Agricultural Market Reforms and Nutritional Transition in Rural China

Kathy Baylis
Assistant Professor, Department of Agricultural and Consumer Economics
University of Illinois

Linlin Fan*
PhD Student, Department of Agricultural and Consumer Economics
University of Illinois
E-mail: lfan3@illinois.edu

Lia Nogueira
Assistant Professor, Department of Agricultural Economics
University of Kentucky

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

 The authors would like to thank Nolan Miller, Alex Winter-Nelson, Robert Jensen for comments nd the University of Illinois Research Board for funding

Agricultural Market Reforms and Nutritional Transition in Rural China*

Kathy Baylis, Linlin Fan and Lia Nogueira

Abstract

In the 1990s, prior to its accession to the WTO, China dramatically reduced market distortions in its agriculture. We use panel data of 10,488 households from 1989 to 2000 and ask whether these reforms improved the welfare of rural Chinese households measured by the share of calories from non-staples (SCNS). We identify the effect of market liberalization by calculating the degree to which local markets reflect world prices. We find that market liberalization enhances both undernourished and nourished farmers' nutrition by increasing their value of agricultural production and off-farm income. Market liberalization is particularly beneficial for horticulture producers and remote, inland provinces.

Keywords: market liberalization, household food security, rural China

JEL No. I32, O12, O24, Q18

Introduction

Spurred by a dramatic increase in grains imports, this past year has seen a heated debate about the effects of trade and market liberalization on food security in China. Some argue that increased imports of grains and lower prices will cause grains farmers to earn less farm income and to leave farming, generating food insecurity in China (Wong and Huang 2012). Others point out that China may not have a comparative advantage in grain production, and switching to higher-value agriculture such as horticulture or working off-farm may increase grain farmers' income. Higher household income, in turn, may more effectively increase food security than merely producing more grains domestically (Zhu, Hare and Zhong 2010). In this paper, we evaluate the effect of past trade and market liberalization on rural Chinese household's food security. By better understanding the linkages between market liberalization, value of agricultural production, off-farm income and nutrition, we hope to contribute to the current debate on how to best address rural food insecurity in China.

China underwent tremendous agricultural market, price and trade reforms in the 1990s prior to its accession to the WTO. These reforms drastically decreased domestic market distortions (Huang et al. 2009). In the 1990s, market liberalization in urban China included the abolition of food coupons, the reduction in state subsidies for education, health, housing and pensions, and increased job uncertainty for employees of state-owned enterprises (SOE). A key rural reform was the gradual elimination of China's procurement and rationing system from 1978 to 2000. This system required farmers to sell a pre-determined amount (grains quota) to the government at a lower-than-market price which the government sold to urban consumers at a lower-than-market price, effectively taxing grains producers. China reduced the quota and the price disparity over time, eventually eliminated the grains quota system around 2000. The government also decentralized much of the trading authority, reduced the scope of non-tariff barriers, relaxed tariff

rates at the border, reduced tariff rate quotas and relaxed licensing procedures for some crops (e.g. removing oil and oil seed imports from the jurisdiction of state trading firms) (Huang and Chen 1999). From 1992 to 1998, the average agricultural import tariff rate fell from 42.2% to 23.6% (MOFTEC 2001). At the same time, massive infrastructure construction took place and significantly reduced transactions cost in agricultural markets (Luo et al. 2007). In this article, we ask how agricultural market liberalization has affected value of agricultural production, off-farm income and consequently the welfare of rural Chinese households. We use household food security as our measure of well-being.

Based on data from the China Health and Nutrition Survey (CHNS), we find that households' value of agricultural production and market off-farm income[1] rose from 1989 to 2000. Value of agricultural production increased from 7814 Yuan to 8599 Yuan while market off-farm income more than doubled from 4263 Yuan to 9642 Yuan.[2] We also find that the rate of commercialization, defined as the share of agricultural production value sold, increased from 30.7% to 48.6% from 1989 to 2000.

At the same time, Chinese household food security and nutrition increased significantly. Following the approach by Jensen and Miller (2010), we find that the share of calories from non-staples (SCNS) for farmers increased from 20.6% to 25.5% from 1989 to 2000. A SCNS greater than 20% is a reasonable measure of being out of hunger (Jensen and Miller 2010). That said, nutritional sufficiency varied greatly by region. While people in the wealthy, coastal regions were shifting their food consumption from staples to animal products, those in poor rural areas often still struggled with inadequate food for subsistence (Zhu, Hare and Zhong 2010). Based on CHNS data, rural households consumed 21% of their calories from non-staples while those in urban areas consumed 27% in 1989. In 2000, rural households consumed 26% of calories from non-staples compared to 39% in urban areas.

Rural poverty is still an urgent policy concern and improving accessibility to adequate quantity and diversity of nutrients in rural areas is a major food security objective for Chinese policy makers (Mangyo 2008; Huang and Rozelle 2009; de Brauw and Mu 2011). To be able to improve rural household food security, one must first understand how the dramatic changes to the agricultural market have affected the production and consumption of Chinese farmers.

Market liberalization and the resulting agricultural commercialization can be a powerful means to improve agricultural efficiency, increase rural household income and, therefore, enhance household access to food (Immink and Alarcon 1991; Bouis and Haddad 1990; Von Braun and Webb 1994; Kennedy and Haddad 1994). Market-oriented food production can also facilitate access to credit, technological adoption, diversify production and mitigate production shortfalls (Von Braun 1988; Rubin and Webb 1988; World Bank 2002; DFID 2002; Govereh and Jayne 2003; Ali and Farooq 2003). In China, Wang et al. (2009) argue that agricultural market reforms have allowed relatively small and poor farmers to participate in emerging horticulture markets and increase their agricultural income through commercialization. That said, market liberalization is not unambiguously good for farmer welfare. Market liberalization can harm rural households who have little access to credit and are constrained from switching production (Paolisso et al. 2002). If

[1] Market off-farm income includes salary income, business income if the household runs a small business, rent income and remittances.

[2] All income data are in constant 2009 Yuan.

market prices are highly volatile then market liberalization may cause the household to face highly variable income which can negatively affect nutrition (Gross and Underwood 1971; Von Braun and Kennedy 1986; Von Braun, Hotchkiss and Immink, 1989; Bouis et al. 1984; Haaga et al. 1986; Fleuret and Fleuret 1991). Thus, the relation between market liberalization and household food security is not obvious ex-ante, while the answer is crucial to be able to predict the effect of agricultural and trade policy, and the potential need for domestic food assistance.

In our paper, we identify the effect of market liberalization by using the fact that some markets are more isolated than others, and therefore market reforms will affect regions differently. We identify the degree of local market liberalization by comparing the variation in local and world prices. While many studies use reduction of tariffs and import quotas to identify market liberalization (Hertel et al. 2003; Goldberg and Pavcnik 2004; Hertel et al. 2004), trade protection often comes in the form of non-tariff barriers (NTBs) that are hard to quantify. Our measure of market liberalization accounts for NTBs and serves as an index of how tightly the locality is linked to world agricultural markets.

Next, we use this measure of effective market liberalization to estimate whether the change in market liberalization has affected household food security for farming households in rural China. Following Jensen and Miller (2010), we use share of calories from non-staples (SCNS) as our measure of household food security. Although people have individual-varying, unobservable caloric thresholds and caloric absorption, SCNS allows us to use household consumption behavior. We can determine when a household has passed a subsistence level of consumption, where the focus is on consuming sufficient calories from the cheapest sources (staples) and when the household substitutes away from staples to satisfy non-caloric attributes such as micronutrients and taste.

We use a panel of rural households from 1989 to 2000 to explore the relation among value of agricultural production, off-farm income and nutrition using three-stage least squares, where value of agricultural production, off-farm income and nutritional outcomes are each estimated as part of a simultaneous system of equations. We instrument value of agricultural production using the grains quota. The farmer's off-farm income is instrumented by the share of off-farm labor force in the community. Last, we estimate nutritional outcomes as a function of off-farm income and value of agricultural production along with household demographic information, the access to food market, wealth, local food prices, and community communication scores. We study these effects using household, county and then province, fixed effects to control for time-invariant unobservable factors.

One may be concerned that market liberalization might affect poor and better-off farmers differently. Therefore we split the sample into high and low nourished households. We define households who have more than 20% of calories from non-staples as the nourished group and under 20% as undernourished following Jensen and Miller (2010). We also consider different agricultural production types including field crops, horticulture, livestock and mixed. Because we are using secondary data and the relation is complex, we run several robustness tests on the definitions of farmer, the rural sample, the nutritional measures.

We find that market liberalization increases both undernourished and nourished households' nutrition through the value of agricultural production and off-farm income. Results show that

market liberalization drives mixed, field crops and horticulture producers to focus on agriculture and is particularly beneficial for horticulture producers and remote, inland provinces. Notably, conventional nutritional measures such as caloric intake may mask important information.

Our paper has a number of potential contributions. First, to our knowledge this is the first evaluation of the effect of market liberalization on nutrition in rural China. Second, we use variation in relative prices to identify the effect of market liberalization, which is a relatively novel approach in this literature. Third, this paper is one of the few to study how market liberalization in China affects a farmer's decision to seek off-farm work. Fourth, we use a relatively novel measure of nutrition, as proposed by Jensen and Miller (2010), to estimate the effect of agricultural liberalization on household outcomes. We test these measures against more common measures of nutrition and largely finding that the results are consistent. We do find, however, that a commonly used measure: the number of calories consumed, may mask important changes in a household's welfare.

Data and Identification

We use data from the China Health and Nutrition Survey (CHNS) conducted by the Population Center at the University of North Carolina at Chapel Hill. The dataset we use includes 156 rural communities and 10,488 rural households in 9 provinces: Heilongjiang, Liaoning, Jiangsu, Shandong, Hubei, Hunan, Henan, Guizhou and Guangxi in 1989, 1991, 1993, 1997 and 2000. In this paper, we consider only rural communities, defined as communities having over 25% of income from agriculture in any of the survey years. Around 96% of communities which have agricultural data are included by this definition. The CHNS recorded detailed data on household nutrition, agricultural production, off-farm income and community-level economic and retail information. The measure of nutrition and market liberalization are identified as follows:

Nutrition. Jensen and Miller (2010) utilize the CHNS data from 1991 to 2000 to test the validity of using the share of calories from staples (SCS) as a measure of household nutrition. They show that the empirical SCS threshold where households pass subsistence closely matches what would be estimated from a minimum cost diet calculation based on economic theory. Therefore, they argue that SCS is advantageous over other measures of nutrition in allowing consistent preferences of food, avoiding individual-varying and unobservable caloric absorption and caloric thresholds. They conclude that instead of using a standard caloric threshold, policy makers should care more about helping the consumer reach a point where he surpasses subsistence and a low marginal utility of calorie which is indicated by SCS. Following Jensen and Miller (2010), we use the share of calories from non-staples (SCNS) as our measure of nutrition.

To investigate the suitability of SCNS as a measure of nutrition, we plot kernel density distributions of log SCNS from our sample in rural China for different income groups (figure 1). Low, medium and high income households are chosen to be those who have gross income less than 2401 Yuan per adult (25 percentile), between 2401 Yuan and 6444 Yuan per adult (75 percentile), and more than 6444 Yuan per adult respectively. It is clear from figure 1 that the distribution of log SCNS shifts to the right as gross income per adult increases. The majority of the households have log SCNS from 3 (20% in SCNS) to almost 3.3 (27% in SCNS) when income increases. Significantly fewer people in the high income group than in the low income group have a log

SCNS below 3 (equivalent to a SCNS of 20%) . Because the individual nutritional sufficiency threshold varies, income may not be a perfect indicator of hunger. But SCNS may be subtle enough to capture the change in the distributions of nutritional sufficiency within the same income group.

