Changes in Fruit and Vegetable Consumption over Time and across Regions in China: A Difference-in-Differences Analysis with Quantile Regression

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Abstract. Recently, there has been considerable interest in estimating food demand structure in China due to its huge market for food products. Previous literature has focused on the primary food products such as grains and meats, but studies on fruits and vegetables are limited. To fulfill this gap, this paper investigates the changes of fruit and vegetable consumption in Chinese urban households between 1993 and 2001. In this study, we use the difference-in-differences method with quantile regression to demonstrate how these changes of fruit and vegetable consumption over time may differ across regions. Additionally, how these changes may differ over the entire distribution. Using household survey data from 1993 and 2001 of three selected provinces, our results show that fruit consumption of Chinese urban households increased from 1993 to 2001 for households in the central and southern parts of China. Additionally, the magnitudes of the increasing trends differ across the entire distribution. In contrast, significant decreases of vegetable consumption are found, and results are robust across regions. However, the disparities of vegetable consumption across regions are not significant.

Key words: Fruit and vegetable consumption, China, inequality, quantile regression, difference-in-differences model.

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Introduction

Since the late 1970s, economic reforms have resulted in an average annual 8% economic growth in China and the rapid income growth and urbanization have boosted food consumption considerably (USDA-FAS, 2001). Due to China's huge market demand for food products, there has been considerable interest in estimating its food demand structure. To meet the dramatically increasing food demand, U.S. exports of processed food products to China have increased eight-fold over the past two decades. Among all of the food commodities, fruit and vegetable exports to China have accelerated with an average annual increase of more than 50 percent since the early 1990s (Han and Wahl, 1998).

The primary focus of this paper is to examine the changes in fruit and vegetable consumption in China. The importance of fruit and vegetable consumption can be recognized in several aspects. First, fruits and vegetables are both highly perishable products and are very heterogeneous as they include a disparate variety of items with prices ranging from extremely cheap to highly expensive. Secondly, adequate consumption of fruits and vegetables is positively associated with better health. A recently published World Health Organization report has recommended a population-wide intake goal of 200-400 grams of fruits and vegetables per day for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity, as well as for the prevention and alleviation of several micronutrient deficiencies. Overall, it is estimated that up to 2.7 million lives in the world could be saved each year if fruit and vegetable consumption were sufficiently increased (USDA-DHHS, 2005). With a rapid growth of per capita income in China over the past decades, it can be reasonably expected that the primary concerns of food consumption will be more health-orientated in China. Therefore, a better understanding of the changes in fruit and vegetable consumption of households over the past decade would be helpful in assessing Chinese dietary quality as well as implications for future agricultural trade.

Along with the rapid economic growth in China, the inequality of both income and consumption patterns has been increasing as well. It has been shown that the coastal areas have experienced considerably higher growth than the inland areas. Also, the intra-personal inequality of income and consumption has risen, which resulted

from the increasing return in human capital. Therefore, understanding the inequality of consumption is of particular interest to policy makers and it is appropriate to call for more effort in ongoing research in this area (Wan and Zhang, 2006).

Although considerable literature has examined food consumption in China, our study departs from previous studies in several aspects. First, unlike previous studies of food demand in China focusing on primary food products such as grains and meats, our emphasis is on fruit and vegetable consumption. Almost all existing literature has paid little attention to the study of fruit and vegetable consumption in China except Han and Wahl (1998). Second, in contrast to most of the previous studies on food demand using aggregate time series data or the aggregated cross-sectional data (e.g., Kueh, 1988; Fan *et al.* 1994; Wu *et al.* 1995), a household survey of fruit and vegetable consumption in China is utilized. Using the micro-level survey allows us to investigate heterogeneous consumption patterns of fruits and vegetables among households. Third, we examine both time and regional effects on demands for fruits and vegetables; i.e., we investigate not only the changes in fruit and vegetable consumption of Chinese urban households from 1993 to 2001 but also their differences among regions. Compared to the widely available literature of income inequality in China, our study is one of few investigations that demonstrate consumption inequality in China.

Using the urban household survey of three provinces, Guangdong, Jiangsu and Shandong in the years 1993 and 2001, we first examine how the economic factors, such as income and the price of selected food items, and household characteristics, e.g., household size and education level of a householder, may determine a household's demands for fruits and vegetables. Second, by applying the difference-in-differences (DID) method to rule out the unobservable effects that are associated with a household's fruit and vegetable consumption, we identify the factors that caused the changes in fruit and vegetable consumption between 1993 and 2001 and among regions. To further investigate how the changes in fruit and vegetable consumption may be heterogeneous across the entire distribution, we also estimate the model using the quantile regression (QR) method. This methodology uniquely sets our analysis apart from most of the literature addressing the inequality issue.

Several interesting findings are revealed from our empirical analysis. First, our results show that fruit consumption increased from 1993 to 2001 for households in the central and southern parts of China. Additionally, changes in fruit consumption over

this time period differ across the entire distribution; especially, at the upper percentiles of the fruit distribution, the changes are more pronounced. With respect to regional disparities, our results indicate that differences in the changes of fruit consumption over time are statistically significant across households in different regions for households with high consumption levels. The story on fruits is different from vegetable consumption. Vegetable consumption unambiguously decreases over time for households in different providences; however, the regional disparities of vegetable consumption are not evident.

The remainder of this paper is organized as follows. The data used in this study are introduced in the next section. We then outline the econometric strategy and discuss the results. The final section concludes this paper with some policy implications and suggestions for future research.

Data

The data used in this paper are drawn from the national survey of Chinese urban households conducted by the National Bureau of Statistics of China (NBSC). The main contents of this NBSC survey included quantities and expenditures of major commodities purchased in the market, cash flow of each household, detailed household demographic characteristics, housing condition and the ownership of durable goods at the end of the year; each household possessed 1,548 variables in total. Since access to the entire NBSC household survey data is unavailable, three coastal provinces were obtained and employed in this study, including Guangdong (north of Hong Kong), Jiangsu (adjacent to Shanghai) and Shandong (near Beijing) for 1993 and 2001. This database has been utilized by Fang and Beghin (2002), Min *et al*. (2004), and Gould and Villarreal (2006). Details of how the survey was conducted were revealed in those papers, especially in Min *et al*. (2004).

