplied consumers with some types of food produced by meat alternatives with characteristics of reducing the risk of spreading animal diseases and promoting health, protecting the environment, and saving energy, which are attractive to consumers. In general, meat alternatives could be an appropriate substitute for traditional meat and consist of plant-based meat and cultured meat. Plant-based meat is also called bean protein meat, which is mainly made from pea protein. It is rich in protein, low in fat, and hence healthy. Cultured meat is made from stem cells from farmed animals by modern tissue engineering techniques, which is almost the same as real meat. Compared to conventional meat, plant-based meat and cultured meat are both environmentally friendly, energy saving, ethical and animal friendly, and can reduce emissions of greenhouse gas. This survey aims to learn about the consumers' willingness to pay for meat alternatives and is completely anonymous and voluntary. Please fill in the questionnaire truthfully based on your actual situation and opinions!'.

Previous literature suggests that such prior information could educate, rather than affect respondents, thus improving the accuracy of respondents' answers to the questions (Verbeke et al., 2015a, 2015b; Malavalli et al., 2021).

Then, respondents in our online survey answered questions about WTP for meat alternatives, consumers' perceptions and individual economic preference measures. In addition, we also recorded demographic variables for each individual. We collected 1060 respondents in total who were randomly selected from different cities in China. After purging incomplete or unqualified responses, we have 1021 respondents left aging over 16. In addition, our dataset consists of 480 women and 541 men.

5.3.2 Survey Design

Firstly, we set three questions about the attitudes towards the environment, food safety and gym to capture consumers' perceptions (see Table 5.4). Additionally, we design questions to elicit six economic preferences (risk, trust, positive reciprocity, negative reciprocity, patience and altruism) based on Falk et al. (2018) and show the detailed descriptions of these individual preference measures in Table 5.4. These preference measures are expected to capture useful and accurate information about participants' underlying preferences (Lades et al., 2021). Moreover, empirical studies have demonstrated that these preference measures can predict a wide range of consumer behaviours and decisions, such as smoking, saving behaviour and volunteering (Falk et al., 2018).

Risk measures how willing consumers are to take risks in general (Falk et al., 2018; Ziegler, 2021). It is particularly significant for predicting pro-environmental behaviours typically generating uncertain benefits (Lades et al., 2021). Based on the smaller environmental footprints in contrast with conventional food items, consuming meat alternatives could be regarded as a type of pro-environmental behaviours. To some extent, consuming meat alternatives is risky because the benefits from it are uncertain and its price can change substantially, e.g. due to uncertain production costs in the future. In our survey, participants conduct a self-assessment about risk preference on an 11-

point Likert scale with ‘0 representing completely unwilling to take risks and 10 representing very willing to take risks’.

The identification of trust is the belief that others could contribute to the society or environment (Meyer and Liebe, 2010; Falk et al., 2018; Ziegler, 2021). It has been examined that trust is linked to pro-environmental behaviours (Tam and Chan, 2018). We measure trust by asking respondents about the extent to the statement ‘I assume that individuals have only the best intentions’. It is also an 11-point Likert scale with ‘0 not describing the respondent at all and 10 describing the respondent perfectly’.

Positive reciprocity is manifested in how individuals give to kindness, while negative reciprocity refers to how individuals revenge themselves on the harm caused by others (Caliendo et al., 2012; Falk et al., 2018; Ziegler, 2021). People with more positive reciprocity prefer to positively react to perceived pleasures of nature and animals (Ziegler, 2021). Additionally, the effect of negative reciprocity on behavioural outcomes may be ambiguous (Lades et al., 2021). Variables for positive and negative reciprocity measuring the willingness to respond to kindness and unkindness respectively, are both answered on an 11-point Likert scale with ‘0 representing completely unwilling to do so and 10 representing very willing to do so’.

Patience preference is based on the situation where how willing participants are to receive more benefits in the future by giving up current interests. Generally, patience is correlated with more concern about well-being in the future (Meyer and Liebe, 2010; Caliendo et al., 2012). Consuming meat alternatives as a type of pro-environmental behaviours may be costly at present and beneficial in the future, which can be affected by the preference for patience. Some studies have supported the relationship between patience and pro-environmental behaviours (Fuerst and Singh, 2018; Lades et al., 2021). This variable ranges from 0 (completely unwilling to give up current benefits) to 10 (very willing to give up current benefits).

In our empirical analysis, we define the variable ‘altruism’ as the amount donated to help others in need by participants. Lades et al. (2021) has found that altruism could have a positive influence on pro-environmental behaviours. The value of altruism ranges from 0 to 1000 yuan and a larger amount of donation means more altruism.

