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The Impact of Family Members Serving as Village Cadres on Rural Household Food Waste: Evidence from China

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Abstract: Based on nationwide survey data from China, we used a fractional logit model for analysis and propensity score matching (PSM) to evaluate the impact of family members serving as village cadres on household food waste. We found that, first, one household in rural China wasted an average of 1.62% of total food per day; in particular, the waste of staple foods was the most serious, with 5.14% of rice wasted per day. Differences in economic development, the geographical environment and diet habits caused differences in food waste in various regions of China. Second, empirical analysis showed that family members serving as cadres significantly increased household food waste. Third, the PSM results showed that family members serving as village cadres significantly increased household food waste and the waste of rice products. Households with members serving as cadres wasted 1.98% of total foods and 7.15% of rice products, on average, while other households wasted only 1.22–1.55% of total foods and 3.55–4.74% of rice products, on average.

Keywords: food waste; rural household; village cadres; food security; China

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1. Introduction

The world food system is facing many challenges, such as the global COVID-19 pandemic, climate change, economic recession, conflicts and wars, and natural resource constraints [1]. A report on the food crisis showed that the number of people in need of emergency relief globally has reached the highest level in 5 years, a total of 55 countries or regions around the world suffered from food insecurity in 2020, and the number of people affected by hunger increased by approximately 20 million compared with the 2019 level [2].

As the Earth is facing resource constraints, it is more difficult to increase grain production by expanding the area of cultivated fields and then increasing grain production, especially for countries with large populations and limited water and land resources [3]. Hence, reducing food loss and waste has become a critical issue and a priority of food policy in global governance [4].

The United Nations estimated that nearly 1 billion tonnes of food is wasted at the consumption and retail levels, which means that approximately 20% of the total food produced is ultimately not used by consumers [5]. This waste also causes the meaningless consumption of food production inputs and even reduces the profit of food value chain actors, which is extremely important for poor farmers [6]. The literature has shown that 24% of irrigation water, 23% of arable land and 23% of fertilizer used for food production were lost because of food waste [7]. Therefore, decreasing food waste not only means increasing food supply but also saving the Earth's precious resources [8].

The incidence of food waste varies significantly in different regions and countries; in general, food waste is more serious in developed countries [9]. However, these countries should have assumed more important responsibilities in the world food system and made

greater contributions to global food security [10]. In the United States, over 33% of total food is lost each year, which is equal to one American family wasting more than USD 1400 every year, on average [11]. In EU–28 countries, nearly 90 million tonnes of food is wasted every year, meaning that nearly 170 kg of food is wasted by each individual European [12]. In Egypt, solid waste (SW) has become a major problem. In 2015, SW in Egypt amounted to approximately 22 million tonnes, and most SW is food leftovers; the average Egyptian throws out more than 70 kg (154 pounds) of food each year [13,14]. According to the Waste and Resources Action Programme (WRAP), the UK produced approximately 9.5 million tonnes of food waste in 2018, and the concentration of carbohydrates in food waste was 22.7% [15,16].

With rapid economic development, food waste represents the largest portion of postharvest loss and waste in China; more than 7% of total food is wasted during the consumption stage in China, and the average food waste rate in Chinese households is 11.28% [17,18]. In the catering industry, approximately 20 million tonnes of food is wasted annually in this country [19]. Based on survey data from 9192 students, researchers found that 74% of college students generated plate waste in university canteens, and on average, each student wasted 61 g of food per meal [20]. The annual food waste has an ecological footprint extending over 62.54 million ha in China [21]. Hence, as it becomes more difficult to increase food production, reducing food waste has become a key food policy of the Chinese government.

Reducing food waste requires not only the accurate assessment of food waste but also an analysis of the determinants that affect food waste [22]. First, household income is positively correlated with food waste, especially in less developed economies [23]. As income increases, families have higher requirements for food quality and food diversity, such that some food that can still be eaten is discarded, thereby increasing food waste [24]. Second, regarding the number of family members, if families have more members, the number of people eating at home may often change, which is more likely to cause food waste [25,26]. Third, socioeconomic factors, for example, the food donation policy, encourage people to donate edible food to poor individuals, not only to help others but also to reduce waste [27,28]. Finally, researchers have also explored some ways to dispose of food waste; for example, people have developed various ways of fermentation and decomposition to generate hydrogen from food waste, enabling waste reuse [29].

Although existing studies have obtained fruitful results and support the introduction of targeted policies to reduce food waste, there are still some gaps that can be filled with further research. First, in most studies, the data come from secondhand sources, which can easily affect the accuracy of the results [30]. Although studies have started to adopt the survey method, their sample size and survey scope are limited, and the representativeness of these studies needs to be improved [31]. In the 40 years since the reform and opening up, the income of farmers has increased significantly, and it is reasonable to believe that food waste in rural China will gradually increase [32]. Second, most of the existing literature focuses on food waste in high-income regions, and research on rural food waste is inadequate [33]. Third, most studies only measure food waste or consider the impact of some intuitive characteristics on food waste, and there is a need for in-depth analysis [34].

