Agricultural Market Liberalization and Household Food Security in Rural China

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Abstract

In the 1990s, prior to its accession to the WTO, China dramatically reduced market distortions in agriculture. We use a panel of 6,770 rural households from 1989 to 2000 to ask whether agricultural market liberalization affected rural household food security as measured by the share of calories from non-staples (SCNS). Given that some households may not be able to benefit from market opportunities, we focus on the distributional effect of market liberalization. Unlike most previous research on the effects of liberalization, we consider the effects of liberalization on both farm and off-farm income. We find that liberalization primarily improves household food security by increasing off-farm income, and the effects vary greatly by initial food security status and producer types. While many households benefit from liberalization, some food insecure households producing import-competing products have lower food security as a result of agricultural market liberalization.

Keywords: agricultural market liberalization, trade liberalization, household food security, off-farm income, rural China

JEL codes: Q17, Q18

Recent WTO disputes have brought China's agricultural trade policy back into the spotlight. In November 2008, China issued the nation's first Outline of Mid- and Long-term Plan for National Food Security, in which it is stipulated that the country will seek to stabilize the area sown to grain, and achieve more than 95% grain self-sufficiency. Trade restrictions are part of this plan, with the argument that increased imports of grains and soybeans will lower prices, causing grains and soybeans farmers to leave farming, generating food insecurity (Wong and Huang 2012). However, others suggest that China may not have a comparative advantage in grains or soybeans production, and switching to higher-value agriculture such as horticulture or working off-farm could increase the income of both rich and poor farmers (Zhu, Hare and Zhong 2010). In this article, we evaluate the effect of past agricultural market liberalization on rural Chinese household food security as a measure of household welfare. Because market liberalization is likely to differ in its effect across households, we explore the distributional effect of liberalization on rural household food security.

Prior to its accession to the WTO in 2001, China undertook tremendous reforms of agricultural markets, prices and trade. The average agricultural import tariff rate fell from 42% to 24% from 1992 to 1998, and domestic agricultural policy reforms dramatically decreased market distortions (MOFTEC 2001; Huang et al. 2009). The government lowered the mandatory amount of grain farmers had to sell to the government, called the grains quota. The government also reduced the price disparity between in-quota versus out-of-quota sales, and fully eliminated the

grains quota around 2000. The government decentralized much of the agricultural trading authority, reduced the scope of non-tariff barriers and relaxed licensing procedures for some crops (Huang and Chen 1999). Over the same time, the government invested heavily in infrastructure and significantly reduced transactions costs in domestic agricultural markets (Fan, Zhang and Zhang 2004; Fan and Chan-Kang 2005; Luo et al. 2007).

Agricultural production value, off-farm income and household food security rose over this time. We find that the share of calories from non-staples (SCNS) in rural China increased by 5 percentage points, from 21% in 1989 to 26% in 2000, where a SCNS of greater than 16% is a reasonable measure of being out of hunger (Jensen and Miller 2010). That said, rural poverty and food insecurity are still a salient concern. Economic growth has been concentrated in urban areas and urban incomes are now more than three times higher than their rural counterparts. Poverty remains primarily a rural phenomenon, with 99% of the poor in China coming from rural areas (World Bank 2009). In 2010, 152 million people (11.2%) in rural China still lived under the poverty line of less than $1.90 per person per day (World Bank 2014), and in 2015, 133.8 million people were food insecure with food intake insufficient to meet daily energy requirements (FAO 2015). Improving access to adequate quantity and diversity of nutrients in rural areas is a major objective for Chinese policy makers (Mangyo 2008; Huang and Rozelle 2009; de Brauw and Mu 2011).

We identify the effect of liberalization by noting that while market liberalization is largely

driven by central government policies, it will affect each community differently. Some markets are more isolated than others, and will be less affected by the decrease in protection from the world market. We measure the degree of local market liberalization by using the price difference between world, regional and local prices for seven agricultural products. This metric captures both transportation costs and policies such as non-tariff barriers that are hard to quantify.

Following Jensen and Miller (2010), we use the household's share of calories from non-staples (SCNS) as our measure of food security. We control for time-invariant unobserved household characteristics through household fixed effects and agro-climatic shocks and general economic trends through county by year dummy variables. We also control for other potential channels through which liberalization could affect household food security, namely demographics, changes in market access, information and food prices, to obtain the effects of liberalization on food security solely through income. By using a longitudinal household survey (China Health and Nutrition Survey, CHNS), we can analyze the impacts of liberalization econometrically without restrictive assumptions such as complete markets and perfect information common in simulation models of trade liberalization.