Common methods to measure WTP for non-market goods include contingent valuation methods (CVM), discrete choice experiments and experimental auction (Yu et al., 2014). The payment card approach as a type of CVM method is applied in our survey due to its flexibility when survey respondents can not specify their real WTP values. It collects respondents' WTP values by separating potential WTP into different intervals. Therefore, our survey designs WTP questions as follows. First, given that the major type of meat consumed among Chinese is pork, the WTP question for plant-based meat is 'compared with the current market price of pork, how much are you willing to pay for plant-based meat?' and the choices of price for plant-based meat in the payment card have nine intervals: [-100%,-80%], (-80%,-50%], (-50%,-20%], (-20%,-0), 0, (0,20%], (20%,50%], (50%,100%] and more than 100%. Second, the WTP question for cultured meat is 'compared with the current market price of normal pork, normal beef and normal chicken, how much are you willing to pay for cultured pork, cultured beef and cultured chicken respectively?' and intervals are [-100%,-80%], (-80%,-50%], (-50%,-20%], (-20%,-0), 0, (0,20%], (20%,50%], (50%,100%] and more than 100%.

5.3.3 Empirical Strategy

We specify the following regression model:

$$WTP_i = \alpha_0 + \gamma X_i + Z_i\beta + \mu_i \quad (5.1)$$

Where WTP_i is the WTP value for meat alternatives for the observation i, and it is unobserved but $WTP_{1i} \leq WTP_i \leq WTP_{2i}$ in this study ($[WTP_{1j}, WTP_{2j}]$ is an interval); X_i are independent variables of interest and γ are their corresponding coefficients (when we study the impacts of consumers' perceptions on the WTP for meat alternatives, X_i are environment, food safety and gym; when we study the impacts of economic preferences on the WTP for meat alternatives, X_i are risk, trust, positive reciprocity, negative reciprocity, patience and altruism); Z_i is a vector of other socioeconomic variables (age, gender, education, employment, marriage, vegetarian, income2, income3, family size, children, old people) and the corresponding coefficient vector is β. μ_i is the error term. The descriptive statistics for the main variables

involved in our study are summarized in Table 5.4.

[Insert Table 5.4 here]

We use the interval regression approach to estimate Equation 5.1. This approach was proposed by Amemiya (1973) and has been widely used to estimate interval data (Davidson and MacKinnon, 2004, Section 11.6; Tian et al. 2011; Yu et al., 2014). Additionally, Ordinary Least Squares (OLS) is employed to do the robust check, where the true WTP value is point data equal to the middle-point value in one closed interval and equivalent to the sum of the lower boundary plus the half distance of the adjacent interval for the left-censored data (Yang et al., 2013; Yu et al., 2014).

5.4 Results Discussion and Policy Implications

5.4.1 The effects of Consumers' Perceptions on the WTP for Meat Alternatives

The relationship between consumers' perceptions and the WTP for meat alternatives is examined by interval regression analysis. The results in Table 5.5 show that all variables of consumers' perceptions significantly affect the WTP for meat alternatives, which are consistent with results in Table B1 presenting interval regressions including only three variables of consumers' perceptions as independent variables.

[Insert Table 5.5 here]

Specifically, people caring more about environmental protection are only willing to pay more for plant-based meat. The conclusion is in line with some studies which have also found that there is a significantly positive correlation between the environmental variable and the purchase intention of meat substitutes (Mancini and Antonioli, 2019; Carlsson et al., 2021; Liu et al., 2021; Malavalli et al., 2021). Meanwhile, the more familiarity with meat substitutes consumers have, the higher acceptance they reveal (Bryant et al., 2019; Liu et al., 2021). Therefore, one possible explanation for the insignificant effect of environmental awareness on the WTP for cultured meat is food neophobia (Ortega et al., 2022). That is to say, Chinese people are too unfamiliar with cultured meat to purchase it even if they are environmentally conscious. Furthermore, consumers have higher WTP for two types of meat alternatives

if they are more satisfied with the current status of food safety. This is consistent with previously empirical evidence that worrying about safety risks of artificial meat could decrease purchase intentions (Malavalli et al., 2021). Besides, residents showing more satisfaction with the food market are expected to have more confidence and trust in meat alternatives. Thus, they are more likely to pay more for meat alternatives. Lastly, liking fitness is a manifestation of health concern, while the effect of health awareness on the WTP for meat alternatives has been proved to be significantly positive (Bryant et al., 2019; Carlsson et al., 2021; Malavalli et al., 2021). As a result, we find that consumers preferring gym have a higher level of WTP for both plant-based meat and cultured meat.

5.4.2 Effects of Economic Preferences on the WTP for Meat Alternatives

We explore potential effects on the WTP for meat alternatives of a set of economic preferences by interval regressions. Table 5.6 presents results containing six preference measures and other control variables. We also report results of interval regression models with only six economic preferences as independent variables (see Table B2). Due to the similarity of results, we will focus on results in Table 5.6 to explain the power of economic preferences. On the whole, our results strongly indicate that risk preference, trust, positive and negative reciprocity could influence the Chinese consumers' WTP for meat substitutes, but patience and altruism are not linked to the WTP for meat alternatives. Moreover, our results provide suggestive evidence of economic preferences differently affecting various kinds of meat substitutes.