Compared with ordinary villagers, families with members serving as cadres have a higher and more stable income, and the food waste of cadre households may be higher than that of ordinary families. Hence, in this study, based on nationwide survey data, we used a fractional logit model for analysis and propensity score matching (PSM) to evaluate the impact of family members serving as village cadres on household food waste.

2. Survey Design and Data Collection

To more precisely grasp the current state of the food waste of rural households in China, in the summer of 2016, we collaborated with the Rural Fixed Observatory Point Office (RFOPO) of the Ministry of Agriculture and Rural Affairs (MARA) of China to conduct a nationwide survey on the food waste of such households. The RFOPO is a rural

survey system that was established in the 1980s. Currently, this system covers more than 23,000 farming households in 31 provinces, and it adopts the method of stratified random sampling to select farmers. First, in each province, the counties in the province are divided into three groups, i.e., high, medium and low, based on income. Second, several representative villages (usually 2 to 3) are selected in each county. Third, based on the population size of the village, farmers are randomly selected for continuous follow-up surveys.

This system is used to investigate the production and living conditions of Chinese farmers. It mainly consists of the following parts. The first is family member information, including whether they serve as village cadres. The second is the household land situation, such as the land area. The third is household fixed assets, such as agricultural machinery ownership. The fourth is household production, such as food production. The fifth is household income and consumption, such as annual income. The sixth is other information, such as whether there is access to the Internet.

We selected samples in the RFOPO system to conduct the food waste survey as follows. First, we divided China into six regions based on factors such as the geographical environment, economic development and food culture. Food preferences and socioeconomic conditions were similar in the same region. Second, in each region, the indicator that determined the sample size of each province was the population. A province had more samples if its population was greater. Third, in each province, we randomly selected four or more villages from two randomly selected counties, and in each village, we randomly selected 15 or more households. Finally, the sample households conducted a book-entry survey for three consecutive days. They used electronic scales to weigh food before and after consumption and then calculated the waste of each meal. Hence, this waste did not include the portion discarded during food preparation.

Based on the type and frequency of consumption, we divided food into nine categories, and rural households weighed them separately. These categories included staple foods (flour, rice and potato products), soybeans, pork, beef and lamb, poultry, aquatic, and eggs. We also obtained information about cooking behavior and socioeconomic characteristics (including whether a family member served as a village cadre) as well as other information, such as family size and the land area. We obtained 1560 valid samples in total (Table 1).

Table 1. Sample distribution.

Region	Provinces (Municipalities and Autonomous Zones)	Observations
Northeast China	Inner Mongolia, Liaoning, Jilin, Heilongjiang	351
Northwest China	Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang	299
North China	Beijing, Tianjin, Hebei, Shanxi, Henan, Shandong	314
Southwest China	Guangxi, Sichuan, Chongqing, Yunnan, Guizhou	212
Southeast Coastal Area of China	Jiangsu, Zhejiang, Fujian, Guangdong	146
Central China	Hunan, Jiangxi, Hubei, Anhui	238
Total	28	1560

3. Methodology and Empirical Strategy

3.1. Methodology

Food waste is the result of human consumption behavior. Hence, most studies establish frameworks based on the principles of consumer theory when analyzing the problems of food waste [35]. However, traditional consumption theory has certain limitations in explaining the phenomenon of food waste. For example, the neoclassical theory of consumption assumes that consumers are rational [36]. However, in real life, individuals are often irrational; with economic development, the food supply becomes more abundant, it becomes difficult for individuals to always maintain balanced rations, and limited information further reduces individuals' ability to make rational decisions [37].

The existing literature shows that the most important factor affecting food waste is income [23]. As income increases, households pursue richer nutrition and diverse food choices, which easily leads to food waste [38]. For the purposes of this study, village cadres

have a stable wage income, and they may accept bribes, which makes their household income much higher than that of ordinary villagers and thus increases their food waste. Additionally, owing to their official duties, rural cadres have more banquets (including private and official banquets) than ordinary villagers, which can easily lead them to develop a habit of extravagance and waste. This consumption habit may increase household food waste [39]. Hence, we proposed the hypothesis of this study: if one family member serves as a rural cadre, the household's food waste will increase (Figure 1).