Since our primary objective of this paper is to investigate the changing consumption patterns of fresh fruits and vegetables among households in urban China over time and across regions, the sample distributions of both fruits and vegetables are presented in Table 1 and their changes in consumption from 1993 to 2001 are depicted in Figures 1 and 2, respectively. We computed the per capita consumption figures by the percentiles of both fruit and vegetable consumption ranging from the lowest 10 % (i.e., 0.1 percentile) to the highest 10% (i.e., 0.9 percentile). It appears that fruit and vegetable consumption present different patterns. Fruit consumption increased

uniformly from 1993 to 2001. With the exception of the 0.8 percentile in Guangdong and the 0.3 percentile in Shandong, the higher the percentile of the distribution, the larger the increment of fruit consumption. That is, the largest consumption of fruits has the largest absolute increase in fruit consumption from 1993 to 2001. Nevertheless, the distributional changes of fruit consumption in Jiangsu seem to be the most notable among these three provinces. In particular, the 0.9 percentile of per capita fruit consumption in Jiangsu reached 131 Kg in 2001, representing a 39 Kg increase from 1993; it is interesting to note that this level of fruit consumption is close to the 134 Kg of average per capita fruit supply in Taiwan, 2001 (Food Balance Sheet, 2001).

[Insert Table 1 and Figures 1 and 2 about here.]

As to vegetables, the changing consumption patterns from 1993 to 2001 are considerably disparate among regions. Comparing vegetable consumption between 1993 and 2001 in Shandong, the distribution of vegetable consumption shifted uniformly to the left, indicating an overall decrement among all percentiles. In Jiangsu province, there was a different pattern of distributional changes. Most percentiles, except 0.1, of vegetables had a higher consumption in 2001 than in 1993. As to Guangdong, differences among sample percentiles are relatively diminutive, ranging only from -2 to 8; in particular, the median and 0.6 percentile were identical for both years. This phenomenon indicates that vegetable consumption distribution in Guangdong for both years was very close especially in the middle range of the distribution.

Based on consumer theory, household income and prices of fruit, vegetables, meat and grain are specified and considered as demand determinants for fruits and vegetables. It is worth noting that these four food items are the major foods consumed in urban China. Other socioeconomic variables associated with fruit and vegetable consumption are also included, such as household size, some characteristics of the household head and the number of refrigerators owned by the household. For comparison purposes, they were depicted on the basis of the previous findings, for example, in Fan, Cramer and Wailes (1994), Fang and Beghin (2002), Gould and Villarreal (2006) and Jiang and Davis (2007).

The definitions and the sample descriptive statistics of the selected variables are exhibited in Table 2. Income and prices of grain, meat, fresh vegetables and fruits in 2001 are deflated by the consumer price index. Most of the mean real prices of the selected four major food items were relatively lower in 2001 than in 1993 except for

meat in Shandong, showing that the prices seemed to be stable over these two years. In addition, all food prices in Guangdong were on average higher than the other two provinces, exhibiting regional differences. Real total household living expenditure was overall higher in 2001 than in 1993. The average income in Guangdong reached 7,000 Yuan, almost twice as high as the average income in either Shandong or Jiangsu. In spite of changes in the economic factors, changes in some socio-demographic factors were also noticeable. For example, in each province, the proportion of college-graduated household heads and the number of refrigerators in a household increased from 1993 to 2001, but the number of persons living in a household decreased. An investigation of these important factors associated with demands for fruits and vegetables in urban China is presented later in this paper.

[Insert Table 2 about here.]

Econometric Strategy

To examine the changes in fruit and vegetable consumption between 1993 and 2001 among the three selected provinces, a difference-in-differences model is utilized. Originally, this DID method is used when the data were collected from a natural experiment or a quasi-experiment, i.e., some subjects were affected by a policy intervention or treatment and others were not (Wooldridge, 2006). To date, this method has become increasingly popular to estimate causal relationships. Examples include the evaluation of labor market programs (Ashenfelter and Card, 1995; Blundell et al. 2001) and health insurance (Gruber and Madrian, 1994). The application of the difference-in-differences method to food demand analysis is rare. Our study is among the first to apply the DID method to the fruit and vegetable demand analyses. In this study, time change is considered as a natural treatment in that it is unlikely to be endogenous to households' choice of fruit and vegetable consumption. The exogeneity of the treatment validates the application of the DID method.[1]

Following the conventional definitions of the DID model (Wooldridge, 2006), for each household in the selected provinces, the fruit (or vegetable) demand function can be specified as:

[1] One shortage of the empirical application of the DID method is the endogeneity of the treatment on the outcome variable. That is, the DID analysis may not be validated if each individual can choose if he/she would like to participate in the program or not. In this case, self-selection bias is necessary to be corrected.

(1) $y_{ij} = \alpha_0 + \alpha_1 T01_{ij} + \alpha_2 GD_{ij} + \alpha_3 GD_{ij} * T01_{ij} + \beta_1 JS_{ij} + \beta_2 JS_{ij} * T01_{ij} + \gamma X_{ij} + \varepsilon_{ij}$

where y_{ij} is the fruit (or vegetable) consumption of household *i* in province *j*. The variables *GD* and *JS* are dummies which specify whether the household was located in Guangdong or Jiangsu, respectively. The variable *T01* is a dummy indicator which takes the value 1 if the household is included in the 2001 survey. The variables *GD*T01* and *JS*T01* are interaction terms between year and regional dummies. X_{ij} is the vector of exogenous socioeconomic variables, and ε_{ij} is the random error. Under this setup, the parameters $(\alpha_1 + \alpha_3)$, $(\alpha_1 + \beta_2)$ and α_1 capture the effects of the changes of fruit (or vegetables) between 1993 and 2001 for households in Guangdong, Jiangsu and Shandong, respectively. Furthermore, the parameters α_3 and β_2 represent the differences of fruit (or vegetable) consumption over time between households in Guangdong and Jiangsu compared to households in Shandong province (the reference group), respectively. These are usually referred to as the DID effects. Applying the conventional ordinary least squared (OLS) method to equation (1) can obtain consistent estimators of $(\alpha_0, \alpha_1, \alpha_2, \alpha_3, \beta_1, \beta_2, \gamma)$.

An important methodological contribution that sets our analysis apart from previous studies of the DID method is that, instead of utilizing the conventional OLS to estimate the equation (1) which investigates the conditional *mean* effects of the factors on demand for fruit (or vegetables), we apply the quantile regression method to investigate how these effects may vary across the entire distributions of each fruit and vegetable consumption. In contrast to the conventional least squared estimation, quantile regression estimation examines the potential heterogeneity of the effects of the explanatory variables on the entire distribution of the dependent variable. In our case, using the quantile regression to estimate equation (1), we are able to investigate if regional differences and the differences of fruit and vegetable consumption over time may differ depending on the different consumption levels of fruits and vegetables.