[Insert Table 5.6 here]

Specifically, residents with more risk-taking preference have higher WTP for all meat alternatives, which is consistent with our expectation. Indeed, the literature has found that the preference for risk could influence economic outcomes and individual behaviours (Qiu et al., 2014; Falk et al., 2018; He et al., 2019). As sustainable and environmentally friendly alternatives, meat substitutes especially cell-based meat, are novel and energy-saving food products for Chinese consumers. Normally, people with

more preference for risk are braver to try new things and have a more positive attitude towards energy-saving renovation decisions (Fischbacher et al., 2021). Additionally, how consumers pay for meat alternatives is an economic decision with some uncertainty reflected by the level of the maximum WTP, while risk-taking preference is positively linked to decisions generating uncertain results (Qiu et al., 2014). Consequently, Chinese residents would like to pay more for plant-based meat and cell-based meat if they prefer risks.

Additionally, trust is significantly and negatively correlated with the WTP for plant-based meat instead of cultured meat. In our daily life, consumers may prefer more conventional food such as meat if they have a high level of trust, so they are willing to pay less for plant-based meat. Trust is rather abstract and generally defined by the agreement to the statement 'People have only the best intention' (Korff and Steffen, 2019). As aforementioned, strong trust may lead to the low acceptance of novel meat alternatives. In addition, trust is negatively correlated with environmental values (Ziegler, 2021), while meat alternatives are environmentally friendly. Hence, trust is a negative factor in the WTP for vegetarian meat.

Finally, positive reciprocity has a significantly positive effect on the WTP for plant-based meat, but does not influence the WTP for cultured meat, while participants with a higher negative reciprocity score are willing to pay more for cultured pork. These associations between different reciprocity and consumer decisions have been proved by previous literature (Falk et al., 2018). Specifically, positive reciprocity measures how people are inclined to return favours, whereas negative reciprocity captures the attitude towards taking revenge when people are treated unfairly (Korff and Steffen, 2019). As a result, it is reasonable that positive and negative reciprocity have differential effects on the WTP for various types of meat alternatives. Additionally, positive reciprocity may be a proxy for prosocial behaviour, which is related to subjects having a more pronounced sense of positive externalities such as positive consequences on the environment, so it is positively correlated with the WTP for plant-based meat.

Nevertheless, the estimation results in Table 5.6 recommend that patience and altruism do not significantly affect the WTP for meat alternatives. Patience is the

assessment of time discount consideration defined as the willingness to forego short-term gains for higher profits in the future (Korff and Steffen, 2019). It is connected with the individual perspective on future well-being and with more concern for future generations (Meyer and Liebe, 2010). Altruism represents how much people care about others' well-being (Korff and Steffen, 2019). Consumers in our survey may fail to take the future or others' well-being into account when they choose the price interval, suggesting no effects on the WTP for both vegetarian and cultivated meat.

5.4.3 Effects of Other Control Variables on the WTP for Meat Alternatives

Tables 5.5 and 5.6 also present results of demographic variables including age, employment, marriage, income and older people which are all statistically significant. Compare to young people, elders have lower WTP for meat alternatives, which is in line with other studies (Slade, 2018; Zhang et al., 2020). It can be explained that old consumers might not have the essential knowledge about novel meat alternatives to enable them to pay for meat substitutes (Liu et al., 2013; Carlsson et al., 2021; Liu et al., 2021). This may explain why households with more old individuals have lower WTP for cultured pork. Also, employed or married consumers would like to pay more for meat alternatives. Moreover, the higher income group of individuals has higher WTP for meat alternatives, which is consistent with one previous study suggesting those with high income are more likely to have a higher purchase likelihood of meat alternatives (Bryant et al., 2019). It is possible that high-income consumers probably have broader horizons, while the breadth of vision could bring about more positive attitudes towards meat alternatives (Zhang et al., 2020).

5.4.4 Robustness Check

For the robust check, we use the OLS to estimate Equation 5.1 and present effects of consumers' perceptions and economic preferences in Table 5.7 and 5.8 respectively, controlling the same set of demographic variables in the interval regressions.

[Insert Table 5.7 and 5.8 here]

We can find that the estimated results of OLS coincide with the interval regressions above. Indeed, consumers' perceptions and economic preferences have strong effects on the Chinese residents' WTP for meat alternatives.

5.4.5 Policy Implications

Previous literature suggests that the predicted WTP can play an important role in policy implications (Thompson, 1998; Yu et al., 2014). Table 5.9 reports the means and medians of the WTP for meat alternatives.

[Insert Table 5.9 here]

For the raw data, the definition of the true WTP ratios is synonymous with that in the OLS analysis. Chinese consumers will pay roughly 27% less for plant-based meat than traditional pork. Similarly, they prefer lower prices for cultured meat than traditional meat. Values of the predicted WTP from interval regressions by consumers' perceptions and economic preferences also imply evidence that consumers would not pay more for plant-based and cultured meat than conventional meat. Therefore, commercial companies should be more deliberate when setting the prices for meat alternatives based on the price of conventional meat. Additionally, since the cost of producing artificial meat is still high (Zhang et al., 2020), commercial business subsidies can help promote the development of sustainable meat alternatives. Lastly, propagating more information to the public may be an effective way to make people accept and consume artificial meat (Zhang et al., 2020).