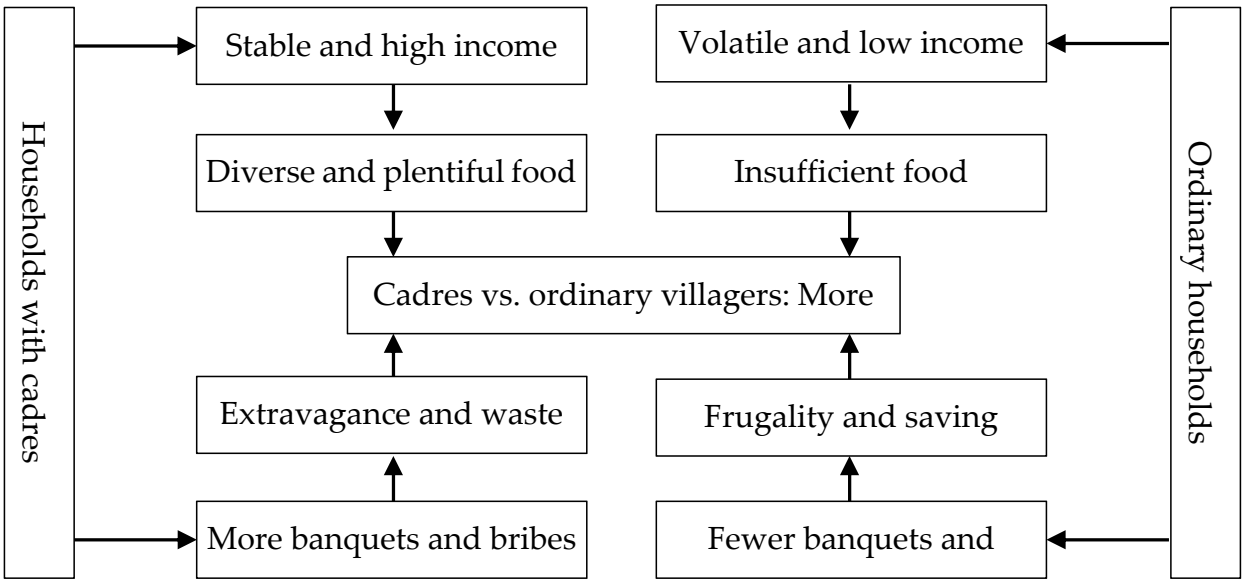

Figure 1. Difference in food waste between cadre and ordinary households.

Based on the analysis, we added the variable of rural cadre household to the model, and incorporating the results of the existing literature, we established the following model for estimation:

$$y_i = \alpha_0 + \alpha_1 cadre_i + \alpha_2 cp_i + \alpha_3 household_i + \alpha_4 social_i + \alpha_5 local_i + \varepsilon_i \quad (1)$$

where y_i is the food waste of household i and $cadre_i$ is a dummy variable that shows whether a member of household i serves as a rural cadre. In this study, we also replaced the dummy variable of cadre households with the annual salary income of rural cadres to verify the robustness of our results. cp_i is a vector of the cooking practices of household i, including its cooking equipment, taste preference and attitude toward food preparation. $household_i$ refers to the characteristics of decision makers. $social_i$ refers to the socioeconomic characteristics of household i, including its annual income, the number of residents in the household, the total grain output, and other related variables. $local_i$ is the location dummy variable.

3.2. Empirical Strategy

In this study, household food waste is expressed as a proportion of total consumption. Thus, it is a number in fractional form bounded between 0 and 1, inclusive. When the explanatory variables change, bounded dependent variables often present a nonconstant response [40]. Linear models may produce predictions that lie outside the unit interval [41]. Hence, ordinary least squares (OLS) and other linear methods were not suitable for this study.

Researchers recommend that the fractional response model (FRM) can well address cases in which the dependent variable is in fractional form [42]. It can address most of the defects of traditional estimation methods for bounded dependent variables [43]. Moreover, the FRM can directly estimate the conditional expectation of the dependent variable, allowing for extreme values, such as 0 and 1 [44]. Hence, following the suggestions from the literature, we used logit quasi maximum likelihood estimation to estimate the FRM.

Furthermore, to verify the credibility of our results of the econometric model and to evaluate the difference in household food waste between rural cadre families and ordinary villager families, we used PSM to calculate the effects of family members serving as village cadres on household food waste. PSM can solve the problem of selection bias with cross-sectional data [45–47].

The impact of family members serving as village cadres on household food waste was estimated in four stages. First, the propensity scores of serving as a rural cadre were estimated by a logit model. Second, three matching algorithms (radius matching, caliper matching and kernel matching) were used to match cadre households and non-cadre households. Third, we calculated the average effect of the treatment on the treated (ATT). Finally, a sensitivity analysis was performed to test whether the results were sensitive to hidden bias.