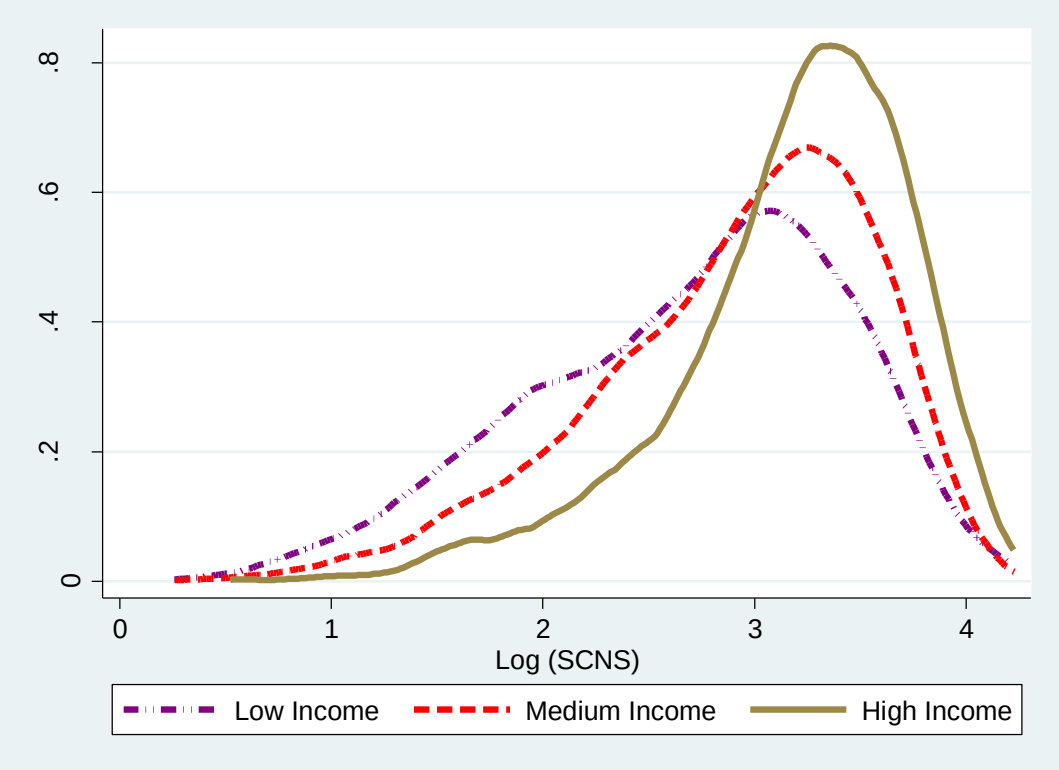

Figure 1. Log SCNS Kernel Density Distributions for Different Income Groups

We next run OLS and quantile regressions of log gross income per adult on the log of SCNS, with the results shown in table 1. Graphs of the fitted regression lines are presented in the appendix. We observe a clear positive relation between the log SCNS and log gross income per adult. We also observe a clear decreasing marginal effect of income. The coefficient of log income on log SCNS decreases as we move from 20 percentile to 80 percentile quantile regression. This result is consistent with the theory of diminishing marginal utility of calories in literature (Jensen and Miller 2010). We next consider more traditional measures of nutrition. OLS, quantile regressions and correlation tables find little correlation between income and alternative nutritional measures in contrast to the SCNS. Caloric intake is even negatively correlated with income (table 2). Therefore, we use SCNS as our measure of household nutrition and welfare.

Table 1. Nutritional Measures and Log Gross Income per Adult Regression Table

	20th	40th	60th	80th	OLS
SCNS	0.351***	0.265***	0.190***	0.146***	0.220***
	(0.014)	(0.010)	(0.009)	(0.008)	(0.008)
Calories	-0.020***	-0.028***	-0.030***	-0.038***	-0.029***
	(0.005)	(0.004)	(0.004)	(0.005)	(0.004)

Protein	0.019***	0.013***	0.011**	0.008	0.011***
	(0.007)	(0.004)	(0.005)	(0.006)	(0.004)

Note: *, **, *** indicates significance level 10%, 5% and 1%. Standard errors are in parenthesis. All nutritional measures are in logs

Table 2. Correlation Coefficients between Nutritional Measures and Income

	Log SCNS	Log caloric intake per capita	Log protein intake per capita
Log gross income per adult	0.2561	-0.0750	0.0270
Log SCNS	1	-0.0256	0.1551

Market liberalization. Given that many of the communities in the CHNS are remote, they will have been affected differently by trade policy changes than those communities that are already highly linked to the world market. Traditional measures of market liberalization such as the Nominal Rate of Assistance at Farm Gate (NRAf) and tariffs usually do not vary by region (Anderson et al., 2008; Huang et al 2009). By incorporating differences between community and prices of regional markets plus the differences between regional markets prices and world prices, we can capture the market liberalization at community level taking regional transactions costs into account.

NRAs are calculated based on the percentage difference between the border and world price (Huang et al 2009). To measure distortions within China, Huang et al. (2009) use the Nominal Rate of Assistance at the farm gate (NRAf), which measures the percentage difference between the world price and the farm gate price for different commodities, and take the domestic market distortion as the difference between NRA and NRAf. A negative NRA or NRAf indicates that the government is taxing the farmers of that commodity, while a positive value indicates implicit or explicit farm subsidies.

Regional heterogeneity may result in misleading measures for the NRAf. For example, a low ratio of farm gate to port price of an import-competing product may result from a low level of protection. Conversely, the relatively low farm-gate price might be a result of high transactions costs of getting the product to the regional market, where the regional market still is highly protected from import competition (illustrated in figure 2). As shown in figure 2, for an import competing product, the border price (P_b) is higher than the world price (P_w) because of import tariffs. Because of transactions cost (tc1) to ship the good from borders to regional markets, the regional markets price (P_p) will be even higher than the border price (P_b). Suppose that a local community of the province has a comparative advantage in the production of that product, then the local price (P_i) is actually lower than the world price (P_w). However, because of high transactions cost (tc2) to ship the product to regional markets, the regional markets price (P_p), will be much higher than the local price (P_i).In this case, the NRAf will indicate low market distortion and thus high market liberalization locally while actually the local communities are very much isolated from the world market.

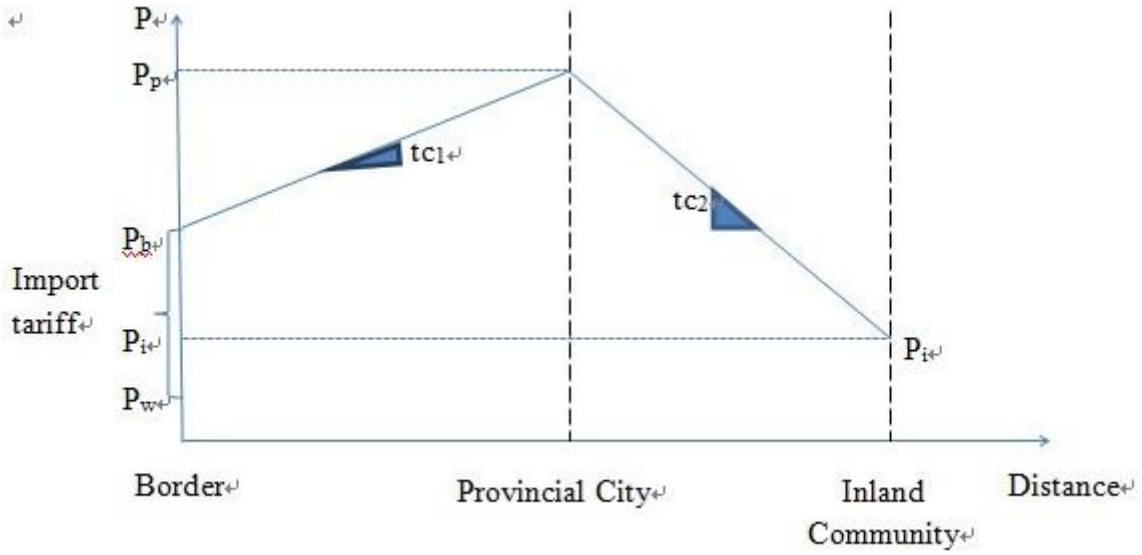

Figure 2. Import Competing Good With High Transaction Costs from Farm

As shown in Park et al. (2002), transactions costs from transport bottlenecks and other constraints actually increased the autarky rate for grains in China from 1988 to 1995. If a rural area faces sufficiently high transactions costs, it will be protected from imports regardless of whether the country has a restrictive trade policy or not (Miller, Morrissey and Rudaheranwa 2000; Helble, Shepherd and Wilson 2009). This research builds on the approach of Anderson et al. (2008) and Huang et al. (2009), and attempts to generate a local measure of NRAf. We calculate the difference between the local and the regional market price, and the difference between regional market price and world price to identify which regions face effective market liberalization and which regions do not.

Price differences incorporate the effects of trade-distorting policies such as export subsidies, import tariffs and domestic market distortions. For example, all else equal, an export subsidy on corn would cause the local price to be higher than the world price. The price differences also capture transportation and other transactions costs of moving the product from port cities to inland markets and then to rural communities. We calculate a market liberalization index by taking the reciprocal of the sum of the absolute value between local and regional market prices, and the absolute value between regional market price and world price across crops in the community (equation 1). We then multiply the market liberalization index by 100. The higher the market liberalization index, the more liberalized is the community. In equation 1, I is the market liberalization index, Pc_i is the local community price, Pw_i is the world price and Pp_i is the regional market price for product i. The regional market price is represented by the price of the most urbanized city in the province.[3] We use rice, wheat, corn, poultry, pork, vegetables and soybeans oil because they account for more than 50% of the total value of agricultural output in China (Huang et al. 2009).

[3] Urbanicity of the community is based on Jones-Smith and Popkin (2010). Urbanicity is a weighted average of population density, economic activity, traditional markets, modern markets, transportation infrastructure, sanitation, communication, housing, education, diversity, health infrastructure and social services scores.

$$I = [\sum_i (\frac{|Pc_i - Pp_i|}{Pp_i} + \frac{|Pp_i - Pw_i|}{Pw_i})]^{-1} \quad (1)$$

Following the definition of local market liberalization, we compare NRAfs with our local market liberalization index (table 3). We find that our local market liberalization index is generally consistent with NRAfs. Both indicate a decline of market distortion over this period.

Table 3. NRAf (%) for Selected Agricultural Products, and Local Market Liberalization

Variables	1989	1991	1993	1997	2000
NRAf Export Products					
Rice	-38.0	-33.4	-32.4	-10.7	-9.2
Vegetables	-55.8	-33.5	-11.2	0	0
Poultry	-7.5	-4.5	-1.5	0	0
Pork	-37.6	-22.6	-7.5	0	0
Corn	-36.8	-31.6	-27.3	8.9	7.3
NRAf Import Competing Products					
Wheat	7.7	25.1	-7.1	25.4	11.5
Soybeans	-4.9	12.4	-11.1	32.9	17.4
Average Local Market Liberalization	24.2	22.1	23.7	28.3	26.8

Source: Huang et al. (2009) and author's calculations

To explore the relation between market liberalization, income and nutrition, we divide our rural sample into three categories of liberalization: low, medium and high. Low liberalized communities are defined as localities which have market liberalization index lower than 18.8 (25 percentile of the whole sample). The high liberalized communities are categorized as those localities whose market liberalization indices are over 27.7 (75 percentile of the sample). The rest of the sample is grouped as middle liberalized communities. We compare the distributions of log gross income per adult for different liberalized communities as shown in figure 3. The mode of log gross income shifts to the right from about 8 (2981 Yuan in gross income) to 8.3 (4024 Yuan in gross income) with liberalization. This suggests a positive relation between gross income per adult and market liberalization. The effect of liberalization appears to differ between value of agricultural production and market off-farm income. The distributions of log value of agricultural production between different liberalized communities are similar (figure 4), with most households between 7 (1097 Yuan in real terms) and 9 (8103 in real terms). It appears that the distribution of value of agricultural production broadens somewhat with higher liberalization. The distribution of log market off-farm income, however, notably shift to the right with the increase in market liberalization (figure 5). The number of households that have zero market off-farm income declines with liberalization, and the mode increases from 7.5 in log market off-farm income (1808 Yuan) for low liberalized communities to 8 (2981 Yuan) for high liberalized communities. Last, we explore the effect of market liberalization on nutrition (figure 6). We can see that the mode of log of household SCNS increases from 3.2 (24.5%) to 3.5 (33.1%) with increase in market liberalization.