Additionally, the regression result shows that risk-averse consumers might not be willing to take the risk of consuming meat alternatives due to uncertainty for environmental outcomes and the variance in food quality, even though meat alternatives could bring about positive expected returns from a societal perspective. Therefore, future policies could focus on reducing such individual risks. First, the government should promote positive externalities of the environment made by meat alternatives. The positive linkage between positive reciprocity and the WTP for meat alternatives also suggests this measure. Second, to reduce the risk resulting from the variance of

food quality, relevant organizations could provide detailed information on the quality of meat alternatives for the general public.

5.5 Conclusion

Conventional meat production is linked to global issues of greenhouse gas emissions, environmental pollution, public health risks and animal suffering (Bryant et al., 2019). In recent years, we have seen that more concern about the acceptance of meat substitutes as a viable way of replacing traditional meat. However, only a few scholars have investigated the effects of consumers' perceptions and economic preferences on the WTP for plant-based and cultured meat in China. Consequently, this study explores how consumers' perceptions affect the Chinese consumers' WTP for meat alternatives. Additionally, we firstly incorporate preference structures of risk attitude, trust, reciprocity, patience and altruism into the framework of the WTP for meat alternatives and analyze their impacts among Chinese residents.

Generally, we have two main conclusions as follows. First, we find that the WTP for meat alternatives is affected by consumers' perceptions of environmental protection, food safety and fitness. Second, there exist relationships between economic preferences and the WTP for meat substitutes, and different preference measures have various impacts on the consumers' WTP for plant-based meat, cultured pork, cultured beef and cultured chicken. Of particular importance is that residents with a higher risk score are more likely to pay more for both plant-based meat and cultured meat.

Our research findings may contribute to the literature studying the linkage between consumers' perceptions or economic preferences and the WTP for meat alternatives. Moreover, this study has some potential implications for policy making aiming to promote the development of meat alternatives. Policy interventions should lay stress on advertising the environmentally friendly attributes of meat alternatives, and it is beneficial for producers to target consumers with a high level of risk preference or more positive reciprocity. Additionally, it is necessary to set reasonable prices for both plant-based and cultured meat.

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Figures and Tables

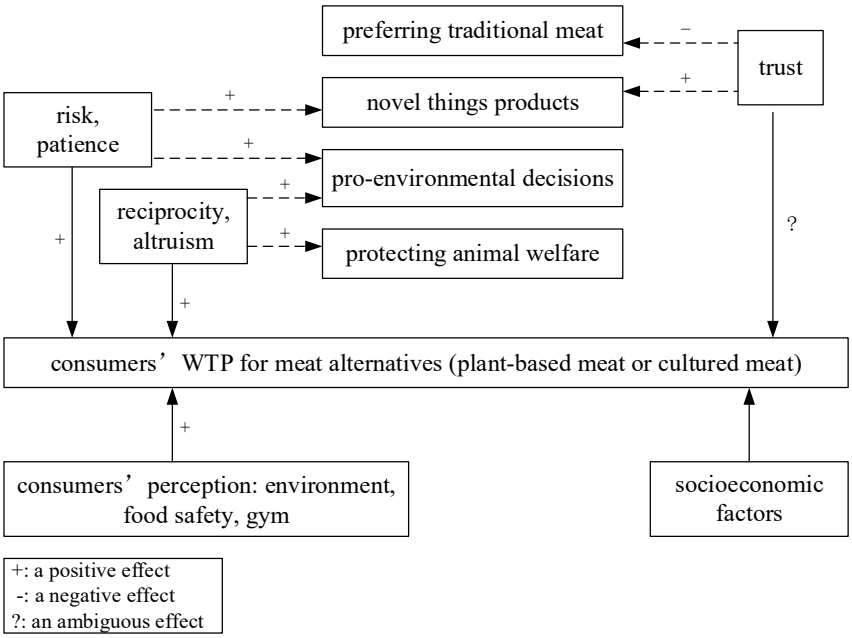

Figure 5.1 Conceptual framework to test the hypotheses

Table 5.1 Covariance matrix for consumers' perceptions

Variables	Environment	Food safety	Gym
Environment	0.420	/	/
Food safety	0.118	1.763	/
Gym	0.421	0.324	6.052

Table 5.2 Collinearity diagnostics by VIF

Variables	VIF	Tolerance	R^2
Consumers' perceptions:			
Environment	1.090	0.918	0.082
Food safety	1.020	0.977	0.023
Gym	1.080	0.926	0.074
Mean VIF		1.060	
Condition number using scaled variables = 14.97			
Economic preferences:			
Risk	1.160	0.860	0.141
Trust	1.230	0.811	0.189
Pos. reciprocity	1.360	0.737	0.263
Neg. reciprocity	1.070	0.931	0.069
Patience	1.130	0.885	0.115
Altruism	1.150	0.869	0.131
Mean VIF		1.180	
Condition number using scaled variables = 13.26			