In this study, we used Stata 16 software for analysis. Compared to the previous literature, we made the following improvements. First, we conducted our research based on primary survey data from more than 1500 rural households in 28 provinces in China. The nationwide data ensured that our research results were representative and had high credibility. Second, we focused on the food waste of households in rural areas as a supplement to existing research, which focuses on urban food waste. However, there are few studies on the status of food waste in rural China. Third, we analyzed the influence of cadre status on household food waste, and there is very limited information on this topic. Although economic conditions have been greatly improved, the political ecology of rural China has been criticized by many people [48]. Compared with ordinary villagers, rural cadres have not only stable wages but also higher status; they may become corrupt and obtain extra income [49]. Hence, the food waste of households with cadres may be more serious. Meanwhile, cadres have an important influence on the behavior of ordinary villagers. They can not only formulate policies to intervene with farmers but also use their social status to impact the lifestyle of villagers. For example, if a cadre is extravagant and wasteful, ordinary villagers may follow suit and waste more food. Hence, cadres play an important role in the village and have a great impact on the behavior of ordinary farmers. To the best of our knowledge, this study is the first to attempt to solve this problem.

4. Results

4.1. Household Food Waste in Rural China

Table 2 shows that, on average, 1.62% of total food was wasted in each rural household per day. In the nine food categories, the most serious waste was rice products, and 5.14% of total rice was wasted in each rural household per day. The food categories with the least waste were beef and lamb, with 0.21% of total beef and lamb wasted in each rural household per day. This information showed that the waste of plant food was more serious than that of animal-derived food. In China, the price of meat (especially beef and lamb) is much higher than the price of staple foods, and this economic signal gives farmers a stronger awareness of the need to save meat.

Table 2. Rural household food waste in different regions of China (unit: %).

Region	Flour Products	Rice Products	Potato Products	Soybean Products	Pork	Beef and Lamb	Poultry	Aquatic Products	Eggs	Total Waste
Northeast China	2.41	6.18	2.31	1.91	1.23	0.26	0.53	0.79	1.23	1.87
Northwest China	2.99	1.06	2.06	0.33	0.65	0.32	0.19	0.04	0.29	0.88
North China	3.64	1.92	1.44	0.80	0.59	0.07	0.56	0.51	0.69	1.14
Southwest China	1.71	8.20	1.98	0.82	1.31	0.13	0.56	0.87	0.59	1.80
Southeast Coastal Area of China	1.80	11.60	1.49	1.89	2.22	0.14	1.68	2.96	1.17	2.77
Central China	2.33	6.32	3.47	1.19	1.27	0.27	0.73	1.11	0.79	1.94
Average	2.60	5.14	2.14	1.13	1.10	0.21	0.61	0.85	0.78	1.62

China covers a vast territory, and there are obvious differences in the geographical environment, climatic conditions and economic development in different regions. Hence, cooking practices, food preferences and habits, and food waste may show different characteristics in different regions [22]. Table 2 shows that the most serious food waste occurred in the southeast coastal area of China, with 2.77% of total food wasted in each rural household per day, and the southeast coastal area of China is the most developed region in China. This finding meant that economic development easily increased food waste [50]. Meanwhile, the southeast coastal area of China is adjacent to the sea; thus, the consumption of seafood products was more frequent, and the waste of such products was higher in this region than in other parts of China. Moreover, rice is the staple food in northeast China, South China and Central China, while the staple food in other regions is flour products. Hence, the waste of rice products was more serious in northeast China, South China and Central China, while the waste of flour products was more serious in other regions. These findings showed that factors such as diet culture and dietary habits were also correlated with food waste [51].

As mentioned above, compared with ordinary villagers, village cadres have not only a stable salary income but also a higher status in the village, which can easily lead to corruption. For example, some cadres often organize banquets and develop a habit of extravagance and waste. Moreover, some village cadres may accept bribes [52]. These behaviors may increase their households' food waste. Table 3 shows the difference in food waste between families with members serving as rural cadres and ordinary families. In our samples, there were 127 households with members serving as village cadres and 1433 ordinary households. Except for poultry and aquatic products, all types of food were wasted to a greater extent by families with members serving as village cadres than by ordinary families. In particular, the total food waste (1.97 vs. 1.59%) and rice product waste (7.09 vs. 4.97%) of village cadre households were significantly higher than those of ordinary families.

Table 3. Food waste between rural cadre families and ordinary villager families (unit: %).

Variables	Ordinary Villager Families (n = 1433)		Rural Cadre Families (n = 127)		t-Test
	Mean	Std. Error	Mean	Std. Error	Difference
Food waste	1.59	2.21	1.97	2.56	−0.38 *
Flour products	2.56	4.60	3.10	6.13	−0.54
Rice products	4.97	8.67	7.09	12.98	−2.12 **
Potato products	2.14	6.11	2.24	5.97	−0.10
Soybean products	1.11	2.57	1.35	2.96	−0.25
Pork	1.07	2.44	1.42	3.15	−0.35
Beef and lamb	0.20	0.84	0.27	0.90	−0.07
Poultry	0.61	1.64	0.61	1.58	0.00
Aquatic products	0.86	2.25	0.81	1.87	0.05
Eggs	0.77	1.97	0.84	1.86	−0.06

Note: Significance levels are indicated as ** $p < 0.05$, * $p < 0.1$.