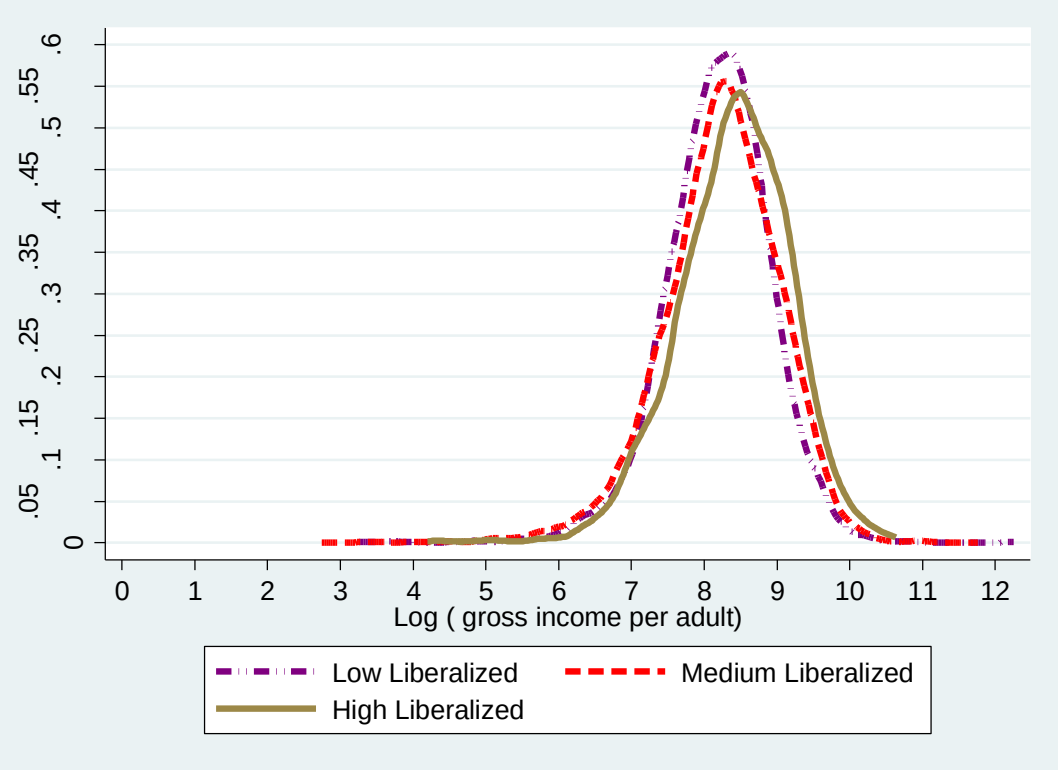

Figure 3. Log Gross Income per Adult for Different Liberalized Communities

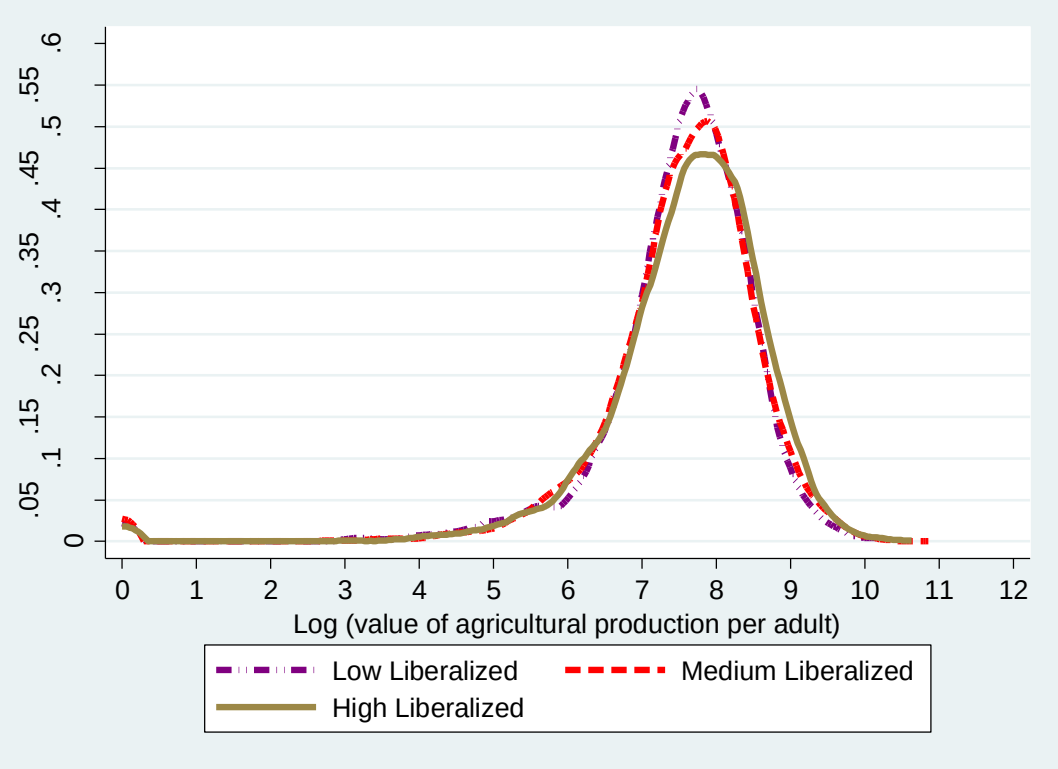

Figure 4. Log Value of Agricultural Production per Adult for Different Liberalized Communities

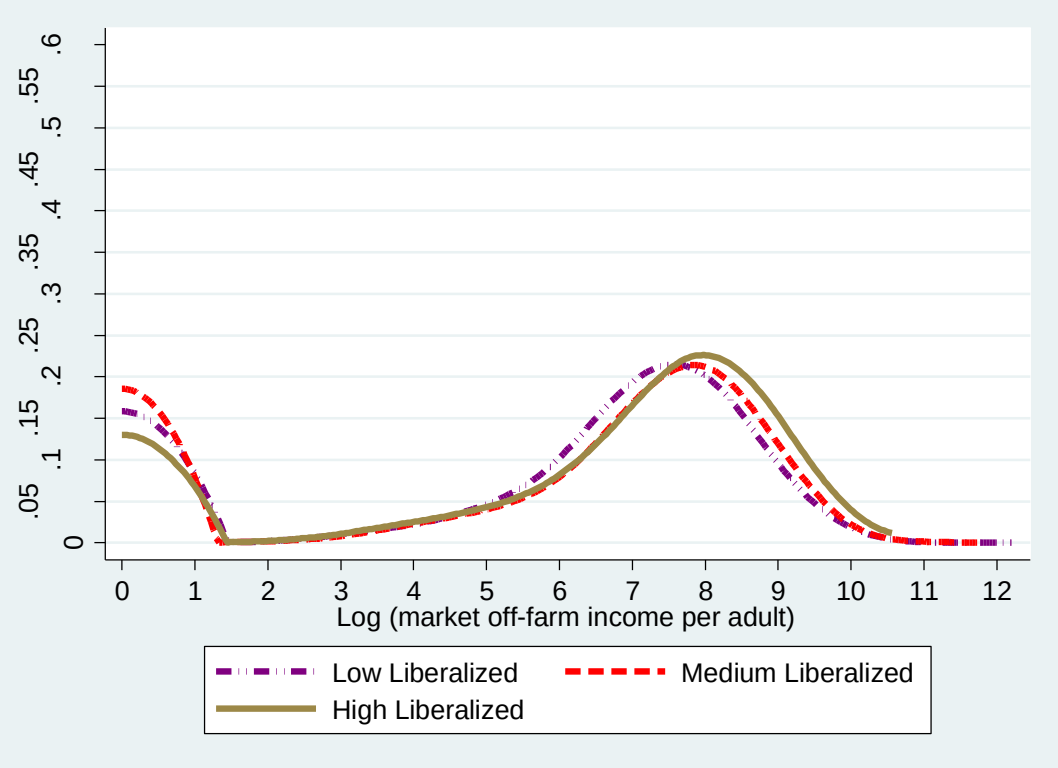

Figure 5. Log Market Off-farm Income per Adult for Different Liberalized Communities

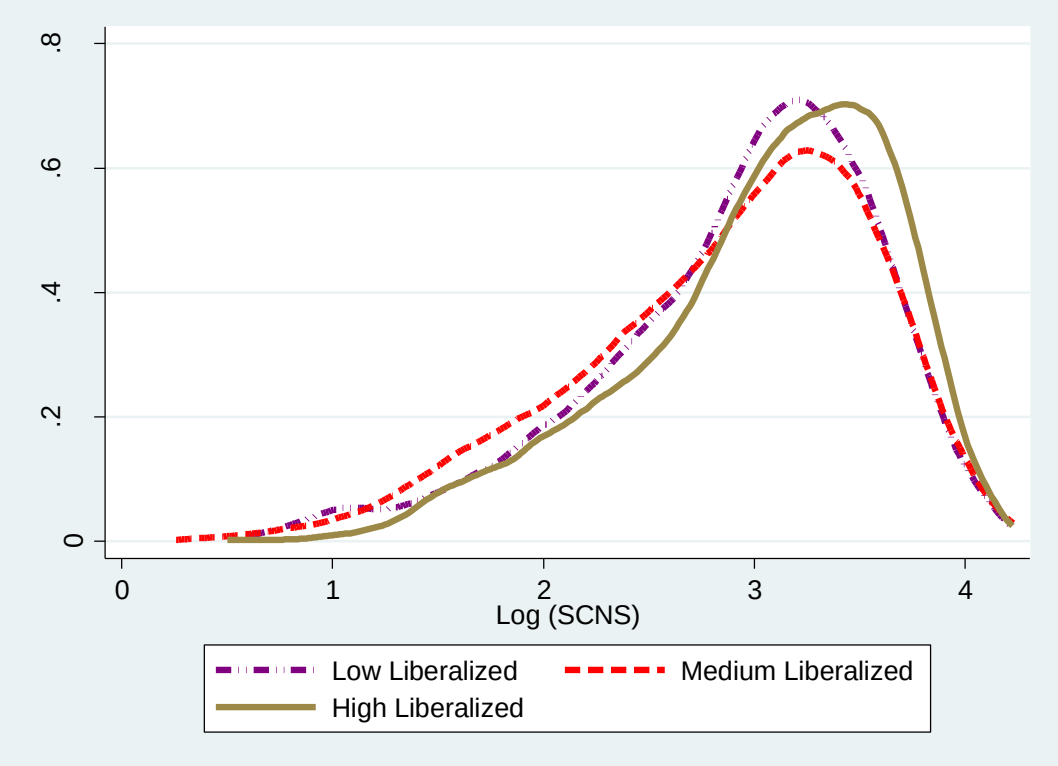

Figure 6. Log SCNS for Different Liberalized Communities

Methods

To study the relation between market liberalization, value of agricultural production, off-farm income and nutrition, we use a three-stage least squares (3SLS) regression, where value of agricultural production, off-farm income and nutritional outcomes are each estimated as part of a simultaneous system. To control for time-invariant household heterogeneity and trend, we control for both household and year fixed effects.

When deciding how much to produce, a farmer will consider her off-farm income, land, labor and the expected value of the production, which is affected by local market liberalization. Her off-farm income will depend on her agricultural income, land, labor, off-farm work opportunities, access to information and market, and market liberalization. Her nutrition is influenced by agricultural production, off-farm income, demographic composition, land, access to market and information, and food prices (Masanjala 2006). These relations are represented by the following system of simultaneous equations:

$$A_{it} = \alpha_0 + \alpha_1 K_{it} + \alpha_2 X_{it} + \alpha_3 \hat{O}_{it} + \varepsilon_1 \quad (2)$$

$$O_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 Y_{it} + \beta_3 \hat{A}_{it} + \varepsilon_2 \quad (3)$$

$$N_{it} = \delta_0 + \delta_1 \hat{O}_{it} + \delta_2 \hat{A}_{it} + \delta_3 P_{it} + \varepsilon_3 \quad (4)$$

In equation (2), log value of agricultural production value, A_{it} for household i at time t is a function of a vector of variables K_{it} including farm land, farm labor supply and local market liberalization. The instrument (X_{it}) for agricultural production is household grains quota. The instrumented log of off-farm income is $\hat{o}_{it}$. In equation (3), log of market off-farm income, O_{it}, is a function of instrumented log value of agricultural production ($\hat{A}_{it}$), instruments (Y_{it}) and control variables (R_{it}). The instrument (Y_{it}) is the community off-farm work opportunities. Control variables (R_{it}) are labor, land, market liberalization, market access and market information. In equation (4), the nutritional outcome (our measure of household food security), N_{it}, is a function of instrumented log of market off-farm income ($\hat{o}_{it}$), instrumented log value of agricultural production ($\hat{A}_{it}$) and control variables (P_{it}). Control variables (P_{it}) include land, labor, access to market, information and food prices.

The value of agricultural production is calculated as the sum of the sale, consumption and gifts value of field crops, horticulture, livestock and fish produced by the household. Farm land is the land the household had for cropping last year. Farm labor supply is represented by household size. Local market liberalization is measured by equation (1).