Agricultural market liberalization may affect different rural households differently. While wealthy and well-educated farmers may benefit from increased off-farm work opportunities and income (Wang et al. 2009), the poorest farmers may lack access to income-generating assets, credit and technology, and thus have limited ability to switch production or into off-farm jobs,

making them vulnerable to market liberalization (Chen and Ravallion 2004; Anderson, Huang and Ianchovichina 2004). Conversely, agricultural market liberalization can improve agricultural efficiency, increase rural household income of the poor and enhance household access to food (Kennedy and Cogill 1988; Ingco 1997; Huang Li and Rozelle 2003; Huang et al. 2007).

Trade theory would predict that producers of export-oriented products (hereafter called export producers) benefit from agricultural market liberalization and producers of import-competing products (hereafter called import producers) may lose from liberalization (Huang, Li and Rozelle 2003; Huang et al. 2007). While prior research has studied how economic reforms affect the distribution of *urban* residents' nutrition availability (e.g. Meng, Gong and Wang 2009), it is unclear how liberalization affects the food security of the full distribution of households living in rural areas.

Existing research on the effect of agricultural reforms largely focuses on how liberalization affects agricultural production value and thereby farmers' welfare. But off-farm jobs can be an effective way for farmers to raise income and reduce rural poverty (Rozelle 1996; de Janvry, Sadoulet and Zhu 2005; de Brauw and Giles 2017). Based on the CHNS, from 1989 to 2000, off-farm income gradually increased from 30% to 50% of total rural income. Therefore, unlike much previous research, we analyze how agricultural market liberalization affects farmers both through agricultural production value and off-farm income.

Because food secure and insecure households may have different tradeoffs in the face of

market liberalization, we use Instrumental Variable Unconditional Quantile Regressions (IVUQR) to study the distributional effects of market liberalization on household food security while addressing the endogeneity of agricultural production and off-farm income. This article is the first empirical application that addresses the endogeneity of continuous regressors when analyzing the unconditional distributional effects.[1] By comparing effects at several points on the unconditional distribution of SCNS, this article evaluates the impact of market liberalization on the most vulnerable population.

The largest effect of liberalization is through facilitating off-farm employment. We find that market liberalization primarily benefits food secure households by increasing off-farm income. By relaxing the grains quota, farmers had more freedom to work off-farm, potentially increasing their income. Further, market liberalization may have caused some farmers and local processor to specialize in the production of agricultural products in which China has a comparative advantage. This specialization may have increased the demand for labor. However, we also find that market liberalization does not substantially improve food security for food insecure households. In particular, import-producing households who are food insecure appear to be worse off after agricultural market liberalization. Our findings suggest that while some farmers clearly benefited from market liberalization, some food insecure rural households may have been left behind. Agricultural market liberalization may have contributed to inequality in income and

[1] Unconditional quantile effects with endogeneity for a discrete treatment variable have been examined in Frolich and Melly (2012).

level of food security in rural China.

In the next section, we describe the CHNS data and explain how we construct the two key variables: the household food security indicators and the market liberalization index. We then discuss our empirical specification, the IVUQR methodology and identification strategy. In the following section, we present the main results, particularly emphasizing the heterogeneous effects of market liberalization and its implications in terms of calories. The final section concludes.

Data

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 and the National Institute of Nutrition and Food Safety (NINFS) at the Chinese Center for Disease Control and Prevention (CDC). The data cover 104 rural communities and 6,770 rural households in 8 provinces in 5 waves: Liaoning, Jiangsu, Shandong, Hubei, Hunan, Henan, Guizhou and Guangxi in 1989, 1991, 1993, 1997 and 2000.[2] In this article we consider only farmers who are defined as households having more than 10% of their gross income from agriculture in rural communities, where rural communities are defined as communities having over 25% of income from agriculture in at least one of the survey years. By this definition 96% of communities with agricultural data are included and 94% of all households in rural communities are defined as farmers and included.

[2] The CHNS also includes Heilongjiang in 1997 because Liaoning cannot participate in the survey in the same year. However, because in our model we use grains quota per mu (1/6 of an acre) in 1989 to construct one of our instruments, we end up dropping the province of Heilongjiang

The CHNS records detailed data at both the household and community level including household agricultural production, off-farm income and community-level economic and retail information.