4.2. Descriptive Statistics

In Table 4, we report the definitions and descriptive statistics for the key variables used in our study. In the statistics, we divided the variables into four categories: key variables, cooking practices, the characteristics of household decision makers, and socioeconomic variables.

Table 4. Variable definitions and descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max
Food waste: as a proportion of total consumption (%)	1.62	2.24	0	15.56
Village cadres: whether family members serve as village cadres (yes = 1)	0.08	0.27	0	1
Village cadres: annual salary income of village cadres (yuan [1])	1470.65	6423.26	0	72,000
Cooking practices				
Staple food cooking equipment: using traditional cooker (yes = 1)	0.46	0.50	0	1
Using a traditional wok for stir-frying (yes = 1)	0.36	0.48	0	1
Preferring spicy food (yes = 1)	0.56	0.50	0	1
Preparing the correct amount of food (yes = 1)	0.76	0.43	0	1
Characteristics of household decision makers				
Gender of the decision maker (male = 1)	0.83	0.37	0	1
Age of the decision maker (years)	53.79	10.64	21	89
Years of schooling of the decision maker	7.28	2.65	0	16
Socioeconomic characteristics				
Annual income (yuan [1])	63,183.58	57,778.78	2090	727,670
Number of residents in the household (at home for more than 180 days per year)	3.58	1.46	1	6
Area of land designated for agriculture (mu [2])	12.50	21.42	0	297
Total grain output (tonne)	6.11	9.90	0.00	136.20
Percentage of purchased grain in total consumption in one year (%)	0.33	0.41	0	1

Note: [1] The yuan is the unit of currency in China, and CNY 1 = USD 0.16; [2] the mu is a unit of area used in China, and 1 ha = 15 mu.

On average, 1.62% of total food was wasted in each rural household per day in China, and there was a great difference between different samples. Some rural households claimed that they had no food waste, but other households exhibited severe waste of up to 15.56% of total food.

In this study, we used the dummy variable of whether family members served as village cadres to identify whether a family was a village cadre household. In our sample, 8% of families had members serving as village cadres. Moreover, we obtained information on the annual salary income of the village cadres. On average, the annual salary income of village cadres was CNY 1470.65 (worth USD 235.30) per household, but the salary income of village cadres in some households was extremely high, up to CNY 72,000 (worth USD 11,520).

Cooking practices included four variables: staple food cooking equipment, stir-frying equipment, taste preferences, and cooking preferences. We divided the equipment into two categories: traditional cookers and modern cookers. A total of 46% of households used traditional cookers to process staple foods, and 36% of total households used a traditional wok for stir-frying. The dummy variable of whether households enjoy spicy food was used to express the household's taste preferences, and 56% of total households preferred spicy foods. Meanwhile, some farmers chose to prepare more food at noon, which can save the time spent in the kitchen at night. In our sample, 76% of households chose to prepare the correct amount of food.

In our sample, 83% of the household decision makers were male, and on average, the age and years of schooling of the decision makers were 53.79 and 7.28, respectively. On average, the annual income of each household was CNY 63,183.58 (worth USD 10,109.37). The average number of residents was 3.58 for each household. The households cultivated,

on average, 12.50 mu of land. On average, 33% of the total grain consumed in one year was purchased from the market, and one household produced 6.11 tonnes of grain per year.

This study focused on the impact of family members serving as village cadres on food waste in rural China. Hence, we established some important statistical information on families with members serving as village cadres. For example, the food waste of households with members serving as cadres was 1.97%, which was higher than the average food waste of all farmers. Meanwhile, the average income and number of residents in households with members serving as cadres were CNY 84,980.51 and 3.68, respectively. The income of households with members serving as cadres was higher than that of ordinary families, and the difference in the number of residents between cadre and ordinary families was not obvious.

4.3. Estimation Results of the Fractional Logit Model

Table 5 shows the estimation results of the fractional logit model for the impact of family members serving as village cadres on household food waste. In Column 1 of the table, the key explanatory variable is a dummy variable of whether a family member served as a village cadre. In Column 2, we replaced the dummy variable with the annual salary income of rural cadres to test whether the salary income of rural cadres had a significant impact on household food waste and verified the robustness of our conclusions. The results showed that village cadres were significantly positively correlated with household food waste in both cases, and the results for most variables were consistent, confirming that they are credible.

Table 5. Impact of family members serving as rural cadres on household food waste.