We use the grains quota as the instrument for value of agricultural production because it is likely that grains quota will only affect off-farm income or nutrition through value of agricultural production. The Chinese government had mandatory delivery quotas for grains and oilseeds in the 1990s which were eliminated from 2000 to 2004. Although some counties had procurement delivery quotas for oilseeds, this quota was not as widespread as for grains (Huang et al. 2009). We use the quantity of grains sold to the government to identify the size of the grains quota. Since the government procurement price (quota price and negotiated price) was lower than the free-market price during the existence of the grains quota system (Huang, Rozelle and Wang 2006), we assume that farmers do not sell more than the required amount to the government. One constraint is that the survey does not contain the amount sold to the government in 1999. But

Huang et al. (2009) show that reformers largely eliminated the distortion caused by grains quota by the end of 1990s. Thus, we assume that the effective grains quota in 1999 was 0 for all households. One might be concerned that grains quota also affects households' nutrition through food coupons. But we find from the dataset that the food coupons barely existed in the 1990s in rural areas. Only 25 households in our sample received food coupons averaging 83.1 Yuan per month compared to average monthly net income of 976 Yuan for farmers in 1991.

The effects of grains quota and market liberalization on value of agricultural production are not clear ex-ante. On one hand, the grains quota can increase households' value of agricultural production by mandating that households stay in agriculture. On the other hand, the grains quota may decrease households' value of agricultural production by limiting farmers' crop choices and decreasing grains procurement price less than free market price. The grains producers could have produced more horticulture and livestock products or sell grains to the free market at higher prices. The effect of market liberalization is not clear either. Market liberalization can increase value of agricultural production through more efficient allocation of inputs, increased agricultural production efficiency and higher prices of agricultural outputs. But it is also possible that farmers will get out of agriculture and migrate to cities for more lucrative off-farm jobs and therefore decrease their value of agricultural production.

We calculate market off-farm income by adding up wage, business income and other sources. Non-market off-farm income is largely related to government policies and includes retirement wage and subsidies. We use community off-farm work employment ratio as our instrumental variable for market off-farm income. In the CHNS, surveyors ask the community head the share of households who mainly work for agriculture in the community. Then we calculate the off-farm employment ratio by subtracting agriculture employment ratio from 100.

We expect that instrumented value of agricultural production decreases off-farm income while off-farm work opportunities, household size, market access and market information[4] increase market off-farm income. The impact of market liberalization is not clear ex-ante. Market liberalization may have different effects on farmers and non-farmers in terms of off-farm income. It may propel non-farmers to continue getting out of agriculture, migrate to cities and become more specialized in non-agricultural work, thus increasing their off-farm income. It is also likely that for some farmers, market liberalization will facilitate them to grow large, specialized and achieve economies of scale in agriculture, thus, decreasing their off-farm income.

We expect that instrumented value of agricultural production, instrumented off-farm income, communication and market access in the community increase household food security while all non-staple (non-rice) prices have negative effect on household food security.

Because market liberalization may affect different nourished households distinctively. After estimating equations (2), (3), (4) using 3SLS regressions, we split the sample into nourished and

[4] we use modern markets score and communication score of the community from Jones-Smith and Popkin (2010). The modern markets score is calculated based on the number of supermarkets, restaurants and stores within the community. The communication score depends on the percentage of households with a television, computer or phone, and the availability of newspapers, telephone, postal offices, cinema within the community. These scores are both scaled from 0 to 10. The higher the score, the better the modern markets access and communication facilities of the community. we use modern markets score and communication score of the community from Jones-Smith and Popkin (2010). The modern markets score is calculated based on the number of supermarkets, restaurants and stores within the community. The communication score depends on the percentage of households with a television, computer or phone, and the availability of newspapers, telephone, postal offices, cinema within the community. These scores are both scaled from 0 to 10. The higher the score, the better the modern markets access and communication facilities of the community.

undernourished households using the consumption of 20% of calories from non-staples as the cut-off value. We then interact household nourishment status with market liberalization and study how market liberalization affects rural households differently. Different agricultural producers may also be affected by market liberalization differently. Thus wet run the regressions by different agricultural production types. Because of our definitions of farmers and rural sample are arbitrary, we run several robustness tests of the definitions of rural sample and farmers. We also compare SCNS with more traditional nutritional measures such as food diversity, caloric intake and protein intake. Lastly, since coastal and inland provinces are different in distances to world markets, infrastructure and so on, we interact market liberalization index with costal dummy and study how market liberalization impacts different regions respectively.

Summary Statistics

Because coastal and inland provinces differ a lot in market infrastructure and distances to world markets, market liberalization may affect coastal and inland provinces differently. In tables 4 and 5, we present the summary statistics for inland and coastal provinces by year. Liaoning, Shandong, Jiangsu and Guangxi are defined as coastal provinces while Heilongjiang, Henan, Hubei, Hunan and Guizhou are defined as inland provinces.

The value of agricultural production in both inland and coastal provinces increases over the time. But value of agricultural production in inland provinces dips in 93 and that in coastal provinces drops in 91 too, possibly because of the gradual elimination of grains quota before 1995 in China. We can see from the table that grains quota also dips in 1993 for both regions. The relaxation of grains quota frees farmers to seek off-farm jobs and thus, may decrease their value of agricultural production. Value of agricultural production is higher in inland provinces because most of them are encouraged to be the agricultural production bases by government policies (Lin and Yao 2001). But in 2000, the value of agricultural production in inland provinces is slightly lower than that in coastal areas. This is likely driven by the increasingly large scale of horticultural production in coastal areas.

The trend of increase in value of agricultural production and particularly horticulture production in coastal provinces coincides with the reduction of land in coastal provinces in 2000. The land area of the two regions is similar in size before 2000 but since 1997, after the land reform, the land area of inland provinces surpassed that of coastal provinces. It is likely that for wealthier and more urbanized coastal provinces, farmland has a higher opportunity cost and is more likely to be transformed into commercial or industrial land given the booming industrial economy in coastal areas. Also the land in coastal areas are more used for labor intensive horticulture production instead of land intensive field crops production in inland regions.

Similar to the value of agricultural production, market off-farm income also increases for both regions. But contrary to value of agricultural production, the market off-farm income of coastal provinces is much higher than that of inland provinces, and that the gap increases over time.

The increase in market off-farm income and value of agricultural production for both regions comes along with the rise of market liberalization and community communication scores over time. However, the market liberalization and communication scores differ a lot between inland and coastal provinces. In most of the years, average market liberalization and community

communication facilities are much better in coastal provinces. The kernel density distributions of market liberalization (figure 7 and 8) in inland and coastal provinces demonstrate that markets are getting more liberalized over the years for both regions and the distributions for inland provinces are broader.

Although households' value of agricultural production, market off-farm income and market liberalization has increased a lot, local food prices do not change much. The prices of rice and soybeans oil fall over time for both regions. Vegetables prices are relatively constant over the years but chicken prices are much more volatile given the long production cycles of livestock. The prices of all four kinds of food are higher in coastal provinces possibly because first, the income of coastal areas is higher and second, most of the food is produced in inland provinces.

With increase in value of agricultural production, market off-farm income and relatively stable staple prices, the SCNS for both groups increases over the years. Similar to market off-farm income, the average SCNS of coastal provinces is also higher than that of inland provinces.

Table 4. Summary Statistics for Inland Provinces by Year

Variables	**1989**	**1991**	**1993**	**1997**	**2000**
Share of calories from	21.3	18.2	18.4	20.4	23.4
non-staples (SCNS, %)	(13.7)	(11.8)	(11.3)	(12.3)	(13.1)
Value of agricultural	7956.1	7372.3	7058.6	8297.7	8492.5
production (2009 Yuan)	(6371.1)	(6592.9)	(6190.9)	(6744.4)	(7288.3)
Value of horticulture	2440.8	2578.3	3153.3	3034.2	2906.1
production (2009 Yuan)	(3894.0)	(4343.1)	(4971.4)	(5184.3)	(4135.1)
Grains quota (kg)	338.3	332.2	192.9	439.0	0.0
	(574.2)	(546.0)	(406.3)	(982.6)	(0.0)
Land (mu)	4.4	4.7	4.9	7.6	7.3
	(4.5)	(5.6)	(6.1)	(13.5)	(9.7)
Market off-farm income	3933.4	3578.7	4594.0	5504.5	7687.4
(2009 Yuan)	(20070.5)	(5388.7)	(7606.5)	(8733.0)	(12200.6)
Non-market off-farm income	828.5	531.6	313.1	151.4	397.2
(2009 Yuan)	(1808.7)	(1333.7)	(1126.5)	(844.8)	(2889.9)
Market liberalization index	23.8	20.4	22.9	25.9	28.6
	(6.1)	(4.4)	(5.6)	(5.2)	(6.1)
Community communication	2.0	3.1	3.4	4.0	4.0
score	(1.5)	(1.4)	(1.5)	(1.3)	(1.2)
Rice retail price (2009	4.0	2.9	2.9	2.7	2.3
Yuan/kg)	(1.2)	(0.8)	(0.7)	(0.8)	(0.5)
Chicken retail price (2009	17.1	18.0	17.4	16.3	15.4
Yuan/kg)	(4.0)	(4.0)	(4.2)	(5.2)	(4.4)
Vegetables retail price (2009	1.2	1.4	1.2	1.6	1.5
Yuan/kg)	(0.7)	(0.8)	(0.7)	(0.8)	(0.8)
Soybeans oil retail price	12.9	12.4	11.9	11.2	10.1
(2009 Yuan/kg)	(3.3)	(3.1)	(2.7)	(2.1)	(2.2)

No. of observations	1003	1209	1157	1439	1289

Note: Standard deviations are in parenthesis.

Table 5. Summary Statistics for Coastal Provinces by Year

Variables	**1989**	**1991**	**1993**	**1997**	**2000**
Share of calories from	19.8	20.3	22.6	24.4	28.6
non-staples (SCNS, %)	(11.5)	(12.3)	(12.4)	(12.2)	(12.9)
Value of agricultural	7651.3	6696.4	6751.7	7905.1	8756.5
production (2009 Yuan)	(7202.4)	(4926.9)	(6038.2)	(6759.5)	(9203.8)
Value of horticulture	1609.1	1756.4	2212.2	1689.0	2610.2
production (2009 Yuan)	(2343.3)	(2853.4)	(4067.3)	(3481.7)	(4648.7)
Grains quota (kg)	517.7	479.1	251.2	351.9	0.0
	(929.0)	(886.6)	(615.5)	(626.5)	(0.0)
Land (mu)	4.6	4.5	4.6	4.2	5.2
	(4.6)	(4.4)	(4.6)	(3.5)	(12.5)
Market off-farm income	4639.7	4418.2	6766.0	9718.3	12516.0
(2009 Yuan)	(7399.0)	(6477.1)	(8776.8)	(13083.5)	(15419.3)
Non-market off-farm income	455.5	499.8	391.4	465.1	532.6
(2009 Yuan)	(1054.9)	(1173.4)	(1129.3)	(1883.9)	(2140.7)
Market liberalization index	18.3	20.0	21.8	29.5	21.9
	(3.1)	(6.5)	(3.8)	(4.6)	(7.1)
Community communication	2.4	3.8	4.0	4.5	4.6
score	(1.5)	(1.2)	1.4)	(1.1)	(0.8)
Rice retail price (2009	4.2	3.4	3.1	2.7	2.5
Yuan/kg)	(0.9)	(1.1)	(1.1)	(0.6)	(0.5)
Chicken retail price (2009	19.5	17.8	20.0	17.4	15.0
Yuan/kg)	(8.3)	(7.1)	(8.1)	(5.6)	(7.1)
Vegetables retail price (2009	1.8	1.7	1.9	1.4	1.7
Yuan/kg)	(1.2)	(1.1)	(1.2)	(0.6)	(1.1)
Soybeans oil retail price	13.2	12.8	12.5	11.5	10.0
(2009 Yuan/kg)	(3.7)	(2.8)	(2.7)	(2.6)	(2.8)
No. of observations	877	1010	909	723	875

Note: Standard deviations are in parenthesis.