Table 5.3 Covariance matrix for economic preferences

Variables	Risk	Trust	Pos. reciprocity	Neg. reciprocity	Patience	Altruism
Risk	4.992	/	/	/	/	/
Trust	0.984	6.420	/	/	/	/
Pos. reciprocity	1.301	2.304	5.377	/	/	/
Neg. reciprocity	0.994	-0.777	-0.062	6.331	/	/
Patience	1.300	0.609	1.303	0.604	4.904	/
Altruism	70.038	188.309	233.745	-73.569	90.557	95396.200

Table 5.4 Descriptive statistics of main variables

Variables	Definition and Description	Mean	Std.Dev.
Consumers' perceptions:			
Environment	the degree of concern about protecting the environment: not concerned=1, a little concerned=2, generally concerned=3, very concerned=4	3.420	0.648
Food safety	the degree of satisfaction with the current food safety status: very dissatisfied=1, dissatisfied=2, somewhat dissatisfied=3, generally satisfied=4, somewhat satisfied=5, satisfied=6, very satisfied=7	3.907	1.328
Gym	the degree of liking gym: an integer from 0 to 10, where 0 means "dislike completely" and 10 means "like very much"	6.479	2.460
Economic preferences:			
Risk	the willingness to take risks: an integer from 0 to 10, where 0 means "completely unwilling" and 10 means "very willing"	4.606	2.234
Trust	whether the respondent is the person who assumes that people have only the best intentions: an integer from 0 to 10, 0 means "does not describe me at all" and 10 means "describes me perfectly"	7.039	2.534
Pos. reciprocity	positive reciprocity - the willingness to give to good causes without expecting anything in return: an integer from 0 to 10, where 0 means "completely unwilling" and 10 means "very willing"	6.700	2.319
Neg. reciprocity	negative reciprocity - the willingness to act as the way that "If I am treated very unjustly, I will take revenge at the first occasion, even if there is a cost to do so": an integer from 0 to 10, where 0 means "completely unwilling" and 10 means "very willing"	4.309	2.516
Patience	the willingness to give up something that is beneficial for you today in order to benefit more from that in the future: an integer from 0 to 10, where 0 means "completely unwilling" and 10 means "very willing"	7.006	2.214

Altruism	If you get 1000 yuan by accident, the willingness to donate to help those in need: a scale from 0 to 1000 yuan	489.944	308.863
Other control variables:			
Age	respondents' age	28.578	8.198
Gender	male=1, female=0	0.530	0.499
Education	primary school or below=1, secondary school=2, tertiary education or above=3	2.897	0.313
Employment	employed or retirement=1, unemployed=0	0.976	0.155
Marriage	married=1, unmarried or other=0	0.483	0.500
Vegetarian	the respondent is a vegetarian=1, other=0	0.086	0.281
Income1	(monthly family income≤5000 yuan)=1, otherwise=0	0.452	0.498
Income2	(5000 yuan<monthly family income≤10000 yuan)=1, otherwise=0	0.365	0.482
Income3	(10000 yuan<monthly family income)=1, otherwise=0	0.182	0.386
Family size	the number of members in the family	4.210	1.317
Children	the number of children in the family	0.410	0.593
Old people	the number of old people in the family	1.259	1.205

Table 5.5 Interval regression results of consumers' perceptions

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
Environment	2.557*	1.750	0.243	0.150	0.576	0.360	0.146	0.090
Food safety	3.304***	4.170	3.580***	4.490	3.137***	3.790	3.557***	4.450
Gym	0.758*	1.920	0.857**	2.060	0.983**	2.310	0.984**	2.290
Age	-0.650***	-3.900	-0.548***	-3.230	-0.666***	-3.840	-0.512***	-2.650
Gender	-2.954	-1.640	-0.422	-0.230	-3.956**	-2.060	2.044	1.060
Education	0.428	0.120	2.764	0.740	3.532	0.950	-1.846	-0.480
Employment	14.651**	2.090	11.229	1.420	14.302*	1.830	13.366*	1.690
Marriage	6.915**	2.310	4.737	1.640	6.708**	2.210	3.098	1.020
Vegetarian	4.978	1.370	5.304	1.460	3.962	1.140	5.382	1.470
Income2	8.463***	3.760	5.415**	2.410	4.455*	1.960	5.227**	2.150
Income3	8.009***	2.610	7.728**	2.590	4.351	1.430	7.879**	2.560
Family size	0.741	0.840	-0.106	-0.120	0.262	0.290	-0.718	-0.790
Children	-1.577	-0.800	-1.899	-0.940	-1.464	-0.720	-2.002	-0.990
Old people	-1.084	-1.320	-1.470*	-1.770	-1.207	-1.360	-0.239	-0.270
Constant	-58.401***	-4.130	-48.258***	-3.110	-46.597***	-3.080	-42.345***	-2.790
Observation	1021		1021		1021		1021	
Wald test	88.18***		62.51***		59.85***		57.45***	

Note: ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table 5.6 Interval regression results of economic preferences