A key part of the CHNS is a 24-hour food diary filled out by each household member for three days.[3] Each household member reports what they ate and drank the previous day, including food both at and away from home, by specifically documenting the components of all foods eaten. These foods were recorded in detail to match the 636 detailed food items listed in the 1991 Food Composition Tables developed by the NINFS, which were used to convert food consumption into caloric intake.

SCNS as Household Food Security Indicator

We use the share of calories from non-staples (SCNS) as our measure of household food security.[4] This approach is essentially an application of Bennett's Law at the household level. The SCNS is based on the premise that until a household has passed subsistence, they will prioritize consuming sufficient calories from the cheapest sources (staples) since insufficient calorie intake is associated with a large penalty to individual utility (e.g. physical discomfort from hunger). After the household has enough calories to meet their idiosyncratic needs, the household will substitute away from staples to satisfy non-caloric attributes such as micronutrients and taste. Although any household's caloric intake requirement is unobserved,

[3] The three consecutive days during which detailed household food consumption data were collected were randomly allocated from Monday to Sunday and are almost equally balanced across the seven days of the week for each sampling unit. In a few cases, individuals missed one day because of absence, but over 99 percent of the sample has the full three days of data.

[4] Jensen and Miller (2010) treat SCNS mostly as a measure of hunger. We propose that it is also a good measure of food security.

their choice to switch away from staples reveals they are above their minimum caloric requirement, and thus SCNS can be used to indicate food security.[5]

We construct this measure by first summing the *staple* and *total* calorie intake from various sources for all household members and all diet diary days. Then we divide the staple calorie intake by total calorie intake to get the staple calorie shares (SCS) at the household level.[6] Finally, we subtract SCS from 1 and multiply the result by 100, which scales the SCNS to a range of 0 to 100.

Agricultural Market Liberalization

Traditional measures of agricultural market liberalization such as the Nominal Rate of Assistance at the Farm Gate (NRAf) and tariffs usually do not vary by region (Anderson et al. 2008; Huang et al. 2009). 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). During our period, transactions costs in the domestic Chinese agricultural market are very high (Park et al 2002). We use regional variation in implicit transactions costs to build on the approach of Anderson et al. (2008) and Huang et al. (2009), and generate a local measure of market liberalization. We calculate the

[5] The SCNS has several advantages over staple budget share (SBS) or Engle's curves that are based on expenditure surveys. First, food purchased will not be the same as food consumed if meals are provided by an employer or the food purchased is provided to others. In contrast, SCNS accounts for each household member's food intake from all food sources including free food provided by others. Second, SBS requires detailed price data to calculate the value of the food farmers grow for their own consumption, which may not be very accurate.

[6] We compute the household-level SCNS following Jensen and Miller (2010), not the average of SCS for each member or for the whole household for each of the three days. By summing over all household members and all diet diary days we minimize potential measurement error for specific individuals and/or days.

difference between the local and the regional consumer market price, and the difference between regional consumer market price and world price to identify which communities face effective market liberalization and which communities do not.[7]

NRAfs are calculated as the percentage difference between world prices and farm gate prices for different commodities (Huang et al. 2009). If we use the simple difference between the local and world price as a measure of liberalization, the result might be misleading. For example, a small difference between the price of an import-competing product at the farm gate and the port may result from a low level of protection. Conversely, the relatively low farm-gate price might be caused by high transactions costs of getting the product to the regional consumer market, where the regional market is still highly protected from import competition (illustrated in figure 1).[8] As shown in figure 1, for an import competing product, the border price (P_b) is higher than the world price (P_w) because of import tariffs. As a result of the transactions cost (tc_1) of shipping the good from the border to regional consumer markets, the regional consumer markets

[7] Our liberalization index is informed by work measuring market liberalization using differential regional changes in transportation costs (e.g. Burgess and Donaldson 2010; Aggarwal 2014). Due to the fact that the location of the communities is masked in our data, we cannot use changes in transportation infrastructure to proxy for liberalization. We use the notion that as transportation costs decrease, spatial price transmission increases. Ideally if we had more observations of prices over time, we could estimate a formal price transmission model and construct the trade liberalization index from the model. Unfortunately, while the CHNS data have community prices on a large number of goods, they only have one observation for each of the 5 survey years. Thus, there are not enough detailed time-series data to estimate a price transmission model.