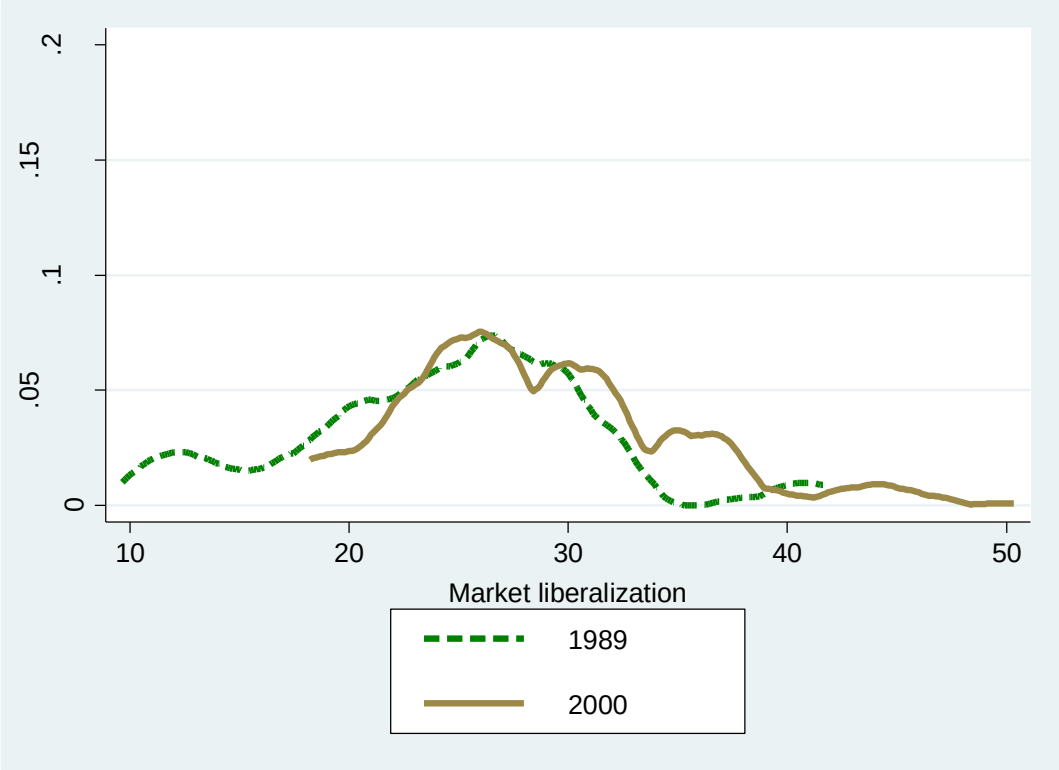

Figure 7 Market Liberalization by Year for Inland Provinces

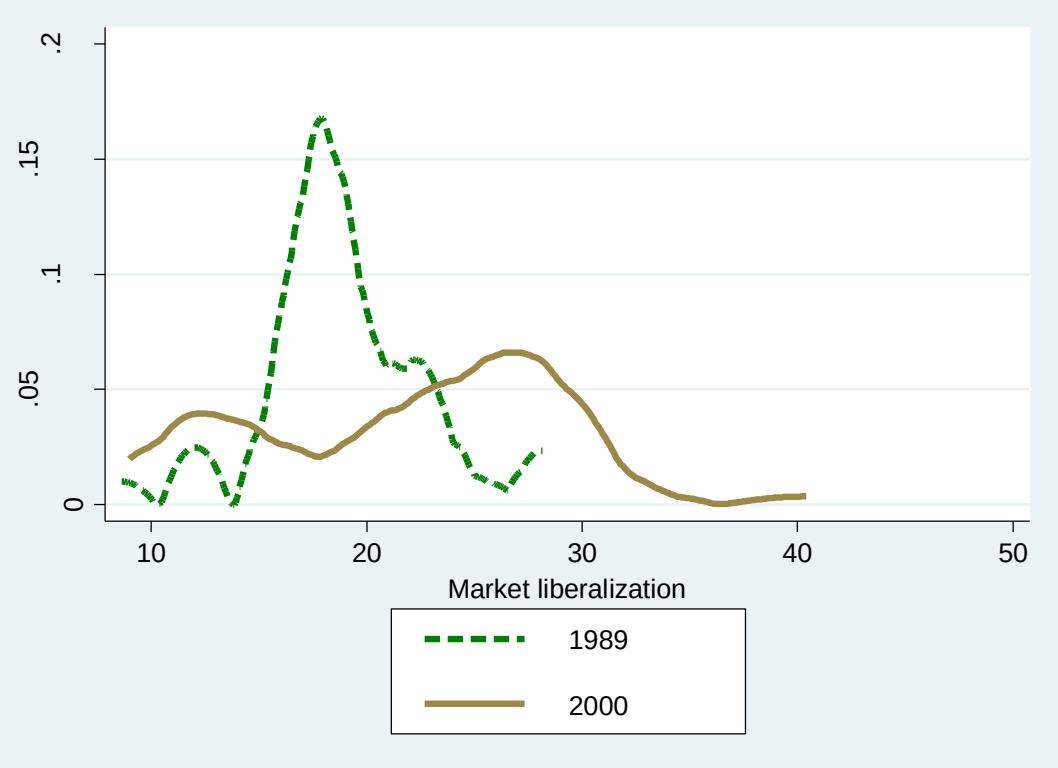

Figure 8 Market Liberalization by Year for Coastal Provinces

Although market liberalization differs between inland and coastal provinces, table 6 demonstrates that market liberalization is pretty diverse geographically. Each province takes up around 11% of each liberalization category. Heilongjiang province only possesses 1% of the low liberalized communities because Heilongjiang is only included in last two years of the sample, which are 1997 and 2000.

Table 6 Share of Sample in Each Province by Market Liberalization

Province	Low	High
Liaoning	12%	7%
Heilongjiang	1%	7%
Jiangsu	7%	13%
Shandong	5%	9%
Henan	10%	14%
Hubei	7%	13%
Hunan	3%	21%
Guangxi	32%	6%
Guizhou	24%	12%

Results

Regression results for log of agricultural production value (equation 2) are presented in table 7. Local market liberalization, land and household size increase value of agricultural production while more off-farm income decreases agricultural production value regardless of the choice of FE. Local market liberalization may promote local agricultural production because market development allows farmers to produce to their comparative advantage and, thus, improves agricultural efficiency. More off-farm income may indicate that more farmers migrate to urban areas for no-agriculture work and, thus, decrease agricultural production.

Table 7. Results for Log of Agricultural Production Value Equation (2)

Variables	**Household FE**	**County FE**	**Province FE**
Land	0.00426***	0.00900***	0.00713***
	(0.00181)	(0.00180)	(0.00168)
Instrumented log of	-0.150***	-0.236***	-0.175***
Off-farm income	(0.0140)	(0.0164)	(0.0108)
Household size	0.140***	0.206***	0.185***
	(0.0116)	(0.0103)	(0.00944)
Grains quota	0.0000358***	0.000111***	0.000124***
	(0.0000176)	(0.0000208)	(0.0000188)
Local market liberalization	0.00430***	0.00673***	0.0107***
	(0.00187)	(0.00241)	(0.00206)
Observations	10488	10488	10488

Note: *, **, *** indicates significance level 15%, 10% and 5%. Standard errors are in parenthesis. Year dummies are

included.

We report the regression results for log of market off-farm income (equation 3) in table 8. Local market liberalization increases off-farm income. Further, we find that household size, off-farm work opportunities and community communication which represents households' access to information increase off-farm income as expected. Agricultural production value decreases off-farm income as predicted. Land increases off-farm income after controlling for agricultural production value. This result suggests that larger land area may be associated with lower land quality. Households with larger land areas but of low quality have more pressing need to find off-farm work to supplement their agricultural income. Market liberalization increases off-farm income overall because it lowers the barriers for farmers to enter off-farm labor markets and increase the opportunities to work off-farm as China's economy is more linked to the world.

Table 8. Results for Log of Market Off-farm Income Equation (3)

Variables	**Household FE**	**County FE**	**Province FE**
Instrumented log of agricultural production value	-3.596***	-1.696***	-1.896***
	(0.637)	(0.250)	(0.230)
Land	0.0128*	0.000401	-0.0149***
	(0.00822)	(0.00653)	(0.00629)
Household size	0.577***	0.500***	0.509***
	(0.0897)	(0.0474)	(0.0445)
Local market liberalization	0.0170***	0.0180***	0.0260***
	(0.00619)	(0.00694)	(0.00621)
Off-farm work employment ratio in the community	0.00490***	0.00888***	0.0160***
	(0.00145)	(0.00177)	(0.00182)
Modern market score of the community	0.0162	0.0643***	0.0679***
	(0.0164)	(0.0145)	(0.0145)
Communication score of the community	0.0861***	0.110***	0.188***
	(0.0332)	(0.0339)	(0.0301)
Observations	10488	10488	10488

Note: *, **, *** indicates significance level at 15%, 10% and 5%. Standard errors are in parenthesis. Year dummies are included.

The results for nutritional outcome (measured by log of SCNS) (equation 4) controlling different FEs are presented in table 9. The instrument for value of agricultural production, grains quota, appears to be valid, with a p-value of 0.7711 for Hansen's overidentification test of all instruments. The instrument for market off-farm income, the off-farm employment ratio in the community, passes Hansen's exogeneity test and serves as a valid instrument (with p-value of 0.8638). Both value of agricultural production and off-farm income increase SCNS (household food security) significantly. After controlling for income and number of dependents, household size, which captures the number of adults in the household, decreases SCNS. This result is possible because there is a larger need for nutrition subject to the budget constraint for those larger

households and consequently their household nutrition on average falls. Better access to market improves households' nutrition because of reduced transactions cost of buying food. The prices of non-staples (chicken, vegetables and soybeans oil) decrease households' nutrition, although chicken prices are not significant. The price of rice increases SCNS, although not significantly.

We then calculate the total marginal effect of market liberalization on SCNS using equation (5) and (6). γ is the total marginal effect of market liberalization on *log* of SCNS. α and β are the direct effect of market liberalization on log of agricultural income and log of market off-farm income respectively. α_3 and β_3 are the marginal effect of log of market off-farm income on log of agricultural production value and the marginal effect of log of agricultural production value on log of off-farm income. δ_2 and δ_1 are the direct effect of log agricultural production value and log of off-farm income on SCNS. ME denotes marginal effects of market liberalization on SCNS per year. $\overline{SCNS}$ is the average share of calories from non-staples in the sample, which is around 21.46166. 2800 is the average caloric requirement for Chinese. The results show that 1 unit increase in market liberalization increases households' share of calories from non-staples by 945.4, which amounts to consuming 1 pound of beef more per year.

$$\gamma = (\alpha + \beta \cdot \alpha_3) \cdot \delta_2 + (\beta + \alpha \cdot \beta_3) \cdot \delta_1 \qquad (5)$$

$$\text{ME} = \{\exp[\gamma + \text{Log}(\overline{SCNS})] - \overline{SCNS}\} \cdot 0.01 \cdot 2800 \cdot 365 \qquad (6)$$

Table 9. Results for Log of SCNS Equation (4)

Variables	**Household FE**	**County FE**	**Province FE**
Instrumented log of market off-farm income	0.212***	0.0724	0.110***
	(0.0533)	(0.0577)	(0.0388)
Number of dependents in the household	0.00981	-0.0360	-0.0815***
	(0.0338)	(0.0344)	(0.0291)
Household size	-0.0682*	-0.00569	-0.00380
	(0.0461)	(0.0507)	(0.0430)
Communication score of the community	-0.00386	0.00468	0.0416***
	(0.00960)	(0.00719)	(0.00884)
Modern market score of the community	0.0122***	0.00571*	-0.00874***
	(0.00466)	(0.00379)	(0.00317)
Land	-0.000127	0.00254**	0.00150
	(0.00176)	(0.00138)	(0.00157)
Instrumented log of agricultural production value	0.343*	-0.0293	0.00939
	(0.211)	(0.158)	(0.154)
Rice price in the community	0.00986	0.00504	-0.0901***
	(0.0232)	(0.00995)	(0.0129)
Chicken price in the community	-0.000920	-0.00647***	0.0152***
	(0.00371)	(0.00271)	(0.00210)

Vegetables price in the community	-0.0461***	-0.0328***	0.0594***
	(0.0100)	(0.00934)	(0.0183)
Soybeans oil price in the community	-0.0187***	-0.0158***	0.00563**
	(0.00339)	(0.00349)	(0.00296)
Average Effects from 1989 to 2000	945.4	407.93	694.18
	(778.92)	(737.60)	(1106.01)
Observations	10488	10488	10488

Note: *,**,*** indicates significance level 15%, 10% and 5%. Standard errors are in parenthesis. Year dummies are included.

One might be concerned that only wealthier farmers benefit from market liberalization. To test this hypothesis, we split the data into nourished and undernourished households and define undernourished households as those who consume less than 20% of calories from non-staples following Jensen and Miller (2010). Accordingly, the nourished households consume more than 20% of calories from non-staples. The regression results in table 10, 11 and 12 show that local market liberalization increases agricultural and off-farm income for both undernourished and nourished households, with no significant difference in the magnitude of coefficients after controlling for different FE. An increase in off-farm income increases nutrition more for the undernourished households than for the nourished households. But agricultural income increases nutrition for both groups alike. After calculating the total marginal effects, we see that market liberalization increases the nutrition of both nourished and undernourished households, and particularly undernourished households.