Following Koenker and Bassett (1978), the conditional quantile expectation of fruit (or vegetable) consumption corresponding to equation (1) can be rewritten as:

(2) $y_{ij\theta} = \alpha_{0\theta} + \alpha_{1\theta} T01_{ij} + \alpha_{2\theta} GD_{ij} + \alpha_{3\theta} GD_{ij} * T01_{ij} + \beta_{1\theta} JS_{ij} + \beta_{2\theta} JS_{ij} * T01_{ij} + \gamma_\theta X_{ij} + \varepsilon_{ij\theta}$,

where θ indicates the quantile of the fruit (or vegetable) consumption conditioned on the exogenous vectors. Note that the distribution of the error term $\varepsilon_{ij\theta}$ is left

unspecified, thus the only requirement for the equation (2) is that the conditional mean evaluated at each quantile is zero. Accordingly, the coefficients $(\alpha_{1\theta} + \alpha_{3\theta})$, $(\alpha_{1\theta} + \beta_{2\theta})$, and $\alpha_{1\theta}$ capture the changes in fruit (or vegetable) consumption between 1993 and 2001 for households in Guangdong, Jiangsu and Shandong at the θ_{th} percentile, respectively. Also, the parameters $\alpha_{3\theta}$ and $\beta_{2\theta}$ represent the differences of fruit (or vegetable) consumption over time between households in Guangdong and Jiangsu compared to households in Shandong at the θ_{th} percentile. Consistent estimators $(\alpha_{0\theta}, \alpha_{1\theta}, \alpha_{2\theta}, \alpha_{3\theta}, \beta_{1\theta}, \beta_{2\theta}, \gamma_{\theta})$ can be obtained from estimating equation (2) by the generalized method of moment (GMM) framework (Koenker, 2005). Although the standard errors of the parameters can be derived from the GMM estimation, it has been evident that these standard errors severely understated the standard deviations of the estimators (e.g., Buchinsky, 1995). In their Monte Carlo simulations, Bertrand, Duflo, and Mullainathan (2004) has shown that using the bootstrap method for estimating the standard errors perform much better than the asymptotic standard errors derived from the GMM. To gain the efficiency of the estimators, the standard errors of the quantile regression estimators are obtained by a bootstrap method with 1,000 replications.

Empirical Results

Several sets of our empirical results are presented. The estimates of fruit and vegetable demand functions are shown in Tables 3 and 4, respectively. In each table, the results of the OLS method and QR technique are exhibited. To highlight the changes in fruit and vegetable consumption distributions, we conduct the QR estimation at 5 percentile increments ranging from the 0.05 to the 0.95 percentiles and the estimations results are depicted in Figures 3-6.

[Insert Tables 3 and 4 and Figures 3-6 about here.]

Changes in fruit and vegetable consumption over time and across regions

The estimations of fruit consumption are exhibited in Table 3. In the first column, the estimations of the OLS method are reported. Additionally, the estimations of the quantile regression method are shown in other columns. Due to limited space, we only report the results at the 0.25, 0.5, and 0.75 percentiles. To highlight the extent to

which fruit consumption may change over time, and how these changes may differ across regions, we present the estimates of the differences over time, and the difference-in-differences effect in the bottom of Table 3 (sections A3 and B3, respectively).

We begin our discussion of the empirical results by looking at the extent to which fruit consumption may change among the Chinese households in each province over time (section A3, the bottom of Table 3). Several interesting findings are noticeable. First, our results show that changes in household fruit consumption from 1993 to 2001 differ across regions. Significant increases in fruit consumption are found for households in Jiangsu and Shandong provinces. In addition, the effects are more pronounced for the households in Jiangsu. For instance, OLS predicts a 5.35 kg per capita increase, and a 1.85 kg per capita increase of fruit consumption for households in Jiangsu and Shandong from 1993 to 2003, respectively. This finding is consistent with the increasing trend based on the sample statistics depicted in Figure 1.

Second, the estimated effects of the changes in fruit consumption are different between the OLS estimates and the QR method. The inconsistency between the OLS and QR estimates is evident across regions. This finding is supportive of the argument that the changes of fruit consumption over time depend on the level of consumption. In other words, this result provides the evidence that the changes of fruit consumption over time are not homogenous across the entire distribution. Therefore, simply applying the OLS method to fruit consumption may cause inconsistent results and mislead policy implications. Furthermore, the increase in fruit consumption is more pronounced for households with higher consumption levels. Taking fruit consumption by households in Jiangsu for example, the time effects of changes in fruit consumption for households in this province are estimated to be 3.99 and 9.27 kilograms per person at the 0.50 and 0.75 percentiles, respectively. This result is also in agreement with the sample statistics depicted in Figure 2 in that the changes of fruit consumption are more conspicuous for households whose fruit consumption level is at a higher percentile.

With respect to the extent to which the changes in fruit consumption from 1993 to 2001 may differ across households in different regions, we report the estimates of the difference-in-differences effects in the bottom of Table 3 (section B3). Taking households in Shandong as the reference group, our results show that differences of fruit consumption over time differ across regions. More specifically, the disparities of

fruit consumption for households in Guangdong are more significant than the households in Jiangsu province when they are compared to households in Shandong province. In addition, the effect is more substantial for households in the upper tail of the distribution of fruit consumption. For instance, at the 0.75 percentile, the differences in differences in fruit consumption are -8.02 and 5.02 when households in Guangdong and Shandong are compared to the households in Shandong, respectively.

To highlight the distributional effects of the difference in differences in fruit/vegetable consumption across households in different provinces, we estimate the fruit consumption at every 5 percentile from 0.05 to 0.95. Due to limited space, we only report the estimates of the quantile regression results for the 0.25, 0.50 and 0.75 percentiles in Table 3. In Figures 3 and 4, we plot the DID effects at all percentiles of fruit consumption *ceteris paribus*. In each figure, we plot 19 distinct QR estimates ranging from 0.05 to 0.95. The shaded area is the 95% confidence interval of the QR based on the bootstrap method with 1,000 replications. For the sake of comparison, we also plot the dashed (horizontal straight) line as the OLS estimate.

Consistent with the estimations in Table 3 (section 3B), the differences of the changes in fruit consumption between households in Jiangsu and Shandong are generally increasing across the entire distribution over percentiles (Figure 3). The disparities of fruit consumption are evident toward the two tail percentiles in that the 95% confident intervals do not contain the zero value of the horizontal axis. However, the story is different when the changes of fruit consumption over time are compared between households in Guangdong and Shandong provinces (Figure 4). The changes in fruit consumption in Guangdong over time are always less than in Shandong province. However, the disparity is mostly statistically insignificant over the entire distribution of the fruit consumption (Figure 4).