[8] We believe that regional market prices are important as Chinese households consume a substantial amount of the agricultural production grown within the province during this time. During this period, most grains were sold to regional consumers due to the provincial governor grains bag responsibility system, associated with the grains quota discussed later. The provincial governor grains bag responsibility system put the provincial governors in charge of grains quota procurement and supply to satisfy urban needs within the province. Thus, most governors prioritized and subsidized grains sales to local regional markets within the province. Transportation and storage costs for horticulture and livestock products are high and therefore local markets are likely the primary markets for these goods as well.

price (P_c) will be even higher than the border price (P_b). Suppose that a local community in the province has a comparative advantage in the production of that product, then the price at the farm gate (P_f) could actually be lower than the border price (P_b). However, because of the high transactions cost (tc_2) of shipping the product from the farm gate to regional consumer markets, the price in the regional consumer market (P_c) will be much higher than the farm gate price (P_f). In this case, the calculated NRAf (the percentage difference between P_w and P_f) will indicate little market distortion, and thus high agricultural market liberalization, while the true low local prices reflects the fact that the local community is very isolated from the world market.

Price differences incorporate the effects of trade-distorting policies such as export subsidies, import tariffs and domestic market distortions. We calculate an agricultural market liberalization index for community *c* in year *t* by taking the reciprocal of the sum of the absolute differences between farm gate and regional market prices, and that between regional market price and world price across commodities in the community for the year (equation 1).

$$I_{ct} = \left[\sum_i \left(\frac{|Pf_{it} - Pc_{it}|}{Pc_{it}} + \frac{|Pc_{it} - Pw_{it}|}{Pw_{it}} \right) \right]^{-1} \quad (1)$$

In equation 1, I_{ct} is the agricultural market liberalization index for community *c* in year *t*, Pf_{it} is the farm-gate price (local community retail price), Pw_{it} is the world price and Pc_{it} is the regional consumer market price for product *i* in year *t*. Thus agricultural market liberalization for a given community varies over time. The regional consumer market price is represented by the

price of the most urbanized city in the province for the given year.[9] We use rice, wheat, corn, poultry, pork, vegetables and soybeans oil because they account for more than 50% of the total agricultural output value in China (Huang et al. 2009) and 86.3% of calorie share in an average household's diet based on our data. We then multiply the agricultural market liberalization index by 100. The higher the agricultural market liberalization index, the more liberalized or more affected by market liberalization policies is the community.

To explore our measure of liberalization, we compare it to NRAfs over time (table 1) and plot the distribution of market liberalization for 1989 and 2000 (figure 2). We find that changes in our local market liberalization index are generally consistent with changes in the NRAfs over time.[10] The table and the figure indicate an increase in not only the mean but also the whole distribution of market liberalization over this period. To test the validity of our measure, we regress it against changes in community infrastructure and market access (see appendix A). We find that better access to communication facilities, market access, and improved transportation infrastructure are positively associated with agricultural market liberalization (appendix A table A1).

[9] The urbanicity of the community is constructed in 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. Given that the province capitals are sampled in the CHNS, it is very likely the most urbanized city of the province is the provincial capital.

[10] In 1993, soybeans and wheat were effectively taxed as indicated by negative NRAfs. In the 1990s, although trade policy protected wheat/soybeans producers by keeping out imports and keeping domestic prices high, domestic marketing policies worked in the opposite direction to trade policies by procuring wheat/soybeans quotas at far below free market price (Huang et al. 2009). In 1993, the negative NRAf for wheat/soybeans indicate that forced deliveries of wheat/soybeans quotas actually lowered the average farm gate prices so much that there was a net tax on wheat/soybeans farmers.

Descriptive Statistics

Means and standard deviations by year for our main variables are given in table 2. All incomes and prices are deflated to 2009 Yuan using the local CPI index calculated by the CHNS survey team.[11] The agricultural production value is calculated as the sum of the sale, consumption and gifts value of field crops, horticulture, livestock and fish produced by the household.[12] Off-farm income includes the household's wage and business income and excludes retirement wage or government subsidies that are dependent on government policies. Other household-level variables are household size that captures the number of household members, the number of adults who are defined as people aged 18 or older, and grains quota per mu, where a mu is equivalent to about 1/6 of an acre.