Table 10. Regression Results for Different Nourished Groups Controlling Household FE

Variables	**Undernourished**	**Nourished**
Log of agricultural production value		
Log of market off-farm income	-0.153***	-0.153***
	(0.0148)	(0.0148)
Local market liberalization	0.00428*	0.00439**
	(0.00266)	(0.00229)
Log of market off-farm income		
Log of agricultural production value	-3.415***	-3.415***
	(0.507)	(0.507)
Local market liberalization	0.0161***	0.0189***
	(0.00815)	(0.00694)
Log of SCNS		
Instrumented log of market Off-farm income	0.142***	+++0.106***
	(0.0370)	(0.0405)
Instrumented log of agricultural production value	0.212*	0.281**
	(0.134)	(0.145)
Average Effects from 1989 to 2000	608.3	847.9

	(744.7)	(413.8)
Observations	10488	10488

Note: *,**,*** indicates significance level 15%, 10% and 5%. $^{+++}$ indicates the coefficient is significantly different between nourished and undernourished groups. Standard errors are in parenthesis. Year dummies are included. The full regression results are available upon request.

Table 11. Regression Results for Different Nourished Groups Controlling County FE

Variables	**Undernourished**	**Nourished**
Log of agricultural production value		
Log of Market off-farm income	-0.235***	-0.235***
	(0.0171)	(0.0171)
Local market liberalization	0.00972***	+0.00380
	(0.00340)	(0.00279)
Log of off-farm income		
Log of agricultural production value	-1.568***	-1.568***
	(0.245)	(0.245)
Local market liberalization	0.0235***	0.00971***
	(0.00987)	(0.00774)
Log of SCNS		
Instrumented log of off-farm income	0.0479*	+++0.0258
	(0.0321)	(0.0329)
Instrumented log of agricultural production value	0.0160	0.0613
	(0.0830)	(0.126)
Average Effects from 1989 to 2000	472.07	192.90
	(585.39)	(309.67)
Observations	10488	10488

Note: *,**,*** indicates significance level 15%, 10% and 5%. $^{+}$ and $^{+++}$ indicates the difference in the coefficients is significant at 5% and 15% level. Standard errors are in parenthesis. All regressions include year dummies. Full regressions are available upon request.

Table 12. Regression Results for Different Nourished Groups Controlling Province FE

Variables	**Undernourished**	**Nourished**
Log of agricultural production value		
log of Market Off-farm income	-0.184***	-0.184***
	(0.0122)	(0.0122)
Local market liberalization	0.00467*	0.00951***
	(0.00299)	(0.00258)
Log of off-farm income		
Log of agricultural production value	-1.635***	-1.635***
	(0.230)	(0.230)
Local market liberalization	0.00195	+0.0182***
	(0.00893)	(0.00790)

Log of SCNS		
Instrumented log of off-farm income	0.0494***	+++0.030
	(0.0236)	(0.0260)
Instrumented log of agricultural production value	0.0147	0.0530
	(0.0840)	(0.124)
Average Effects from 1989 to 2000	-220.99	393.23
	(396.89)	(789.95)
Observations	10488	10488

Note: *, **, *** indicates significance level 15%, 10% and 5%. + and +++ indicates the difference in the coefficients is significant at 5% and 15% level. Standard errors are in parenthesis. All regressions include year dummies. Full regressions are available upon request.

Market liberalization may affect agricultural income and off-farm income for different agricultural producers differently (table 13). Therefore, we interact the market liberalization index with indicator variables for production type and non-farmers. Non-farmers are defined as households who have less than 10% of income from agriculture in that year. We find that market liberalization increases agricultural income for mixed, field crops and horticulture producers particularly but does not affect their off-farm income. For livestock producers, market liberalization does not affect agricultural income but increases their off-farm income. Market liberalization decreases non-farmers' agricultural income but increases their off-farm income. Moreover, the difference in the coefficients of market liberalization on agricultural income and off-farm income between field crops, horticulture, mixed producers, livestock producers, and non-farmers are significant at the 1% level. This result suggests that market liberalization has bifurcating effect on farmers and non-farmers in rural China. On one hand, market liberalization drives field crops, horticulture and mixed producers to concentrate on agriculture. On the other hand, market liberalization leads livestock producers and non-farmers to specialize in off-farm work, increase their off-farm income while reducing their agricultural production. Livestock production is capital intensive and may be less comparatively advantageous to small and poor Chinese farmers who have an average land holding of 1 acre and median income of around 1300 USD per household in 2000 based on CHNS data.

Off-farm income and agricultural value increase households' nutrition for all producers. The marginal effect of agricultural income on household food security does not differ among different producers or non-farmers. The largest effect of market liberalization on SCNS is for non-farmers. For farmers, horticulture and livestock producers benefit from market liberalization while mixed producers do not gain as much. A one unit increase in market liberalization leads to a 1216 increase in calories from non-staples. The total caloric requirement per day for Chinese is 2800 calories, so the marginal effect accounts for almost 43% of it. Market liberalization increases households' consumption from non-staples by 784.12 calories and 716.76 calories (almost 600 grams of beef) for horticulture and livestock producers.

Table 13. Regression Results for Different Production Types

Variables	Mixed	Field crops	Horticulture	Livestock	Non-farmer
Log of agricultural production value					
Log of market off-farm income	0.0747*** (0.0159)	0.0747*** (0.0159)	0.0747*** (0.0159)	0.0747*** (0.0159)	0.0747*** (0.0159)
Local market liberalization	0.00586*** (0.00191)	0.00683*** (0.00175)	0.006673*** (0.00181)	+++0.00041 (0.00199)	+++-0.10385*** (0.00275)
Log of off-farm income					
Log of agricultural production value	0.259 (0.34)	0.259 (0.34)	0.259 (0.34)	0.259 (0.34)	0.259 (0.34)
Local market liberalization	0.00482 (0.00645)	0.00544 (0.00593)	0.00817 (0.00622)	+++0.01271*** (0.00593)	+++0.10267*** (0.03342)
Log of SCNS					
Instrumented log of off-farm income	0.239*** (0.0344)	0.239*** (0.0344)	0.239*** (0.0344)	0.239*** (0.0344)	0.239*** (0.0344)
Instrumented log of agricultural production value	0.176*** (0.0740)	0.09913*** (0.0313)	0.16549*** (0.05094)	0.15034*** (0.0466）	0.13049*** （0.0263）
Average Effects from 1989 to 2000	2654.82*** (1351.82)	2482.45*** (1215.798)	3632.73*** (1284.88)	3320.63*** (1369.35)	5634.22*** (1801.68)
Observations	10488	10488	10488	10488	10488

Note: *, **, *** indicates significance level 15%, 10% and 5%. +++ indicates the coefficient is significantly different between nourished and undernourished groups. Standard errors are in parenthesis. Household and year dummies are included. The full regression results are available upon request.

Robustness Checks

We do several robustness tests of our definitions of rural sample and farmers, different nutritional measures and interacting market liberalization with costal provincial dummies. We find consistent results that market liberalization increases nutrition through agricultural production value and off-farm income for both undernourished and nourished households. Market liberalization is particularly beneficial for horticulture producers and inland provinces. Conventional nutritional measures may mask important information.

Because our definition of rural sample is somewhat arbitrary, we test the robustness of the model under different definitions of rural sample. In table 14, we use an alternative definition for rural communities which have greater than 35% instead of 25% of their income from agriculture in any of the survey years. We find consistent results that market liberalization increases agricultural production value and off-farm income by a similar magnitude. Off-farm income and value of agricultural production boost households' nutrition. Particularly, off-farm income increases nutrition less for the nourished households compared to the undernourished households. Market

liberalization has a bigger marginal effect on SCNS when tightening the rural sample definition. The market liberalization causes consumption of 1837 calories more from non-staples from 1989 to 2000 on average.

To test the robustness of our definition of farmers, we define households who have over 50% of income from agriculture as opposed to 10% to be farmers (table 15). Consistently, we find that market liberalization increases agricultural production value of mixed, field crops and horticulture producers and to a lesser extent, livestock producers while decreasing off-farm income for those households. Market liberalization seems to drive non-farmers to focus on off-farm work and, thus increase their off-farm income while decreasing their agricultural production. Both agricultural and off-farm income enhances households' nutrition. Off-farm income increases households' nutrition to a lesser extent for the nourished households. Agricultural production value for field crops producers has a significantly smaller positive effect on nutrition than for other producers or non-farmers. This result suggests that field crops production may affect households' choice of food consumption. Agricultural income from field crops producers may decrease their consumption of staples less than the income from other agricultural production types. Similarly, market liberalization boosts non-farmers and horticulture producers' SCNS especially. Particularly, market liberalization leads horticulture producers to consume 1867 calories more from non-staples.

Next, we explore the effects of market liberalization on household food security using more conventional nutritional measures. We test the robustness of different nutritional measures including food diversity, household average caloric and protein intake (tables 16, 17 and 18, respectively). Food diversity is measured as the number of food groups consumed by the household on the interview day. There are 12 groups of food defined by the Chinese Food Composition Table (1991): cereals, legumes, roots and stems, vegetables, mushrooms, fruits, nuts and seeds, meats, milk, eggs, fish, and other. We find consistent results that market liberalization leads to more agricultural production and off-farm income for undernourished and nourished households. The value of agricultural production and off-farm income increases household food security, although the effect of agricultural production value is only significantly positive for nourished households. While income increases food diversity overall, it significantly decreases caloric and protein intake. Because there is no consensus on individual caloric intake threshold defining fulfillment of nutritional needs and the income elasticities of calories are usually found to be negative (Deaton and Drèze 2008; Jensen and Miller 2010). Therefore, we believe that caloric intake is not a good measure of household food security in the data.

Because coastal and inland provinces differ a lot in infrastructure, distances to world markets and liberalization policies. It is possible that market liberalization has differential effects on agricultural production and off-farm income and that income has distinct effects on households' food security between coastal and inland provinces. Because coastal provinces are closer to world markets geographically and, thus, have lower transportation cost, market liberalization is expected to be higher than for inland provinces. Thus, the effect of market liberalization on income for coastal provinces is lower than for inland provinces (table 19 and 20). The diminishing marginal effect of market liberalization is shown in these tables. On average, inland households have 5151.61 Yuan of off-farm income and 7863.75 Yuan of agricultural production value while coastal households have 7432.74 of off-farm income and 7507.56 Yuan of agricultural production value.

With expectations of diminishing marginal effect of income on log of SCNS, we observe a larger effect of agricultural production on coastal households and a larger effect of off-farm income on inland households for both undernourished and nourished groups.

Table 14. Robustness Tests of a Different Definition of Rural Sample[6]

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of Market Off-farm income	-0.119***	-0.126***	-0.126***
	(0.0157)	(0.0160)	(0.0160)
Local market liberalization	0.00331**	0.00251	0.00416**
	(0.00189)	(0.00265)	(0.00232)
Log of market off-farm income			
Log of agricultural production value	-2.673***	-2.811***	-2.811***
	(0.618)	(0.505)	(0.505)
Local market liberalization	0.0148***	0.0128**	0.0178***
	(0.00523)	(0.00719)	(0.00627)
Log of SCNS			
Instrumented log of market off-farm income	0.233***	0.158***	+++0.120***
	(0.0465)	(0.0338)	(0.0355)
Instrumented log of agricultural production value	0.272*	0.209**	0.260**
	(0.184)	(0.116)	(0.134)
Average Effects from 1989 to 2000	1837.70***	1110.18	1246.01***
	(931.49)	(858.41)	(541.82)
Observations	10266	10266	10266

Note: *, **, *** indicates significance level 15%, 10% and 5%. +++ indicates the coefficient is significantly different between nourished and undernourished groups at 5% level. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions results are available upon request.