Dependent Variable: Food Waste as a Proportion of Total Consumption	**(1)**		**(2)**	
Variable	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Village cadres: whether family members serve as village cadres (yes = 1)	0.33 **	0.14		
Village cadres: annual salary income of village cadres (yuan [1]) (logarithmic)			0.04 ***	0.01
Cooking practices				
Staple food cooking equipment: using a traditional cooker (yes = 1)	−0.19 **	0.08	−0.19 **	0.08
Using a traditional wok for stir-frying (yes = 1)	0.34 ***	0.08	0.33 ***	0.08
Preferring spicy food (yes = 1)	0.11	0.08	0.13	0.08
Preparing the correct amount of food (yes = 1)	−0.17 *	0.09	−0.18 **	0.09
Characteristics of household decision makers				
Gender of the decision maker (male = 1)	0.002	0.10	0.005	0.10
Age of the decision maker (years)	0.002	0.004	0.001	0.004
Years of schooling of the decision maker	−0.001	0.02	0.0001	0.02
Socioeconomic characteristics				
Annual income (yuan [1]) (logarithmic)	0.05	0.06	0.05	0.06
Number of residents in the household (at home for more than 180 days per year)	0.04	0.03	0.04	0.03
Area of land designated for agriculture (mu [2])	−0.002	0.003	−0.002	0.003
Total grain output (tonne)	0.01 *	0.01	0.01 *	0.01
Percentage of purchased grain in total consumption in one year (%)	−0.67 ***	0.10	−0.66 ***	0.10
Location dummy	Controlled			
Constant	−5.01 ***	0.69	−4.97 ***	0.69
Observations	1560			

Note: [1] The yuan is the unit of currency in China, and CNY 1 = USD 0.16; [2] The mu is a unit of area used in China, and 1 ha = 15 mu; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Some coefficients were very small; therefore, four or five decimal places are displayed.

As we expected, if a family had members serving as village cadres, its food waste was significantly increased. The estimation results in Column 2 also showed that the salary income of rural cadres was significantly related to higher household food waste. Therefore, an important explanation for why families with members serving as rural cadres wasted more food than ordinary villagers was that these families could obtain a stable and

higher income [53]. Doing so enabled rural cadre families to enjoy a richer diet, which directly increased their food waste. In addition, China's rural cadres may be corrupt and extravagant [54]. In the survey, some rural cadres made it clear that they ate meat and drank alcohol at every meal, which obviously indicated a more luxurious living standard and a weak awareness of the need to save food compared to ordinary families. These habits also increased food waste among rural cadre families.

Cooking equipment was significantly related to food waste, most likely because of capacity. For staple foods, traditional cookers have different capacities compared with the standardized capacity of modern equipment, and farmers can purchase sizes that meet their needs. Meanwhile, for stir-frying, the capacity of a modern wok is smaller than that of a traditional wok. Hence, these results meant that the adoption of cooking equipment with appropriate capacity was correlated with less food waste [22]. Similarly, preparing the correct amount of food was related to lower food waste. For example, if a large amount of food was prepared at noon but some family members were absent from the dinner meal, increased food waste could easily result.

Other factors, such as total grain output and the percentage of purchased grain in total consumption in one year, were significantly correlated with food waste, most likely because of awareness of the need to save food. A higher grain output means that more grain can be consumed by farmers, which may weaken their awareness of the need to save food [55]. In contrast, purchasing requires paying money, which gives farmers a direct economic signal; that is, wasting food is wasting money. Hence, a household with a high percentage of grain purchased from the market may have less food waste.

4.4. Impact of Family Members Serving as Village Cadres on Household Food Waste

In the first step of PSM, we used the logit model to analyze the determinants of serving as a cadre and to calculate the propensity to serve as a cadre for each household. The results showed that the gender and the years of schooling of decision makers, family members, annual income, Internet access at home, mobile phones, and participation in cooperatives and agricultural technology training were significantly correlated with members serving as village cadres (Table A1).

In the second step of PSM, we matched the cadre households and non-cadre households based on their propensity scores. Moreover, we used three methods, including the propensity score test (Table A2), statistical tests (Table A3) and visual inspection of the distributions of the propensity scores after matching (Figure A1), to assess whether the matching procedure balanced the distribution of the relevant covariates into two groups. The results of these methods all indicated a very good match.

Next, we calculated the ATT to estimate the impact of family members serving as village cadres on household food waste after matching (Table 6). The results showed that having a family member serving as a village cadre significantly increased household food waste and the waste of rice products, and all the matching estimators provided similar results. Households with members serving as cadres wasted, on average, 1.98% of total food, while non-cadre households wasted, on average, only 1.22–1.55% of total food. Cadre households also wasted significantly more rice products, 7.15%, on average, and non-cadre households wasted only 3.55–4.74% of rice products.

Finally, sensitivity analysis with Rosenbaum bounds was conducted to check for hidden bias (Table A4). The results showed that gamma increased 1.5 times, and the results were still significant for the treatment effect on all outcome variables. The findings suggested that the PSM method was appropriate for this study.

Table 6. Impact of family members serving as village cadres on household food waste.