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
Risk	1.767***	3.810	1.308***	2.640	1.739***	3.510	1.481***	2.830
Trust	-1.177***	-3.000	-0.048	-0.110	-0.177	-0.430	0.116	0.270
Pos. reciprocity	1.215***	2.690	0.291	0.650	0.347	0.730	-0.242	-0.520
Neg. reciprocity	0.488	1.220	0.990**	2.280	0.621	1.560	0.732	1.620
Patience	-0.405	-0.870	-0.342	-0.690	0.250	0.510	0.318	0.610
Altruism	0.002	0.520	-0.003	-0.800	-0.004	-1.130	-0.001	-0.320
Age	-0.734***	-4.300	-0.599***	-3.330	-0.696***	-3.830	-0.548***	-2.750
Gender	-2.672	-1.480	-0.273	-0.150	-4.080**	-2.160	2.015	1.040
Education	0.725	0.210	2.458	0.650	2.841	0.760	-2.351	-0.590
Employment	12.804*	1.920	11.420	1.460	13.257*	1.720	14.025*	1.800
Marriage	7.436**	2.480	4.687	1.580	6.631**	2.170	3.119	1.030
Vegetarian	7.083*	1.950	8.071**	2.170	6.288*	1.800	7.881**	2.100
Income2	8.247***	3.600	5.246**	2.270	4.106*	1.780	5.089**	2.050
Income3	7.817 **	2.510	7.706**	2.520	3.841	1.230	7.579**	2.410
Family size	1.156	1.320	0.376	0.410	0.739	0.820	-0.320	-0.360
Children	-1.183	-0.600	-2.026	-0.990	-1.447	-0.700	-2.115	-1.030
Old people	-1.337	-1.610	-1.784**	-2.160	-1.362	-1.550	-0.438	-0.500
Constant	-38.600***	-2.900	-35.774**	-2.400	-35.496**	-2.370	-32.058**	-2.200
Observation	1021		1021		1021		1021	
Wald test	90.67***		55.89***		61.99***		50.81***	

Note: ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table 5.7 Linear regression results of consumers' perceptions

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
Environment	3.120**	2.604*	0.639	0.405	0.979	0.815	0.424	0.262
	(2.100)	(1.780)	(0.390)	(0.240)	(0.610)	(0.500)	(0.250)	(0.150)
Food safety	4.192***	3.405***	4.441***	3.656***	4.133***	3.357***	4.344***	3.685***
	(4.990)	(4.190)	(5.120)	(4.390)	(4.460)	(3.730)	(5.170)	(4.400)
Gym	0.814**	0.758*	0.904**	0.803*	0.930**	1.014**	1.063**	0.920**
	(2.070)	(1.900)	(2.110)	(1.860)	(2.220)	(2.280)	(2.490)	(2.080)
Other Variables	No	Yes	No	Yes	No	Yes	No	Yes
Constant	-59.624***	-58.506***	-47.389***	-47.211***	-43.560***	-46.779***	-51.851***	-42.347***
	(-10.080)	(-4.080)	(-7.550)	(-2.950)	(-6.600)	(-2.900)	(-8.050)	(-2.750)
Observation	1021	1021	1021	1021	1021	1021	1021	1021
F test	12.86***	6.01***	11.12***	4.05***	8.87***	4.03***	12.13***	3.68***

Notes: 1. t statistics are showed in brackets.

2. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table 5.8 Linear regression results of economic preferences

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
Risk	2.142***	1.762***	1.674***	1.257**	2.023***	1.846***	1.810***	1.416**
	(4.630)	(3.750)	(3.280)	(2.410)	(4.060)	(3.570)	(3.370)	(2.550)
Trust	-0.987**	-1.150***	-0.013	-0.076	-0.014	-0.149	0.093	0.119
	(-2.470)	(-2.890)	(-0.030)	(-0.170)	(-0.030)	(-0.340)	(0.210)	(0.270)
Pos. reciprocity	1.248***	1.178**	0.260	0.238	0.408	0.332	-0.206	-0.268
	(2.700)	(2.580)	(0.550)	(0.510)	(0.830)	(0.670)	(-0.430)	(-0.560)
Neg. reciprocity	0.534	0.532	1.086**	1.084**	0.677	0.695*	0.817*	0.807
	(1.280)	(1.310)	(2.330)	(2.300)	(1.630)	(1.660)	(1.690)	(1.630)
Patience	-0.379	-0.470	-0.233	-0.446	0.262	0.142	0.440	0.283
	(-0.790	(-0.980)	(-0.460)	(-0.860)	(0.510)	(0.280)	(0.850)	(0.520)
Altruism	0.002	0.002	-0.003	-0.002	-0.004	-0.004	-0.001	-0.001
	(0.560	(0.630)	(-0.770)	(-0.690)	(-1.030)	(-1.000)	(-0.180)	(-0.170)
Other Variables	No	Yes	No	Yes	No	Yes	No	Yes
Constant	-39.129***	-38.064***	-33.136***	-33.538**	-32.940***	-34.059**	-40.431***	-31.487**
	(-7.670)	(-2.790)	(-6.230)	(-2.150)	(-6.190)	(-2.080)	(-7.050)	(-2.120)
Observation	1021	1021	1021	1021	1021	1021	1021	1021
F test	7.11***	5.15***	4.30***	3.14***	4.35***	3.54***	4.10***	2.80***

Notes: 1. t statistics are showed in brackets.

2. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table 5.9 Mean and median of WTP for meat alternatives

WTP	Obs	Mean		Median
		%	Std. Dev.	%
Raw data				
Plant-based meat	1021	-27.297	30.329	-35.00
Cultured pork	1021	-21.993	30.977	-10.00
Cultured beef	1021	-18.041	32.292	-10.00
Cultured chicken	1021	-26.538	32.223	-35.00
Predicted values from interval regressions by consumers' perceptions				
Plant-based meat	1021	-27.015	9.183	-26.946
Cultured pork	1021	-21.763	8.373	-21.786
Cultured beef	1021	-17.952	8.356	-17.590
Cultured chicken	1021	-26.263	8.166	-26.230
Predicted values from interval regressions by economic preferences				
Plant-based meat	1021	-27.020	9.183	-26.632
Cultured pork	1021	-21.770	7.699	-21.185
Cultured beef	1021	-17.957	8.172	-17.239
Cultured chicken	1021	-26.275	7.400	-26.056

Appendix B

Table B1 Interval regression results of consumers' perceptions without other control variables

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
Environment	3.022**	2.030	0.445	0.280	0.730	0.460	0.292	0.180
Food safety	4.052***	5.030	4.304***	5.240	3.861***	4.570	4.207***	5.260
Gym	0.812**	2.060	0.946**	2.290	0.907**	2.220	1.110***	2.620
Constant	-58.451***	-10.070	-46.235***	-7.570	-41.412***	-6.640	-50.894***	-8.090
Observation	1021		1021		1021		1021	
Wald test	39.69***		35.93***		28.37***		38.15***	

Note: ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table B2 Interval regression results of economic preferences without other control variables

Variables	Plant-based meat		Cultured meat					
			Pork		Beef		Chicken	
	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio	Coef.	z-Ratio
Risk	2.124***	4.650	1.696***	3.510	1.914***	3.980	1.858***	3.660
Trust	-1.013**	-2.560	0.019	0.040	-0.044	-0.110	0.100	0.230
Pos. reciprocity	1.302***	2.840	0.330	0.720	0.441	0.930	-0.176	-0.380
Neg. reciprocity	0.488	1.180	0.997**	2.310	0.609	1.530	0.747*	1.660
Patience	-0.322	-0.680	-0.143	-0.290	0.366	0.740	0.474	0.940
Altruism	0.001	0.410	-0.003	-0.940	-0.004	-1.220	-0.001	-0.390
Constant	-38.913***	-7.870	-33.720***	-6.700	-32.597***	-6.480	-40.252***	-7.480
Observation	1021		1021		1021		1021	
Wald test	43.39***		26.50***		26.44***		25.58***	

Note: ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Chapter 6 Overall Summary

6.1 Conclusions from Empirical Studies

6.1.1 Food Accessibility, Diversity of Agricultural Production, and Dietary Pattern in Rural China

The primary results indicate that food accessibility contributes to improvements in quality. In particular, food accessibility increases the consumption of oil and decreases the consumption of cereal, potatoes, and beans; fruits; vegetables; and salt. Further estimation finds that along with increasing food accessibility, fruit is converging to the recommended dietary pattern in China Food Pagoda 2016, and the deviations of legumes and nuts, and oil, are increasing. We also observe that the impact of food accessibility on dietary quality is stronger for those not engaged in agricultural production. Our study provides valuable implications for rural development and nutrition security in the developing world.

6.1.2 The Impact of Dietary Knowledge on the Diet Pattern of Chinese Adults

Results show that a high level of dietary knowledge significantly promotes scientific diet patterns, while the preference for unhealthy food mediates the relationship between dietary knowledge and diet quality. Additionally, the coefficient of the interaction term between dietary knowledge and unhealthy food accessibility is significantly negative, implying that increasing the availability of unhealthy food weakens the improving effect of dietary knowledge on diet quality. Further, heterogeneous marginal effects of dietary knowledge, unhealthy food preference and accessibility exist in different groups of populations. Finally, robustness tests confirm the reliability of our research results. This study indicates that government should popularize ‘Chinese Food Pagoda’ and control the number of sites providing unhealthy food at the same time to promote reasonable diet outcomes.

6.1.3 Political Party Support and Consumer Preference for Organic Food in Germany: the Perspective of Social Identity and Social Movements

We find that consumers supporting the Green Party have a 12% lower WTP for organic vegetables after controlling other socioeconomic factors in comparison with other consumers. The lower WTP can be explained by the fact that the Green Party supporters expect that organic food 'shouldn't be a privilege' for individuals, and should be inclusive to the general public.