In regard to vegetable consumption, the estimates of the OLS and QR methods, along with the calculated difference-in-differences effects are reported in Table 4. Section A4 (bottom of Table 4) shows that vegetable consumption from 1993 to 2001 decreased unambiguously among the three selected provinces, and universally, the higher the percentile, the more the decrements in vegetable consumption. Similar to the findings in fruit consumption, the differences in the estimates between the OLS and QR methods reveals the heterogeneity of vegetable consumption across the entire distribution over percentiles. This evidence is supportive for the argument that simply applying the conventional OLS method may result in misleading inferences. Taking

the changes of the vegetable demand for households in Shandong providence for example, OLS predicts a 13.32 kg decrease, while the quantile regression estimations point to a 8.06 kg, 11.86, and 16.49 kg decrease at the 0.25, 0.50, and 0.75 percentiles, respectively. Simply using the OLS results underestimates the effects of the changes in vegetable consumption for households in the upper tail of the distribution.

With respect to the extent to which vegetable consumption over time may differ across households in different regions (i.e. the difference-in-differences effect), we summarize our estimates at the bottom of Table 4 (section B4). In contrast to the estimated DID effect of fruit consumption, the effects of the changes in vegetable consumption from year 1993 to 2001 are not statistically significant for households in these three selected provinces. Also, the difference-in-differences effects of vegetable consumption are insignificant for all percentiles in the distribution. These can also be seen in Figures 5 and 6 in that the 95% confident intervals of the estimations of the quantile regression contain the zero value. This finding of insignificant DID effects may be reasonable since vegetables are the second largest amounts of foods consumed in China and thus the differences over time and across these three costal provinces would be similar.

Effects of other factors on fruit and vegetable consumption

Other than time and regional effects, some important socio-economic factors were also incorporated into the estimation of fruit and vegetable demand functions. Parameter estimates of income and prices are mostly statistically significant in both equations, especially the price of fruit. All income coefficients are positive and estimates of the income square term are negative, indicating that fresh fruit and vegetables are normal goods. In addition, the negative sign of the coefficient for the squared term of income in fruit and vegetable consumption indicates that the effect of income is non-linear. The own-price coefficients are negative, consistent with the law of demand, even though the price of vegetables is mostly insignificant in the vegetable demand function. In addition, estimates for prices of meat and fresh vegetables in the fruit equation are all positive, indicating a gross substitute for fruit; whereas estimates for prices of meat and fresh fruit in the vegetable equation are all negative, presenting a gross complement for vegetables. Our findings are in accordance with the related studies (Yen *et al*., 2004; Gould and Villarreal, 2006).

Table 5 exhibits price and income elasticities for fruit and vegetable demands.

Similar to Tables 3-4, elasticity estimates and their t-values are reported. Most of the elasticities are statistically significant, indicating that they are important factors affecting both fruit and vegetable demands. The own-price elasticities of both fruits and vegetables are negative for each of the OLS and three QR estimates, satisfying the law of demand. In addition, their absolute values are less than unity, indicating both to be less elastic. Cross-price elasticities of meat on fruits are positive and less than one, presenting meat to be substitutes for fruits; in contrast, meats are complements of vegetables due to negative cross-price elasticities. Finally, income elasticities of fruits and vegetables are positive and less than unity, indicating both to be necessities and moreover fruits have a stronger income response than vegetables.

[Insert Table 5 about here.]

Household characteristics, as discussed earlier, are also important to determine household demand for fresh fruits and vegetables. In general, if a householder is a white-collar (W_collar) or blue-collar worker (B_collar), household demand for both fruit and vegetables is less than if a householder has neither a white- nor blue-collar job, such as farmers. As to the education level possessed by a householder, the impacts are the opposite; namely, the higher the education level, the more the fruit demand, but the less the demand for vegetables. In addition, the older the household head, the more the demand for both food items. Our conjecture is that an elder householder is more aware of health concerns. The effect of the household size is negative, as expected, indicating that the bigger the family, the less the quantity available for each member. Finally, since fruits and vegetables are perishable, households possessing a refrigerator demand more of both food items since a refrigerator can store fresh fruits and vegetables longer to keep them from perishing.

Concluding Remarks

With increasing globalization of the food market in China, studying the structure of food demand in China has become of interest to many researchers. Among most of the existing work, the focus is on meat and grain consumption. Relatively little is known about fruit and vegetable consumption in China. To fill this void in the literature, this paper examines the factors that are associated with Chinese households' fruit and vegetable consumption. Special attention is paid to understanding how fruit and vegetable consumption changes over time and how it may differ for households in different regions.

The analytical framework of this paper is relatively novel. We utilize the difference-in-differences model to capture fruit and vegetable consumption and estimate it based on the quantile regression method. This special feature is an important methodological contribution that sets our study apart from previous studies. By applying quantile regression to the fruit and vegetable demand functions, we are able to examine the potential heterogeneity of fruit and vegetable consumption over time and the disparities across regions. Using the household survey in Shandong, Jiangsu and Guangdong provinces, our empirical results show that the changes in fruit consumption over time differ for households in different regions. There are increasing trends revealed for households in Jiangsu and Shandong providences, but not for Shandong. With respect to the disparity of the changes in fruit consumption across regions, our results show that the significant disparity is only evident for households with a higher consumption level. The story is somewhat different for vegetable consumption. It appears that Chinese households' vegetable consumption decreased from 1993 to 2001, and this result is robust across regions. However, the disparities of vegetable consumption among households in different provinces are found to be insignificant.

Another contribution of our findings to the literature is in the area of methodology. Since the OLS and QR methods provide different estimation results, this is supportive of the belief that the fruit and vegetable consumption of Chinese households is not homogenous across the entire distribution. That is, the changes of the fruit and vegetable demand over time differ for households with different consumption levels. Therefore, using a simple regression technique on fruit and vegetable consumption may result in an incomplete understanding of the demand structure for fruit and vegetables in China.

Our results may shed some light on the food policy in China. First, policy should be designed differently for households with different fruit and vegetable consumption since potential heterogeneity of fruit and vegetable consumption across households are found to vary in this study. The second policy implication is related to health concerns. With a rising public concern for a healthy diet, having an adequate consumption of fruits and vegetables has been associated with better health. In this regard, policy that aims to promote the fruit and vegetable consumption of households should take the regional disparities into account, especially for fruit consumption. Households in the southern part of China seem to have a higher risk of inadequate

consumption of fruits. However, this issue can be better addressed by investigating the type of households whose fruit and vegetable consumption are below the dietary recommended guideline. Since this issue is beyond the scope of this study, it provides a direction for further research.