Table 15. Robustness Tests of a Different Farmer Definition

Variables	Mixed	Field crops	Horticulture	Livestock	Non-farmer
Log of agricultural production value					
Log of market	0.137***	0.137***	0.137***	0.137***	0.137***
off-farm income	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)
Local market	0.0192***	+++0.0225***	+++0.0243***	+++0.0157***	+++-0.0295***
liberalization	(0.00211)	(0.00207)	(0.00217)	(0.00207)	(0.00273)
Log of market off-farm income					
Log of	1.385***	1.385***	1.385***	1.385***	1.385***

[6] The results for the other factors that affect agricultural production and household food security are similar to those of 3SLS regressions on agricultural production, off-farm income and nutrition.

agricultural production value	(0.444)	(0.444)	(0.444)	(0.444)	(0.444)
Local market liberalization	-0.0672***	+++-0.0780***	-0.0718***	+++-0.0546***	+++0.127***
	(0.00878)	(0.00877)	(0.0105)	(0.00843)	(0.00864)
Log of SCNS					
Instrumented log of off-farm income	0.0859***	0.0859***	0.0859***	0.0859***	0.0859***
	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0242)
Instrumented log of agricultural production value	0.482***	+0.349***	0.354***	0.315***	0.364***
	(0.172)	(0.125)	(0.105)	(0.126)	(0.136)
Average Effects from 1989 to 2000	1311.08	123.42	1867.04**	-213,26	3072.31***
	(1244.45)	(887.36)	(1012.65)	(1037.57)	(899.36)
Observations	10488	10488	10488	10488	10488

Note: *, **, *** indicates significance level 15%, 10% and 5%. +++ indicates the coefficient is significantly different among production types at 5% level. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions results are available upon request.

Table 16. Robustness Tests of Food Diversity

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of market off-farm income	-0.150***	-0.154***	-0.154***
	(0.0140)	(0.0148)	(0.0148)
Local market liberalization	0.00441***	0.00547***	0.00440**
	(0.00189)	(0.00272)	(0.00236)
Log of market off-farm income			
Log of agricultural production value	-3.600***	-3.412***	-3.412***
	(0.637)	(0.508)	(0.508)
Local market liberalization	0.0184***	0.0250***	0.0180***
	(0.00671)	(0.00952)	(0.008311)
Log of SCNS			
Instrumented log of market off-farm income	0.393***	0.280***	0.295***
	(0.114)	(0.0995)	(0.109)
Instrumented log of agricultural production value	0.654	0.279	+0.597*
	(0.459)	(0.372)	(0.402)
Average Effects from 1989 to 2000	1.69	2.99	1.51
	(3.95)	(3.92)	(3.52)
Observations	10488	10488	10488

Note: *, **, *** indicates significance level 15%, 10% and 5%. +, ++, +++ indicates the coefficient is significantly different between nourished and undernourished groups at 15%, 10% and 5% significance level. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions results are available

upon request.

Table 17. Robustness Tests of Household Average Caloric Intake

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of market off-farm income	-0.150***	-0.153***	-0.153***
	(0.0139)	(0.0148)	(0.0148)
Local market liberalization	0.00552***	0.00588***	0.00458***
	(0.00160)	(0.00225)	(0.00192)
Log of market off-farm income			
Log of agricultural production value	-3.641***	-3.430***	-3.430***
	(0.636)	(0.506)	(0.506)
Local market liberalization	0.0295***	0.0339***	0.0219***
	(0.00635)	(0.00809)	(0.00697)
Log of SCNS			
Instrumented log of market off-farm income	-0.0584***	-0.0729***	-0.0646***
	(0.0214)	(0.0229)	(0.0250)
Instrumented log of agricultural production value	-0.304***	-0.340***	-0.321***
	(0.0937)	(0.0885)	(0.095)
Average Effects from 1989 to 2000	-0.93	-1.69	-0.67
	(0.76)	(1.23)	(0.89)
Observations	10488	10488	10488

Note: *,**,*** indicates significance level 15%, 10% and 5%. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions results are available upon request.

Table 18. Robustness Tests of Household Average Protein Intake

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of market off-farm income	-0.151***	-0.154***	-0.154***
	(0.0139)	(0.0148)	(0.0148)
Local market liberalization	0.00610***	0.00633***	0.00467***
	(0.00170)	(0.00234)	(0.002)
Log of market off-farm income			
Log of agricultural production value	-3.656***	-3.428***	-3.428***
	(0.636)	(0.507)	(0.507)
Local market liberalization	0.0312***	0.0357***	0.0222***
	(0.00735)	(0.00904)	(0.00789)
Log of SCNS			
Instrumented log of off-farm income	-0.0217	-0.0484***	-0.02669
	(0.0203)	(0.0217)	(0.0235)
Instrumented log of agricultural production value	-0.227***	-0.286***	-0.288***
	(0.0894)	(0.0894)	(0.0911)

Average Effects from 1989 to 2000	-0.32	-1.15	-0.28
	(0.41)	(0.92)	(0.44)
Observations	10488	10488	10488

Note: *,**,*** indicates significance level 15%, 10% and 5%. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions results are available upon request.

Table 19. Robustness Tests for Coastal Provinces

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of market off-farm income	-0.149***	-0.155***	-0.155***
	(0.0197)	(0.0220)	(0.0220)
Local market liberalization	-0.000424	-0.00248	0.000167
	(0.00261)	(0.00456)	(0.00339)
Log of market off-farm income			
Log of agricultural production value	-5.456***	-4.560***	-4.560***
	(0.866)	(0.772)	(0.772)
Local market liberalization	0.00461	0.00294	0.01009
	(0.0116)	(0.0205)	(0.0140)
Log of SCNS			
Instrumented log of market off-farm income	0.232***	0.0923***	$^{+++}$0.0413**
	(0.0343)	(0.0221)	(0.0247)
Instrumented log of agricultural production value	1.394***	0.476***	0.436***
	(0.312)	(0.155)	(0.143)
Average Effects from 1989 to 2000	59.99	-84.17	-299.75
	(405.81)	(499.10)	(649.30)
Observations	4394	4394	4394

Note: *,**,*** indicates significance level 15%, 10% and 5%. $^{+++}$ indicates the difference in the coefficients is significant at 5% level. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions are available upon request.

Table 20. Robustness Tests for Inland Provinces

Variables	Overall	Undernourished	Nourished
Log of agricultural production value			
Log of market off-farm income	-0.0979***	-0.0944***	-0.0944***
	(0.0188)	(0.0192)	(0.0192)
Local market liberalization	0.00803***	0.0106***	0.0056**
	(0.00263)	(0.00349)	(0.00337)
Log of market off-farm income			
Log of agricultural production value	-1.334***	-1.555***	-1.555***
	(0.602)	(0.469)	(0.469)
Local market liberalization	0.0223***	0.0359***	0.0283***
	(0.00742)	(0.0109)	(0.009)

Log of SCNS			
Instrumented log of market off-farm income	0.154	0.116**	+++0.084
	(0.149)	(0.0689)	(0.0704)
Instrumented log of agricultural production value	-0.134	-0.143	-0.063
	(0.243)	(0.114)	(0.153)
Average Effects from 1989 to 2000	1022.64	1258.60	1468.82
	(2165.02)	(1426.74)	(1828.87)
Observations	6094	6094	6094

Note: *, **, *** indicates significance level 15%, 10% and 5%. +++ indicates the difference in the coefficients is significant at 5% level. Standard errors are in parenthesis. All regressions include household and year dummies. Full regressions are available upon request.

Conclusions

We find that market liberalization increases value of agricultural production and off-farm income, and through income, improves household nutrition. During the 1980s and early 1990s, poor marketing and transportation infrastructure were major constraints affecting food supply in China (Nyberg and Rozelle 1999). Our study shows that market liberalization improved significantly since then. Local market liberalization promoted by massive price, market, trade reforms and infrastructure construction in the 1990s increased value of agricultural production and off-farm income.

One may be concerned that undernourished households are constrained by credit and/or human capital. Therefore, they are restricted to switching to production that is more comparatively advantageous and may hurt from market liberalization. Our results show that market liberalization enhances the nutrition of both undernourished and nourished households. When splitting farmers by different production types, we find that market liberalization increases agricultural income for field crops, horticulture and mixed producers. This result indicates that market liberalization may lead Chinese farmers to focus on labor-intensive agricultural production with low entry barriers, which is consistent with their comparative advantage.

After presenting the main results, we run several robustness tests of definition of rural sample, definition of farmers, different nutritional measures, differentiating coastal and inland provinces and using different fixed effects. We generally find consistent results. Specifically, when we restrict the definition of rural sample to be those communities which have greater than 35% of gross income from agriculture (instead of 25%), we observe stronger results. Local market liberalization contributes more to the nutrition for a narrower definition of rural villages. Market liberalization enhances nutrition of horticulture producers and households in remote, inland provinces.

When we test the robustness of nutritional measures, the effects of income on the average household caloric intake is negative as sometimes found in literature (Deaton and Drèze 2008; Meng, Gong and Wang 2009; Jensen and Miller 2010). Additionally, there is no consensus on individual caloric intake threshold defining fulfillment of nutritional needs. We conclude that caloric intake is not a good measure of nutrition in the data. As a measure of nutrition or household food security, average household caloric intake is not as informative as SCNS. SCNS offers several advantages, such as avoiding the problem of individual-varying and unobservable thresholds,

imperfect absorption, and a consistency with revealed preferences. Compared with food diversity measured by food count, SCNS is better because it is continuous and more sensitive to changes in households' nutrition.

In conclusion, agricultural market liberalization is a good way to level undernourished rural households from poverty and increase their household food security in China. Therefore, it is advisable for policy makers to promote agricultural market liberalization further by increasing access to markets locally along with massive rural infrastructure investment and more liberalized agricultural policies. More liberalized markets lead to higher agricultural production and off-farm income, and then better nutrition of households.

This paper has some limitations which may lead to interesting future research. So far we identify the relation between agricultural production, off-farm income and nutrition mostly from the production side. Because there is an increasing trend that farmers consume more of their food from stores instead of their own harvests (Barrett 2011), it would be interesting to see how the change in market liberalization affects food prices and thus, households' nutrition. Moreover, our study of agricultural market liberalization only involves output markets and not input markets due to data limitations. Future research may study how input market liberalization including credit, land, and labor markets affect farmers' production and off-farm work decisions and, thus, their welfare.

References

Ali, M. and U. Farooq. Diversified Consumption to Boost Rural Labor Productivity Evidence from Pakistan. Asian Vegetable Research and Development Center, Discussion Paper, 2003.

Anderson, K., M. Kurzweil, W. Martin, D. Sandri, and F. Valenzuela. Measuring Distortions to Agricultural Incentives, Revisited. *World Trade Review*, 7(3), 2008.

Barrett, C. Food Prices and the Poor: the Differential Welfare Effects of Price Levels and Volatility. Paper presented at International Agricultural Trade Research Consortium General Meeting, St. Petersburg FL, December 11, 2011.

Bouis, H., K. M. DeWalt, E. Kennedy, P. Pinstrup-Andersen, I. Nieves and J. Von Braun. A Common Framework for Research on the Income and Nutrition Effects of Increasing Commercialization of Semi-subsistence Agriculture. International Food Policy Research Institute, Washington DC, 1984.

Bouis, H. E. and L.J. Haddad. Effects of Agricultural Commercialization on Land Tenure, Household Resource Allocation and Nutrition in the Philippines. IFPRI Research Report 79. International Food Policy Research Institute, Washington, DC, 1990.

Deaton, A. and J. Drèze. Nutrition in India: Facts and Interpretations, mimeo, Princeton University, Princeton, NJ, 2008.

de Brauw, A. and R. Mu. Migration and the Overweight and Underweight Status of Children in Rural China. *Food Policy*, 36(1), 88-100, 2011.

DFID. Better Livelihoods for Poor People: the Role of Agriculture. Department for International Development, UK, 2002.

Fleuret, P. and A. Fleuret. Social Organization, Resource Management and Child Nutrition in the Taita Hills, Kenya. *American Journal of Physical Anthropology*, 93, 91-114. 1991.

Goldberg K. P. and N. Pavcnik. Trade, Inequality, and Poverty: What Do We Know ? Evidence from Recent Trade Liberalization Episodes in Developing Countries. NBER working paper 10593, 2004.

Govereh, J. and T.S. Jayne. Cash Cropping and Food Crop Productivity: Synergies or Trade-offs? *Agricultural Economics*, 28, 39-50, 2003.

Gross, D. B. and B. Underwood. Technological Change and Calorie Costs: Sisal Agriculture in Northeastern Brazil. *American Journal of Physical Anthropology*, 73, 725-740, 1971.

Haaga J.. J. Mason, F. Z. Omoro, V. Quinn, A. Rafferty, K. Test. and L. Wasonga. Child Malnutrition in Rural Kenya a Geographic and Agricultural Classification. *Ecology of Food and Nutrition*, 18, 297 -307, 1986.

Helble, M., B. Shepherd, and J.S. Wilson. Transparency and Regional Integration in the Asia Pacific. *World Economy*, 32(3), 479-508, 2009.