The Chinese central government had mandatory delivery quotas for each farmer for grains from the 1950s to the 1990s, until they were eliminated between 2000 and 2004.[13] Under the quota, farmers were required to deliver a specific quantity of grains to the government for what was usually less than market price. Along with the mandatory quota, the central government introduced negotiated purchases as an additional component of grains quota by the end of 1985

[11] The local CPI varies by community and year. The average community CPIs are 0.35, 0.36, 0.44, 0.71, and 0.70 in 1989, 1991, 1993, 1997 and 2000 respectively.

[12] The consumption value is based on the survey question "On average, during the past year, how much money would you have to spend per month to buy from the market the agricultural products that were grown and consumed by your household (Yuan)?"

[13] 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.

(Lin 1992; Rozelle et al. 1997; Rozelle et al. 2000). The negotiated purchases were still mandatory but were set at a higher price than the price of the basic grains quota, while still being lower than the free market price. The share of negotiated purchases in the total government grains quota climbed from 25% in 1985 to 58% in 1996 (Wu and McErlean 2003). We calculate the grains quota per mu as the sum of basic and negotiated purchases divided by the land size the household had for cropping last year.

The distance between the community and township center in the CHNS is given by the community leader. The market access scores and communication scores come from Jones-Smith and Popkin (2010) and are provided as part of the CHNS data. The market access scores are calculated based on the number of supermarkets, restaurants and stores within the community. The communication scores depend on the percentage of households with a television, computer or phone, and the availability of newspapers, telephone, postal offices and cinema within the community. These scores are all scaled from 0 to 10. The higher the score, the better the markets access and communication of the community (Jones-Smith and Popkin 2010). The prices of agricultural products are all retail prices in the local community markets.

Table 2 shows that production value and off-farm income increase over time along with better access to communication facilities in communities and improved liberalization over time. We also observe agricultural policy liberalization with the average household's grains quota

steadily declining from 1989 to zero by 2000.[14] The price of soybeans oil declines over time, which is expected since China dramatically increased its imports of soybeans during this period.

After constructing the SCNS and income variables, we investigate the suitability of SCNS as a measure of household food security by comparing the kernel density distributions of log SCNS across different income groups (figure 3). We define low, medium and high income households to be those with gross income less than 2401 Yuan per adult (25th percentile), between 2401 Yuan and 6444 Yuan per adult (75th percentile), and more than 6444 Yuan per adult respectively. The gross income per adult is the sum of agricultural production value and off-farm income divided by the number of adults in the household. The majority of the households improve their log SCNS from 3 (SCNS of 20%) to almost 3.3 (SCNS of 27%) as income increases. Significantly fewer people in the high income group than in the low income group have SCNS less than 20%.

Next, we compare the relation between different measures of food security and income using unconditional quantile regressions. We calculate calorie and protein intake from CHNS data on household consumption divided by the number of household members. From the regression results (table 3), we find while income is strongly positively correlated with SCNS, its correlations with conventional household food security measures is much lower. The correlation with protein intake is only 1/8 of that with SCNS. Caloric intake is actually negatively correlated

[14] One constraint is that the survey does not contain the amount sold to the government in 2000 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 2000 was zero for all households.

with income. In addition, the correlation between protein intake per capita and SCNS is 0.155 while caloric intake per capita is almost uncorrelated with the SCNS with a correlation coefficient of -0.026. The results are similar using caloric intake per adult equivalent when we use equivalence scales following Cutler and Katz (1992). Therefore, SCNS seems to be an informative measure of overall well-being and we use it as our measure of household food security and welfare.

To explore the correlation between our measure of agricultural market liberalization and food security, we first plot the distribution of income from three different sources against liberalization in figure 4. We divide our rural sample into low, medium and high liberalized communities with cutoff points of 18.8 (25^{th} percentile) and 27.7 (75^{th} percentile). As liberalization increases, the median of log gross income shifts to the right from 9.21 (9997 Yuan) to 9.38, or 11849 Yuan in gross income.

As we can see from the middle panel of figure 4, the distribution of the log of agricultural production value does not greatly differ by liberalization, with most households producing between 1097 and 8103 Yuan of agricultural products. The lack of an obvious correlation suggests that agricultural production value may not be the primary mechanism through which market liberalization affects household food security. That said, the distribution of agricultural production value broadens somewhat with higher liberalization. This observation suggests that liberalization may drive some farmers to specialize in agriculture while encouraging others to

leave the sector. In contrast, the distribution of log off-farm income notably shifts to the right from 7.5 (1808 Yuan) to 8 (2981 Yuan) with increased liberalization. Significantly fewer households have zero off-farm income at higher levels of liberalization than at lower levels of liberalization.