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Table 1: Distributions of Per Capita Fruit and Vegetable Consumption (2001 vs. 1993) [1]

	Guangdong			Shandong			Jiangsu		
Percentile	2001	1993	Diff [2]	2001	1993	Diff [2]	2001	1993	Diff [2]
Fruit Consumption (Kg)									
0.1	14	7	7	30	20	10	20	16	4
0.2	22	12	10	40	29	11	29	24	5
0.3	28	17	11	47	38	9	41	30	11
0.4	34	21	13	55	43	12	49	36	13
0.5	40	26	14	63	51	12	59	44	15
0.6	46	31	15	73	60	13	68	52	16
0.7	54	37	17	83	69	14	80	60	20
0.8	63	47	16	98	82	16	98	72	26
0.9	78	61	17	125	108	17	131	92	39
Vegetable Consumption (Kg)									
0.1	61	60	1	46	48	–2	53	55	–2
0.2	76	69	7	61	63	–2	72	69	3
0.3	83	80	3	72	76	–4	87	81	6
0.4	92	89	3	83	88	–5	97	91	6
0.5	99	99	0	92	99	–7	110	104	6
0.6	109	109	0	104	110	–6	124	114	10
0.7	120	122	–2	121	122	–1	140	128	12
0.8	139	137	2	135	137	–2	165	147	18
0.9	170	162	8	163	173	–10	215	204	11

Note: 1. Sample sizes are 600, 650 and 800 for Guangdong, Shandong and Jiangsu, respectively.
2. Diff indicates the difference of each percentile of year 2001 from 1993.

Table 2: Sample Statistics (2001 vs. 1993)

		Guangdong [1]				Shandong [1]				Jiangsu [1]			
		2001		1993		2001		1993		2001		1993	
Label	Definition	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Grain_p	Real price of grain (Yuan/Kg) [2]	1.99	0.56	2.17	0.57	1.17	0.20	1.26	0.23	1.24	0.16	1.27	0.22
Meat_p	Real price of meat (Yuan/Kg) [2]	10.75	1.55	12.11	1.48	7.56	1.33	7.28	1.11	7.91	1.38	8.04	1.32
Fveg_p	Real price of fresh vegetables (Yuan/Kg) [2]	1.71	0.42	2.18	0.60	0.85	0.21	0.86	0.25	1.06	0.30	1.08	0.30
Fruit_p	Real price of fresh fruits (Yuan/Kg) [2]	3.43	1.23	4.43	1.77	1.05	0.35	1.19	0.43	1.13	0.49	1.51	0.79
W_collar	If the householder is a white-collar worker (=1)	0.51	0.50	0.49	0.50	0.58	0.49	0.55	0.50	0.31	0.46	0.45	0.50
B_collar	If the householder is a blue-collar worker (=1)	0.33	0.47	0.35	0.48	0.29	0.45	0.32	0.47	0.36	0.48	0.34	0.48
College	If the householder has a college degree or higher (=1)	0.26	0.44	0.17	0.37	0.29	0.46	0.18	0.39	0.21	0.40	0.18	0.39
High	If the householder has a high school diploma (=1)	0.54	0.50	0.39	0.49	0.43	0.50	0.41	0.49	0.34	0.48	0.39	0.49
Junior	If the householder has a junior high school diploma (=1)	0.15	0.36	0.28	0.45	0.23	0.42	0.30	0.46	0.35	0.48	0.31	0.46
Male	If gender of the householder is male (=1)	0.57	0.50	0.70	0.46	0.59	0.49	0.61	0.49	0.77	0.42	0.74	0.44
Age	Age of the householder (in years)	44.32	9.21	45.69	10.65	43.70	10.45	43.10	10.91	51.31	12.21	46.26	12.20
H_size	Number of persons living in the household (in person)	3.33	0.78	3.49	0.92	3.10	0.64	3.23	0.78	2.94	0.92	3.10	0.88
Age6	Number of children age 6 or under (in person)	0.16	0.38	0.19	0.41	0.14	0.35	0.19	0.39	0.09	0.29	0.18	0.40
Age7_15	Number of children age between 7 and 15 (in person)	0.44	0.55	0.51	0.58	0.42	0.52	0.51	0.56	0.28	0.47	0.43	0.53
Refri	Number of refrigerators in a household (in units)	0.95	0.32	0.82	0.43	0.89	0.41	0.64	0.50	0.92	0.38	0.78	0.62
Income	Real total household living expenses ($1,000 Yuan) [2]	7.01	4.82	4.79	2.89	3.23	2.01	2.02	0.90	3.87	2.62	2.72	1.46

Note: 1. Sample sizes are 600, 650 and 800 for Guangdong, Shandong and Jiangsu, respectively.
2. Prices and income of 2001 are deflated by consumer price index (1993= 1).

Table 3: Parameter Estimates of the Fruit Demand Equation

	OLS		Quantile Regression					
			0.25		0.50		0.75	
Variable	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
T01 (α_1)	1.85	0.91	**3.35**	2.19	3.15	1.43	4.25	1.60
GD (α_2)	**–19.02**	–5.63	**–15.33**	–7.85	**–20.41**	–6.91	**–27.59**	–5.27
T01*GD (α_3)	**–6.02**	–1.99	–1.51	–0.71	–1.59	–0.48	**–8.06**	–1.89
JS (β_1)	**–13.32**	–6.88	**–8.74**	–5.43	**–11.40**	–8.97	**–16.12**	–9.25
T01*JS (β_2)	3.49	1.32	–1.45	–0.90	0.85	0.42	**5.02**	3.16
Grain_p	0.27	0.15	–0.03	–0.03	–0.66	–0.42	0.59	0.24
Meat_p	**0.91**	1.94	**1.04**	3.27	**1.39**	3.34	0.83	1.23
Fveg_p	0.96	0.49	1.85	1.38	2.34	1.47	3.09	1.09
Fruit_p	**–8.58**	–13.08	**–6.28**	–10.40	**–7.56**	–7.86	**–8.14**	–6.83
W_collar	**–3.83**	–1.87	–1.93	–1.01	–3.76	–1.63	–4.81	–1.51
B_collar	**–4.12**	–1.90	–1.46	–0.74	**–3.67**	–1.74	–5.00	–1.36
College	4.02	1.62	2.10	1.12	2.62	1.26	1.69	0.48
High	3.16	1.46	**2.69**	1.73	3.09	1.56	0.34	0.13
Junior	2.62	1.23	2.35	1.30	1.58	0.83	–0.97	–0.42
Male	–0.18	–0.14	–1.14	–1.41	0.14	0.13	0.64	0.40
Age	**0.28**	3.46	**0.14**	2.23	**0.19**	2.27	**0.33**	2.57
H_size	**–9.03**	–12.35	**–3.94**	–6.41	**–5.86**	–7.92	**–9.51**	–9.63
Age6	–1.42	–0.74	1.30	1.00	–1.06	–0.86	0.58	0.23
Age715	–0.37	–0.29	1.12	1.33	1.04	0.82	0.66	0.42
Refri	**5.21**	4.13	**3.58**	3.56	**4.95**	5.74	**5.06**	2.81
Income	**5.40**	14.21	**4.21**	5.75	**4.56**	4.51	**6.31**	4.63
Income-square	**–0.07**	–6.88	–0.09	–1.61	–0.09	–1.54	–0.08	–0.99
Constant	**66.43**	9.83	**29.04**	4.78	**49.95**	8.24	**79.43**	10.33
R square [1]		0.27		0.14		0.16		0.18
	Testing the differences from 1993 to 2001 (A3)							
	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Ho: GD	**–4.16**	0.08	1.84	0.27	1.56	0.55	–3.81	0.14
Ho: JS	**5.35**	0.00	1.91	0.13	**3.99**	0.05	**9.27**	0.00
Ho: SD	1.85	0.36	**3.35**	0.01	3.15	0.15	**4.25**	0.06
	Testing the difference in differences from 1993 to 2001 across regions (B3)							
Ho: GD vs. SD	**–6.02**	0.05	–1.51	0.47	–1.59	0.63	**–8.06**	0.01
Ho: JS vs. SD	3.49	0.19	–1.45	0.42	0.85	0.77	**5.02**	0.09