Hertel, W. T., M. Ivanic, P.V. Preckel, J. A.L. Cranfield and W. Martin. Short- Versus Long-Run Implications of Trade Liberalization for Poverty in Three Developing Countries. *American Journal of Agricultural Economics*, 85(5), 1299-1306, 2003.

Hertel, W. T., M. Ivanic, P.V. Preckel, and J. A.L. Cranfield. The Earnings Effects of Multilateral Trade Liberalization: Implications for Poverty. *The World Bank Economic Review*, 18(2), 205-236, 2004.

Huang, J. and C. Chen. *Effects of Trade Liberalization on Agriculture in China: Institutional and Structural Aspects*. Bogor, Indonesia: United Nations ESCAP CGPRT Centre, 1999.

Huang J., Y. Liu, W. Martin, and S. Rozelle. Changes in Trade and Domestic Distortions Affecting China's Agriculture. *Food Policy*, 407-416, 2009.

Huang J. and S. Rozelle. Agricultural Development, Nutrition, and the Policies Behind China's Success. *Asian Journal of Agriculture and Development*, 7(1), 1-34, 2009.

Immink M. and J. Alarcon. Household Food Security Nutrition and Crop Diversification among Smallholder Farmers in the Highlands of Guatemala. *Ecology of Food and Nutrition.* 15,287-305, 1991.

Jensen T. R. and N. H. Miller. A Revealed Preference Approach to Measuring Hunger and Undernutrition. NBER working paper 16555, 2010.

Jones-Smith J. C. and B. M. Popkin. Understanding Community Context and Adult Health Changes in China: Development of an Urbanicity Scale. *Social Science & Medicine*, 71, 1436-1446, 2010.

Kennedy, E. and L. Haddad. Are Pre-schoolers from Female-headed Households Less Malnourished? A Comparative Analysis of Results from Ghana and Kenya. *Journal of Development Studies*, 30(3), 680 - 695, 1994.

Lin, J.Y. and Y. Yao. Chinese Industrialization in the Context of the East Asian Miracle. In J.E. Stiglitz and S. Yusuf e.d. *Rethinking the East Asian Miracle*. Washington DC: World Bank Press, 143-196, 2001.

Luo, R., C. Liu, L. Zhang, and S. Rozelle. Investing in Rural China: A Report on a Survey of Public Infrastructure Investment. Working paper, Beijing: Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences, China, 2007

Masanjala, W.H.. Cash Crop Liberalization and Poverty Alleviation in Africa: Evidence from Malawi. *Agricultural Economics*, 35(2), 231–240, 2006.

Mangyo, E.. Who Benefits More from Higher Household Consumption? The Intra-household Allocation of Nutrients in China. *Journal of Development Economics*, 86(2), 296-312, 2008.

Meng X., X. Gong and Y. Wang. Impact of Income Growth and Economic Reform on Nutritional Availability in Urban China: 1986-2000. *Economic Development and Cultural Change*, 57(2), 261-295, 2009.

Miller, C., O. Morrissey, N. Rudaheranwa. Policy and Non-Policy Barriers to Trade and Implicit Taxation of Exports in Uganda. *Journal of Development Studies*, 37(2), 67-89, 2000.

MOFTEC [Ministry of Foreign Trade and Economic Cooperation], Individual Action Plan on Trade and Investment Liberalization and Facilitation 2001 of the People's Republic of China. Unpublished document, MOFTEC, Beijing, China, 2001.

Nyberg, A. and S. Rozelle. Accelerating China's Rural Transformation. Washington DC: The World Bank, 1999.

Paolisso M.J., K. Hallman, L. Haddad, and S. Regmi. Does Cash Crop Adoption Detract from Child Care Provision? Evidence from Rural Nepal. *Economic Development and Cultural Change* 50, 313-317, 2002.

Park A., H. Jin, S. Rozelle, and J. Huang. Market Emergence and Transition: Arbitrage, Transaction Costs, and Autarky in China's Grain Markets. *American Journal of Agricultural Economics*, 84(1), 67-82, 2002.

Rubin, D. S. and P. Webb. The Nutrition Effects of Changing Patterns of Cash Cropping in the

Gambia and Kenya: Intrahousehold Processes and the Role of Women. Paper presented in the Symposium on Cash copping and Nutrition, Annual Meeting of the United Nations Agency Committee on Coordination: Sub-Committee for Nutrition. Geneva. February 1988.

Von Braun J.. Effects of Technological Change in Agriculture on Food Consumption and Nutrition: Rice in a West African Setting. *World Development,* 16, 1083-1098, 1988.

Von Braun J., D. Hotchkiss and M. Immink. *Non-Traditional Export Crops in Guatemala: Effects of Production, Income and Nutrition.* Washington DC: International Food Policy Research Institute, IFPRI Research Report 73, 1989.

Von Braun J. and E. Kennedy. *Commercialization of Subsistence Agriculture: Income and Nutritional Effects in Developing Countries*. Washington, DC: International Food Policy Research Institute, 1986.

Von Braun, J. and P. Webb. *Famine and food security in Ethiopia: Lessons for Africa.* Oxford: Blackwell Ltd., 1994.

Wang H., X. Dong, S. Rozelle, J. Huang. and T. Reardon. Producing and Procuring Horticultural Crops with Chinese Characteristics: The Case of Northern China. *World Development,* 37(11), 1791–1801, 2009.

Wong J. and Y. Huang. China's Food Security and Its Global Implications. *China: An International Journal*, 10(1), 113-124, 2012

World Bank. *Reaching the Rural Poor: A Rural Development Strategy for the Latin American and Caribbean Region.* Washington, DC., 2002.

Zhu, J., D. Hare, and F. Zhong. Food Consumption for the Poor: A Supply or an Income Issue? Evidence from Less-favored Regions in Rural China. Paper presented at AAEA annual meeting, Denver Colorado, July 25-27, 2010.

APPENDIX: RELATION BETWEEN NUTRITIONAL MEASURES AND INCOME

Figure A1, A2 and A3 present the OLS and quantile regression fitted lines between different nutritional measures and income. We find that share of calories from non-staples is positively correlated with income. Moreover the slope decreases with higher quantile regressions, which suggests a decreasing marginal effect of income on nutrition. The OLS regression marginal effect is very close to that of median quantile regression. In contrast, the OLS and quantile regression fitted lines imply no clear relation between caloric intake, protein intake and income. The comparison of fitted lines suggest that the share of calories from non-staples may serve as a better measure of nutrition.

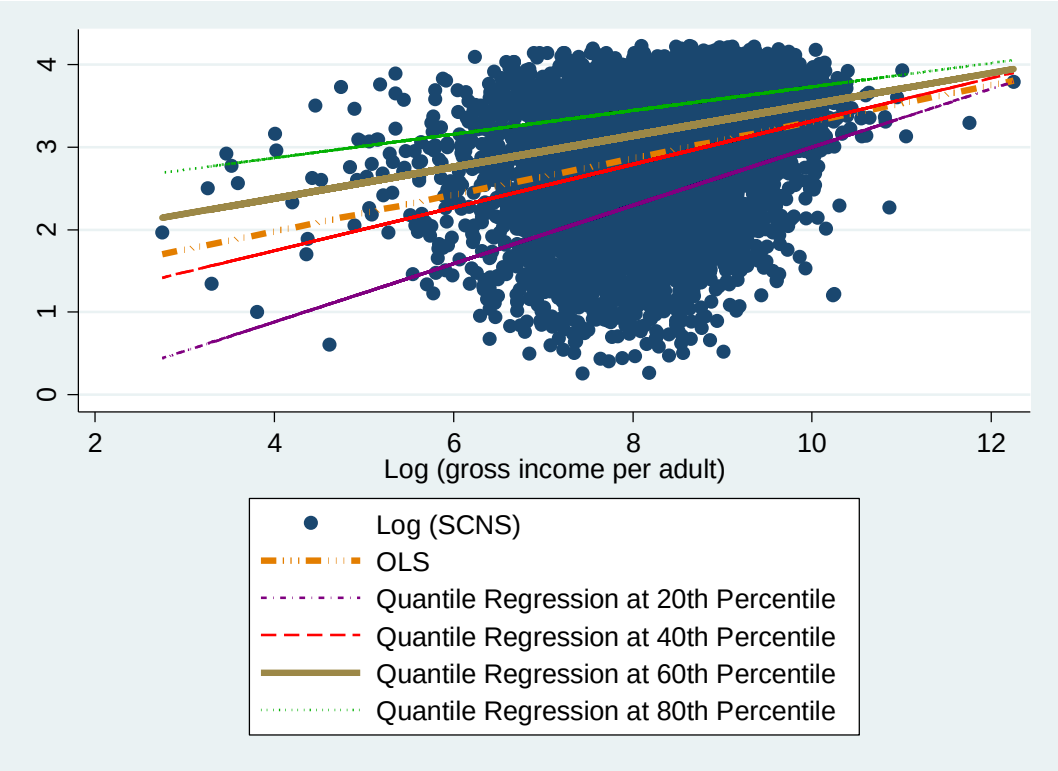

Figure A1. Fitted OLS and quantile regression lines of income on SCNS

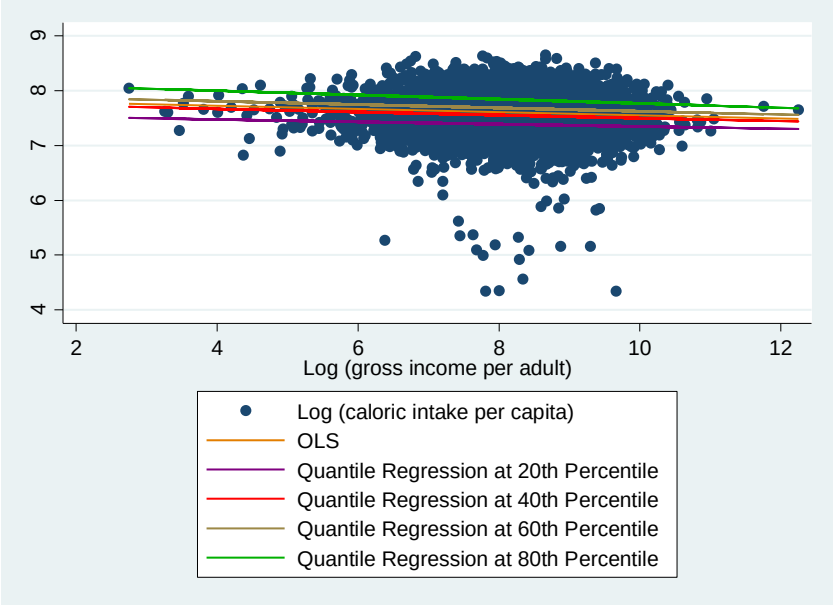

Figure A2. Fitted OLS and quantile regression lines between caloric intake and income

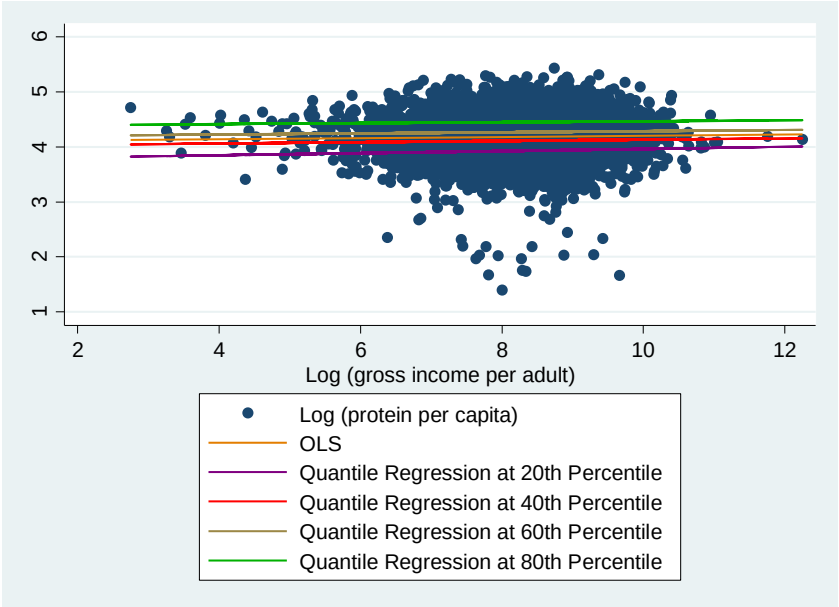

Figure A3. Fitted OLS and quantile regression lines between protein intake and income