Last, we explore the direct association between liberalization and household food security in figure 5 and find that as liberalization increases, the distribution shifts to the right, with the median of log of household SCNS increasing from 3.2 (24.5%) to 3.5 (33.1%).

Methods

Agricultural market liberalization is likely to affect different households differently. Therefore, we use an unconditional quantile regression to identify the effects of liberalization on households located at specific points on the unconditional distribution of food security. By contrasting the estimated effects at several points on the distribution, we can tell whether responses to exogenous shocks differ in informative ways (D'Souza and Jolliffe 2013). We estimate the following model of the impact of liberalization on household food security:

$$A_{hvt} = X_{hvt}\alpha_1 + G_{hvt}\alpha_2 + Z_{vt}\alpha_3 + D_{vt}\alpha_4 + \gamma_h + \upsilon_{ct} + \varepsilon_{hvt} \quad (2)$$

$$O_{hvt} = X_{hvt}\beta_1 + G_{hvt}\beta_2 + Z_{vt}\beta_3 + D_{vt}\beta_4 + \gamma_h + \upsilon_{ct} + \varepsilon_{hvt} \quad (3)$$

$$Q_{F_{hvt}}(\tau) = A_{hvt}\delta(\tau)_1 + O_{hvt}\delta(\tau)_2 + X_{hvt}\delta(\tau)_3 + Z_{vt}\delta(\tau)_4 + \gamma_h + \upsilon_{ct} + \varepsilon_{hvt} \quad (4)$$

where h indexes for household, v for community, c for county and t for year. We assume that households face given prices and choose quantity to produce in agriculture. When deciding the quantity to produce in agriculture given the price (agricultural production value, A_{hvt}), a

household will consider their grains quota per mu interacted with province-year shocks (dummies) (G_{hvt}) and their labor endowment (X_{hvt}) (equation 2). Their agricultural production will also depend on access to off-farm employment and is related to community distance to township center interacted with province-year shocks (dummies) D_{vt} and other community characteristics, Z_{vt}, including, access to markets and information in the community, retail prices of major agricultural commodities and market liberalization as defined in equation 1. These explanatory variables are commonly used in other research to analyze the impact of liberalization or commercialization on income (e.g. Masanjala 2006). Similarly, household's off-farm income (O_{hvt}) will rely on the same set of household (X_{hvt}, G_{hvt}) and community level variables, D_{vt} and Z_{vt} (equation 3).

Agricultural production value (A_{hvt}), and off-farm income (O_{hvt}) will influence the unconditional distribution of household food security, $Q_{F_{hvt}}(\tau)$, where τ represents the τ^{th} quantile of the unconditional distribution of food security indicator F_{hvt}. To control for household-level unobserved characteristics we include household fixed effects (γ_h). In addition, we incorporate county by year dummy variables (ν_{ct}) to control for agro-climatic shocks that are likely to vary by county-year such as rainfall and temperature. The county-level variation is entirely picked up by those county-year dummy variables because county-level variables only vary annually. Therefore, the variation we use is to compare the annual deviations of different households from their long-run average within the same county-year. Finally, ε_{hvt} represent the

error term.

We estimate the parameters using unconditional quantile regression under endogeneity (IVUQR hereafter). The identifying assumptions underlying the IVUQR model are similar to those in an instrumental variables regression. The instruments need to be correlated with the endogenous variables and orthogonal with the error terms in the model. OLS regressions in equations 2 and 3 are simply the first stage of the IVUQR. Equation 4 is the second stage of IVUQR. We use a control variable approach as suggested in Rothe (2010) and Imbens and Newey (2009) to obtain the empirical Cumulative Distribution Functions (CDFs) of the residuals in the first stage regressions and then use the CDFs as control variables in the second stage. Like in a standard control variable approach, the CDFs are a one-to-one function of the error terms in the first stage, which are able to absorb the dependence between the regressors and unobserved error term in the second stage if the instruments are valid. The estimation details and other important features of the IVUQR are provided in appendix B.

In the first stage of the IVUQR, we explore how market liberalization affects agricultural production value and off-farm income while separately controlling for market access, information and prices that themselves may be affected by market liberalization. In the second stage, we study the effects of both agricultural production value and off-farm income on the distribution of household food security, recognizing that both income sources may be endogenous.