Note: 1. Adjusted R^2 is reported for the OLS regression, and pseudo R^2 for quantile regressions.

Table 4: Parameter Estimates of the Vegetable Demand Equation

	OLS		Quantile Regression					
			0.25		0.50		0.75	
Variable	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
T01 (α_1)	**–13.32**	–4.67	**–8.06**	–2.58	**–11.86**	–4.57	**–16.49**	–7.51
GD (α_2)	**30.69**	6.45	**27.93**	8.02	**24.24**	3.66	**27.68**	4.25
T01*GD (α_3)	–6.30	–1.48	–5.63	–1.41	–5.18	–1.06	–1.25	–0.21
JS (β_1)	**5.32**	1.95	**5.46**	1.92	2.07	0.74	–0.43	–0.16
T01*JS (β_2)	–2.05	–0.55	–1.99	–0.47	0.33	0.10	4.83	1.15
Grain_p	3.95	1.51	2.19	1.26	1.75	0.61	**6.42**	2.08
Meat_p	**–4.88**	–7.43	**–3.13**	–5.02	**–4.65**	–5.47	**–5.17**	–7.13
Fveg_p	**–9.23**	–3.38	**–8.75**	–3.21	–6.11	–1.58	**–9.14**	–2.34
Fruit_p	**–4.41**	–4.77	**–2.95**	–2.12	**–2.48**	–2.55	**–3.59**	–2.97
W_collar	**–13.22**	–4.57	**–6.41**	–2.54	**–11.80**	–3.05	**–15.72**	–3.65
B_collar	**–9.50**	–3.10	–3.51	–1.15	**–6.91**	–1.94	**–10.51**	–2.80
College	**–14.61**	–4.19	**–6.05**	–1.83	**–10.82**	–2.95	**–12.28**	–2.50
High	**–9.20**	–3.03	–1.64	–0.60	–5.81	–1.53	**–9.12**	–1.89
Junior	**–6.27**	–2.09	–1.31	–0.44	–4.81	–1.23	–4.86	–1.16
Male	**3.12**	1.80	**3.61**	2.41	**4.35**	3.29	**3.75**	2.42
Age	**1.40**	12.20	**0.90**	8.48	**1.21**	6.72	**1.80**	7.20
H_size	**–15.93**	–15.46	**–7.24**	–10.71	**–11.97**	–14.79	**–17.07**	–13.74
Age6	**–8.27**	–3.07	**–11.71**	–4.66	**–9.83**	–3.05	–3.94	–0.79
Age715	**–5.50**	–3.07	**–4.17**	–2.86	**–5.06**	–3.69	–4.69	–1.63
Refri	2.40	1.35	**4.55**	2.70	**3.03**	1.88	1.12	0.55
Income	**5.89**	11.02	**3.26**	3.40	**4.59**	5.32	**6.00**	5.07
Income square	**–0.10**	–6.33	–0.06	–0.88	**–0.09**	–1.87	**–0.10**	–1.74
Constant	**149.84**	15.74	**90.34**	9.83	**133.71**	13.87	**160.22**	9.75
R square [1]		0.31		0.11		0.13		0.19
	Testing the differences from 1993 to 2001 (A4)							
	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Ho: GD	**–19.62**	0.00	**–13.68**	0.00	**–17.04**	0.00	**–17.74**	0.00
Ho: JS	**–15.37**	0.00	**–10.04**	0.00	**–11.53**	0.00	**–11.66**	0.00
Ho: SD	**–13.32**	0.00	**–8.06**	0.00	**–11.86**	0.00	**–16.49**	0.00
	Testing the difference in differences from 1993 to 2001 across regions (B4)							
Ho: GD vs. SD	–6.30	0.14	–5.63	0.13	–5.18	0.16	–1.25	0.82
Ho: JS vs. SD	–2.05	0.58	–1.99	0.54	0.33	0.92	4.83	0.33

Note: 1. Adjusted R^2 is reported for the OLS regression, and pseudo R^2 for quantile regressions.

Table 5: Price and Income Elasticities of Fruits and Vegetables

Variable	OLS		Quantile Regression					
			0.25		0.50		0.75	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Price of	**Fruit Demand**							
Grain	-0.001	-0.04	0.007	0.150	0.060	1.360	-0.022	-0.780
Meat	**0.146**	1.96	**0.283**	2.860	**0.225**	2.460	**0.118**	1.940
Vegetables	0.024	0.56	0.073	1.390	0.031	0.600	0.058	1.660
Fruits	**-0.313**	-12.96	**-0.389**	-14.500	**-0.319**	-11.020	**-0.231**	-9.180
Income	**0.336**	11.69	**0.444**	13.428	**0.304**	8.858	**0.312**	15.210
Price of	**Vegetable Demand**							
Grain	**-0.117**	-4.670	**-0.142**	-4.560	**-0.138**	-5.380	**-0.102**	-3.840
Meat	**-0.336**	-6.460	**-0.271**	-3.740	**-0.348**	-6.730	**-0.275**	-5.320
Vegetables	**-0.062**	-2.070	**-0.090**	-2.470	-0.038	-1.240	-0.034	-1.070
Fruits	**-0.072**	-4.310	**-0.053**	-2.930	**-0.049**	-2.990	**-0.058**	-3.320
Income	**0.223**	12.060	**0.181**	8.080	**0.188**	9.970	**0.195**	11.530

Note: Bold are significant at the 10% level.