6.1.4 The Impacts of Consumers' Perceptions and Economic Preferences on the Willingness to Pay for Meat Alternatives in China

Results suggest that consumers' perceptions have significant effects on the WTP for meat alternatives. Specifically, environmental awareness only has a positive impact on the WTP for plant-based meat, while the satisfaction with food safety and the degree of liking gym positively influence the WTP for both plant-based and cultured meat. Additionally, risk preference, trust, positive and negative reciprocity also have significant effects on the consumers' WTP for meat alternatives. First, residents with more preference for risk would like to pay more for meat alternatives. Then, the preference for trust could reduce the consumers' WTP for plant-based meat. Moreover, positive reciprocity has a significantly positive effect on the WTP for plant-based meat, while negative reciprocity significantly negatively influences the WTP for cultured meat. Lastly, the public is just willing to pay a lower price for meat alternatives than traditional meat. Our findings are proved to be robust and may provide valuable insights into the Chinese meat alternatives market in the future.

6.2 Policy Implications

6.2.1 General Implications

We observe impacts of food accessibility, dietary knowledge and unhealthy food preference on the diet pattern are significant. Overall, creating a fair and sustainable

food environment (such as increasing the availability of healthy food or the cost of accessing unhealthy food), and popularizing scientific dietary knowledge can increase diet quality in China.

Additionally, it has been confirmed that political party support, consumers' perceptions and economic preferences influence the WTP for sustainable food. On the one hand, more government subsidies to fill in the cost gap between organic and conventional food are important for promoting organic farming in Germany. On the other hand, policy interventions should spend more efforts on advertising the environmentally friendly attribute of meat alternatives. Also, producers of meat alternatives can target consumers with a high level of risk preference or more reciprocity in China.

Overall, this thesis provides various implications for different sectors: For the government, launching initiatives to tax unhealthy food (e.g., junk food) and labelling sustainable food can help. Also, governments should continuously promote public awareness towards consuming healthy (such as more fruits, vegetables and milk) and sustainable (such as organic food and meat alternatives) food among the general public particularly young consumers. For producers of sustainable food, subsidies should be taken into account to offset their high production costs. For business, companies should devote themselves to promoting healthy and sustainable attributes of food items; Additionally, the price of sustainable food needs to be carefully set to make sustainable choices affordable.

6.2.2 Policy Implications for Each Chapter

It is essential to focus on the linkage between each chapter's results and future decisions. From the policy perspective, chapter two indicates that food accessibility could improve diet quality of Chinese farmers, especially those not engaged in agricultural production. It has several policy implications for rural development in China and other developing countries. First, promoting reasonable dietary knowledge is an effective way to help residents choose healthy food, thus improving the diet quality in rural areas. Second,

supplementary measures such as cooking skill programs, in-store stocking policies and increasing the availability of healthy food should be implemented to bridge the gap between consumers' dietary knowledge and purchase behaviour.

Chapter three verifies the important impact of dietary knowledge on Chinese diet patterns. Therefore, comprehensively popularizing scientific dietary knowledge is an effective way to promote reasonable and healthy diet patterns in the near term. However, the relationship between dietary knowledge and diet quality is mediated by the influence of unhealthy food preference. In this case, it is also important to recommend healthy food to the general public by public service advertisements. Especially, advertising among children in schools is considered to be more effective. Additionally, a higher level of unhealthy food accessibility could result in the declining effect of dietary knowledge on diet quality. A fair and sustainable food environment is a key measure to address this problem, such as controlling the number of food sites providing unhealthy food and implementing a tax on unhealthy food.

Chapter four sheds light on the relationship between political party support and consumer preference for organic food in Germany and finds that the Green Party supporters in contrast with other consumers have a lower WTP for organic vegetables. The Green party and its supporters hold the opinion that organic food should not be a privilege for only a group of individuals, and they actively promote organic food in Germany. However, farmers producing organic food still bear huge production costs. Therefore, more government subsidies should be provided for organic farming.

Chapter five demonstrates that the WTP for meat alternatives is affected by consumers' perceptions of environmental protection, food safety and fitness. Individuals with a higher risk score are more likely to pay more for both plant-based meat and cultured meat. Therefore, advertising the environmentally friendly attribute of meat alternatives is essential for policy making, and it is beneficial for producers to target consumers with a high level of risk preference or more reciprocity. Meanwhile, prices for both plant-based and cultured meat should be set at a reasonable level.

6.3 Limitations

In chapter two, we find that the increase in food consumption and dietary diversity does not surely make farmers have a higher level of diet quality. A possible reason may be that increasing food accessibility might also enlarge the deviation between real consumption and recommended consumption if some types of food have been already overconsumed in Chinese rural areas. Future studies are necessary on this topic.

Chapter three uses the data of the China Health and Nutrition Survey (CHNS) from 2004 to 2011, but the latest data on food consumption in CHNS is only updated to 2011. Hence, the results of chapter three may not capture the impact of dietary knowledge on Chinese residents' diet quality in the last ten years. In the future, we need to conduct dietary consumption surveys by ourselves to obtain new data in China.

Chapters four and five investigate consumer preference for sustainable food in Germany and China respectively. However, we did not try to compare consumer preferences of two countries on the same dimension. Therefore, a systematic comparison between two counties is worth more investigations for future research.