Outcome	Matching Algorithm	Treated	Controls	ATT	SE	t-Stat
Food waste	Radius matching	1.98	1.54	0.44	0.25	1.73
	Caliper matching	1.98	1.22	0.76	0.30	2.52
	Kernel matching	1.98	1.55	0.43	0.25	1.71
Flour products	Radius matching	3.12	2.41	0.71	0.59	1.20
	Caliper matching	3.12	2.39	0.73	0.78	0.94
	Kernel matching	3.12	2.39	0.73	0.59	1.23
Rice products	Radius matching	7.15	4.70	2.45	1.23	1.99
	Caliper matching	7.15	3.55	3.60	1.43	2.52
	Kernel matching	7.15	4.73	2.42	1.24	1.96
Potato products	Radius matching	2.25	2.00	0.25	0.61	0.40
	Caliper matching	2.25	1.76	0.49	0.77	0.63
	Kernel matching	2.25	2.03	0.22	0.61	0.36
Soybean products	Radius matching	1.36	1.16	0.20	0.29	0.70
	Caliper matching	1.36	0.81	0.55	0.32	1.73
	Kernel matching	1.36	1.17	0.19	0.29	0.64
Pork	Radius matching	1.41	1.11	0.31	0.31	1.00
	Caliper matching	1.41	0.77	0.64	0.31	2.04
	Kernel matching	1.41	1.11	0.31	0.31	1.00
Beef and lamb	Radius matching	0.26	0.21	0.04	0.09	0.47
	Caliper matching	0.26	0.16	0.09	0.11	0.79
	Kernel matching	0.26	0.21	0.05	0.09	0.55
Poultry	Radius matching	0.62	0.65	−0.03	0.16	−0.17
	Caliper matching	0.62	0.43	0.18	0.19	0.98
	Kernel matching	0.62	0.64	−0.02	0.16	-0.11
Seafood products	Radius matching	0.81	0.82	−0.01	0.20	−0.03
	Caliper matching	0.81	0.35	0.46	0.20	2.36
	Kernel matching	0.81	0.82	0.00	0.20	−0.01
Eggs	Radius matching	0.83	0.83	0.00	0.19	−0.01
	Caliper matching	0.83	0.78	0.05	0.29	0.17
	Kernel matching	0.83	0.84	0.00	0.19	−0.02

5. Conclusions

Based on wide-ranging survey data from 1560 rural households in 28 provinces in China, we evaluated household food waste in rural China and used a fractional logit model to analyze the impact of family members serving as village cadres on household food waste. Moreover, we used PSM to evaluate the effect of family members serving as village cadres on household food waste.

This study found that, on average, one household wasted 1.62% of total food per day. Compared with the low waste of animal-derived foods, with only 0.21% of total beef and lamb being wasted in each rural household per day, the waste of staple foods was more serious, with 2.60% of flour products, 5.14% of rice products and 2.14% of potato products being wasted per household per day. This situation showed that as income increased, household food waste started with staple foods. In addition, economic development, the geographical environment, and dietary habits made household food waste in rural China display different characteristics. This result indicated that the government must consider different factors and environments in food policy making.

The empirical analysis showed that family members serving as cadres significantly increased household food waste because such families can obtain a more stable and higher income than ordinary villages. The PSM results showed that households with members

serving as village cadres wasted more food (1.98 vs. 1.38%) and rice products (7.15 vs. 4.14%) than other households. In general, rural cadres have a stable and higher income, which increases household food waste. Moreover, the democratic political system still needs to be improved. Some rural cadres engage in corruption and accept bribes, which leads them to form a habit of extravagance and waste. Rural cadres have a great influence on ordinary farmers. Hence, the government should introduce targeted policies to improve the awareness of the need to save food among rural cadre households and then drive ordinary villagers to reduce their food waste.

Our study clearly presents the status of rural food waste in China. Of course, some gaps are still unresolved. For example, our data failed to show the situation of vegetable and fruit waste in rural China. However, we found that family members serving as rural cadres have a great impact on household food waste, which is significant for reducing food waste in transition economies. If the people with influence and means in rural areas engage in the most serious food waste, will ordinary people adopt habits of storing and saving food and reducing food waste?

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Appendix A

Table A1. Estimation of the logit model on the propensity to serve as a cadre.

Dependent Variable: Family Member Serves as a Village Cadre			
Group	**Variable**	**Coef.**	**Std. Err.**
Decision maker	Gender of the decision maker (male = 1)	−0.40 ***	0.13
	Age of the decision maker (years)	0.01	0.01
	Years of schooling of the decision maker	0.12 ***	0.02
Household	Population (number of members)	−0.06 *	0.04
	Annual income (yuan [1]) (logarithmic)	0.24 ***	0.09
	Area of land designated for agriculture (mu [2])	0.0001	0.002
Social	Internet access at home (yes = 1)	0.30 **	0.12
	Mobile phone (unit)	0.10 *	0.05
	Cooperative (yes = 1)	0.37 **	0.17
	Agricultural technology training (yes = 1)	0.81 ***	0.14
	Regional dummy variable	Controlled	
	Constant	−5.10 ***	0.97
	Observations	1560	

Note: [1] The yuan is the unit of currency in China, and CNY 1 = USD 0.16. [2] The mu is a unit of area used in China, and 1 ha = 15 mu; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Some coefficients were very small; therefore, four or five decimal places are displayed.