Figure 1: Changes in Fruit Consumption over Time by Percentiles

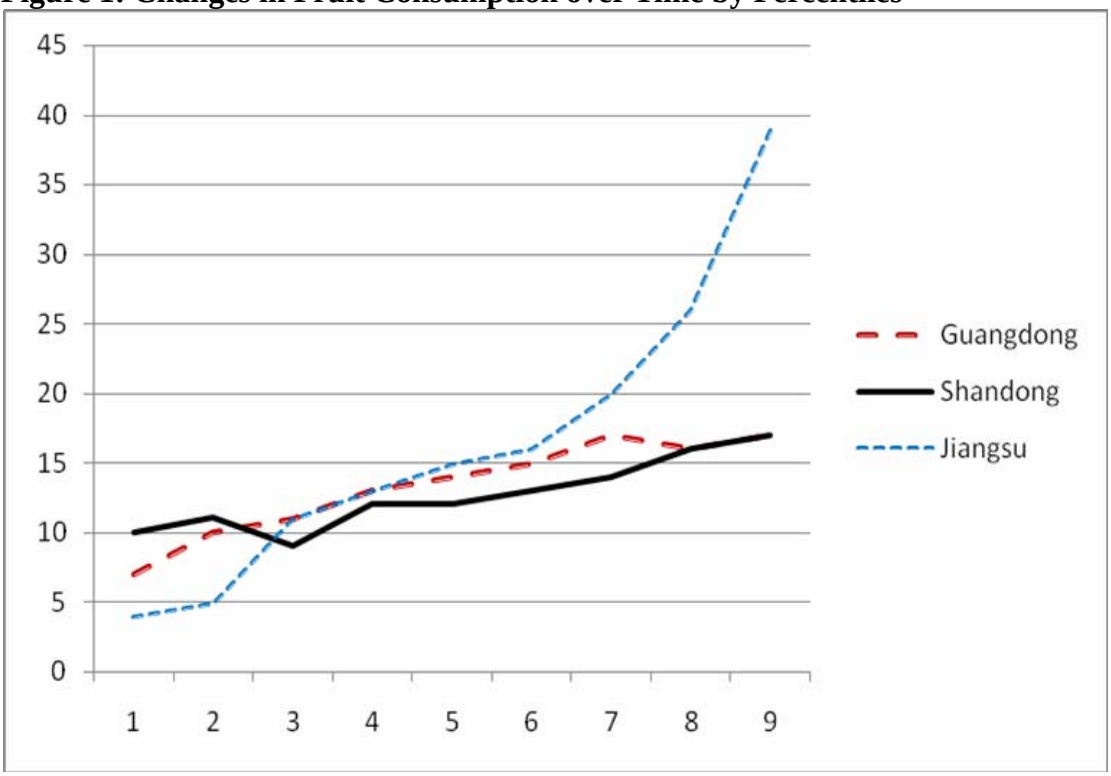

Figure 2: Changes in Vegetable Consumption over Time by Percentiles

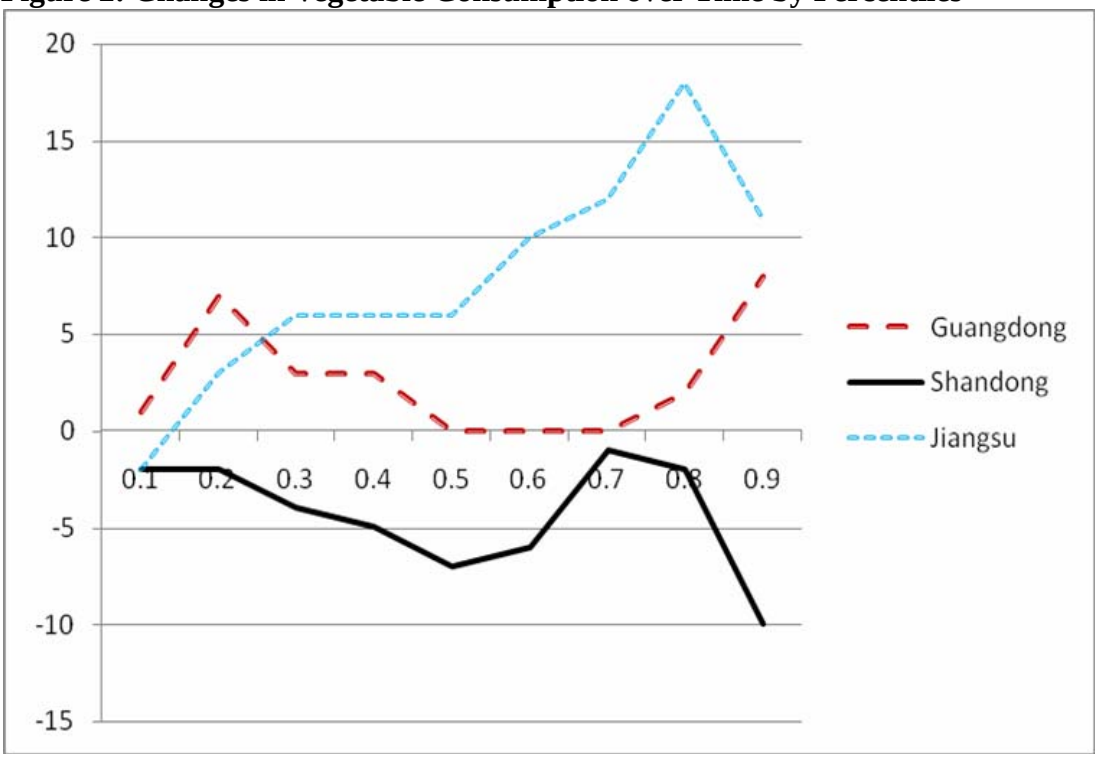

Figure 3: Difference-in-differences of Fruit Consumption between Jiangsu (JS) and Shandong (SD)

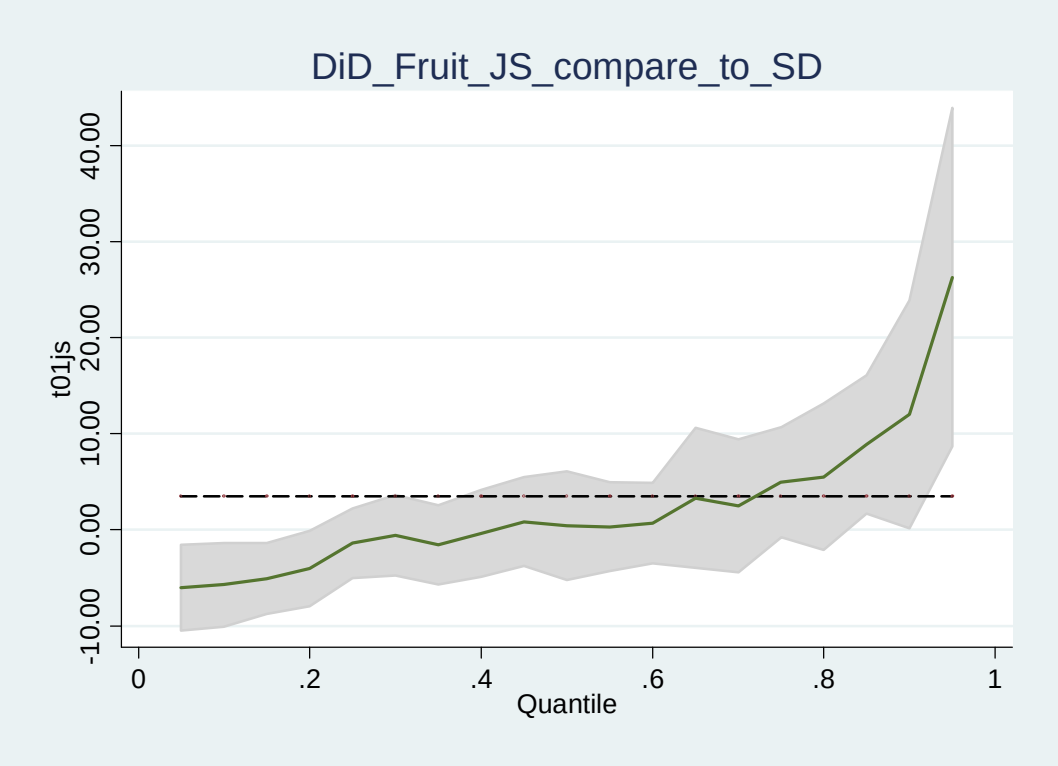

Figure 4: Difference-in-differences of Fruit Consumption between Guangdong (GD) and Shandong (SD)

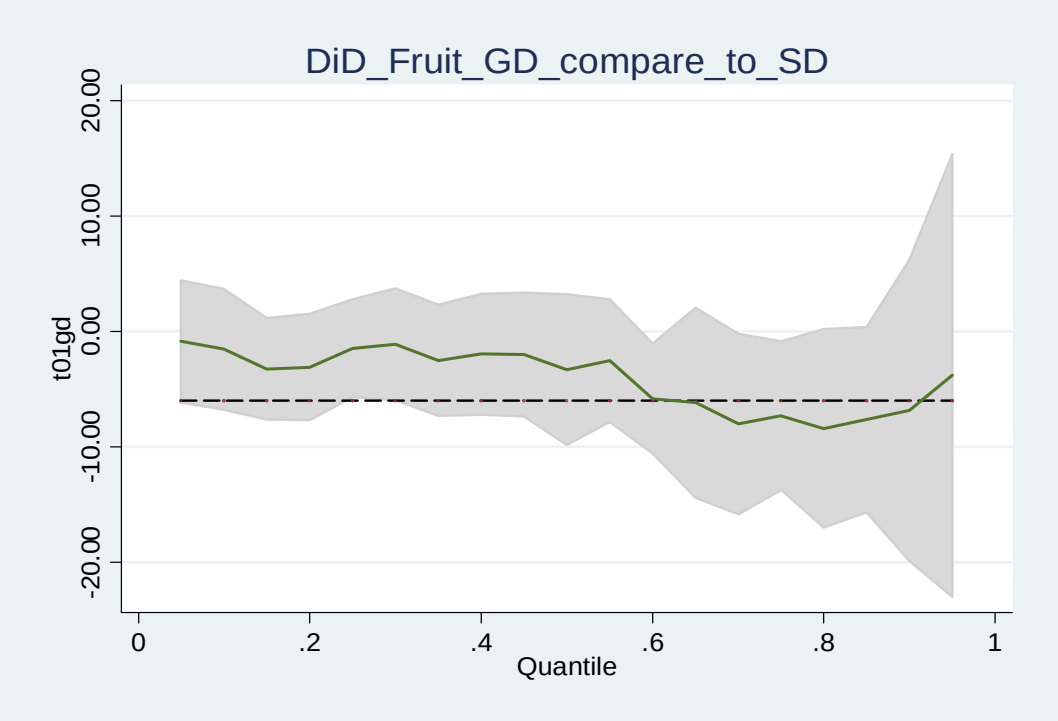

Figure 5: Difference in differences of Vegetable Consumption (Jiangsu vs Shandong)

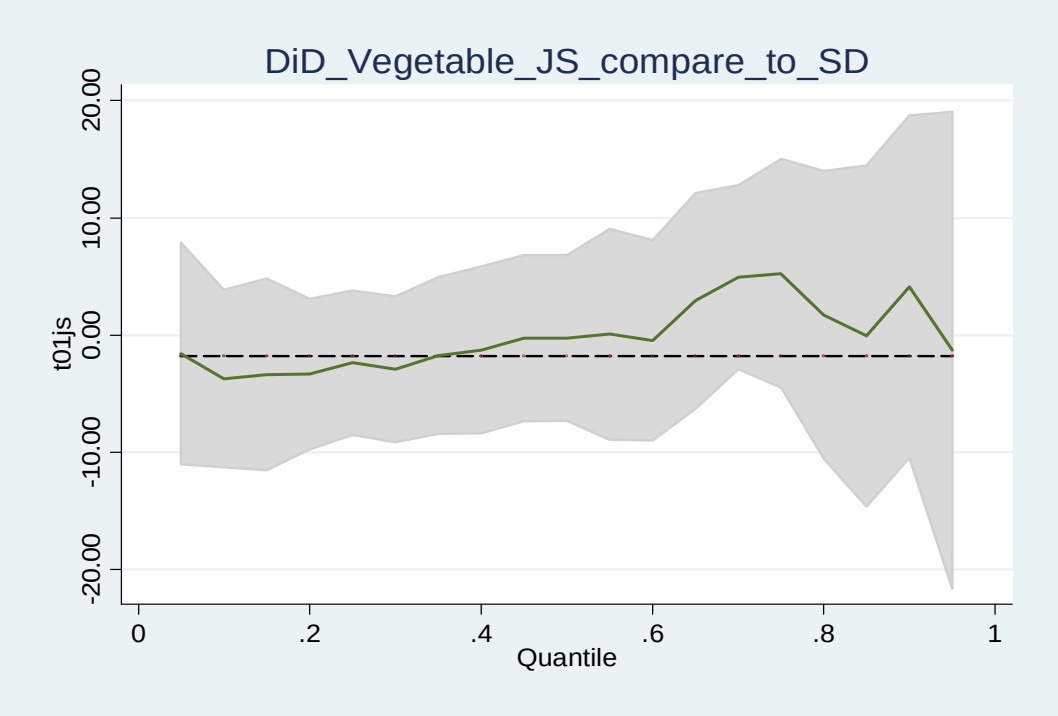

Figure 6: Difference in differences of Vegetable Consumption (Guangdong vs Shandong)