Table A2. Tests for selection bias after matching.

Variable	Matched Sample		Bias		*t*-Test *p* Value
	Treated (n = 126)	Control (n = 1433)	% Bias	% Bias Reduction	
Gender of the decision maker (male = 1)	0.80	0.78	6.60	24.20	0.62
Age of the decision maker (years)	51.61	52.00	−3.80	84.10	0.76
Years of schooling of the decision maker	8.79	8.52	10.50	83.80	0.40
Population (number of members)	3.90	3.89	0.20	89.90	0.99
Annual income (yuan [1]) (logarithmic)	11.11	11.07	6.70	86.70	0.60
Area of land designated for agriculture (mu [2])	16.52	14.85	6.80	64.80	0.62
Internet access at home (yes = 1)	0.37	0.35	4.10	89.10	0.76
Mobile phone (unit)	2.87	2.82	4.00	88.70	0.74
Cooperative (yes = 1)	0.15	0.15	1.90	93.60	0.90
Agricultural technology training (yes = 1)	0.29	0.27	3.20	94.90	0.84

Note: [1] The yuan is the unit of currency in China, and CNY 1 = USD 0.16. [2] The mu is a unit of area used in China, and 1 ha = 15 mu. One household that lacked suitable matches was dropped during propensity score matching.

Table A3. Statistical tests to evaluate matching.

Matching Method	Pseudo-R^2	Likelihood Ratio Chi^2	$p > Chi^2$	Mean Bias	Median Bias
Before matching	0.159	139.72	0	31.4	26.8
Radius matching	0.006	2.1	0.999	5.5	5.4
Caliper matching	0.011	3.77	0.987	5.5	4.4
Kernel matching	0.004	1.44	1	4.8	4.8

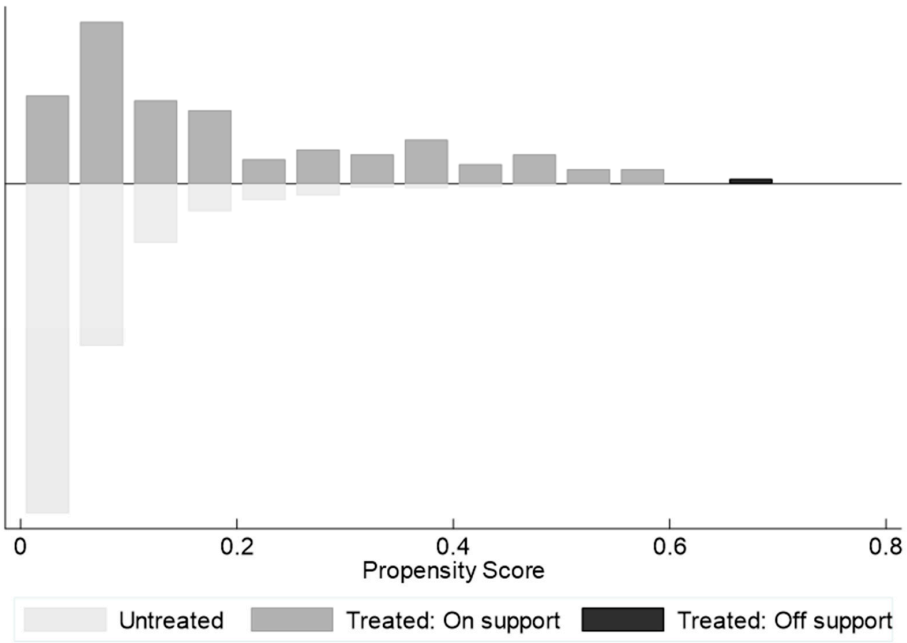

Figure A1. Distribution of propensity scores and common support for propensity score estimation for cadre households and non-cadre households. Note: Cadre households with appropriate matches among the non-cadre households are shown on the chart as "treated".

Table A4. Sensitivity analysis with Rosenbaum bounds.

Gamma	Food Waste		Flour Products		Rice Products		Potato Products		Soybean Products		Pork		Beef and Lamb		Poultry		Aquatic Products		Eggs	
	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.4	0	0	0	0	0	0	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0.09	0

Note: gamma: log odds of differential assignment due to unobserved factors, sig+: upper bound significance level (overestimation of treatment effect), sig−: lower bound significance level (underestimation of treatment effect).

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