There are three central advantages of IVUQR compared to conventional estimators. First, unlike two-stage-least squares, the IVUQR estimator allows the marginal effect of market liberalization to vary across households with different levels of food security. Compared to the Instrumental Variable Quantile Regression (IVQR) (Chernozhukov and Hansen 2005), the IVUQR allows the marginal effects to differ across the distribution without conditioning on observed covariates. The IVUQR estimator is arguably more policy relevant because households at the bottom of the unconditional distribution are food insecure regardless of their other attributes, whereas the bottom of the conditional distribution need not be food insecure, they just have low food security conditional on their attributes, such as income.[15] Second, because the unconditional effects are averages of conditional effects, they can be estimated more precisely. Third, unlike the IVQR, the definition of the unconditional effects does not depend on the explanatory variables included in X. One can, therefore, consider different sets of covariates X and still estimate the same unconditional quantile effects, which is useful for examining robustness of the results to the set of covariates.

Identification Strategy

To identify the distributional effects of liberalization, we use household grains quota per mu in 1989 interacted with the province-year dummy variables in the household and the distance from the community to the township center interacted with the province-year dummy variables as the

[15] SCNS describes absolute levels of food security. We care about household SCNS in an absolute sense, not just relative to their food security status in 1989. Therefore, we do not do a subsample analysis on market liberalization's impact at different deciles of the initial log SCNS distribution.

instruments for agricultural production value and off-farm income in the IVUQR.

From 1989 to 2000, the role of the central government in determining the amount of grains quota in the province was weakened, and the amount of grains quota in each province was largely determined by the provincial government. The total provincial quota was determined by the weather conditions and the grains production plans of the provincial government. Then the provincial grains quota was divided into a grains quota for each county, township and community. So the grains quota for the whole community is assigned by the township government and is independent of the individual household's production decisions. At the local level, the grains quota for each household was determined by the historical household grains quota per mu, household size and allocated land, and thus does not depend on current household crop choice.[16]

The grains quota can be seen as an in-kind local agricultural tax levied on the household. One may be concerned that farmers simultaneously rent out their land, reduce their effective quota burden and reorient towards off-farm employment. In addition, local grain bureaus may accept cash in lieu of grains for the quota payment. Because we use grains sold to government as our measure of grains quota, if either above concern is true, our observed grains sold to government may not be equal to the grains quota initially set by the local community leaders, potentially resulting in measurement error and endogeneity. We address both concerns by using

[16] We also check that grains quota per mu is not correlated with access to irrigation. The correlation coefficients is 0.0078 between grains quota per mu and household irrigation ownership indicator, and 0.0889 between grains quota per mu and share of land under unified irrigation system in the community.

the observed grains quota in 1989 because at that time, the land rental markets are negligible and cash is rarely accepted in lieu of grains. Both existing literature and our data support this argument. China's farmers rented out less than 0.3% of the land they cultivated in 1988 (Brandt, Rozelle and Turner 2004). By 1995, farmers still rented out only 2.5% of their land. In our data, household land size remains essentially unchanged between 1989 and 1991, with no household recording a change in land size greater than one mu. Given the shortage of grains at the provincial level in 1988-1989 (Park et al. 2002), the local grains bureaus strictly enforced grains quota to ensure a sufficient amount of grains were collected, and thus rarely accepted cash in place of grains. Therefore, grains per mu sold to the government are likely required grains quota per mu in 1989.

The historical grains quota per mu affects the later household grains quota because it serves as a benchmark for household quota allocation. For example, if a community-level grains quota declines 10% from 1000 tons to 900 tons, then the grains quota on every mu of land is likely to decrease from their historical level by 10%. Current and historical grains quota per mu of land affects agricultural production value because it is a form of agricultural tax. Therefore, the historical level of grains quota per mu is likely to affect household food security only through agricultural production value, and indirectly, through off-farm income. Ideally, to have an exogenous measure of household quota we would interact the past household quota with provincial or local quota mandates. Given that we do not have specific provincial or local quota

requirements, we proxy this variation using the past household quota times province by year dummy variables.

We use the distance from the household's resident community to township center interacted with province-year dummy variables as the other IV in our model. Township and village enterprises (TVE) located in township centers play an important role in rural off-farm income and employment from 1989-1997. During that time, the average share of rural non-farm workforce in TVEs is still over 50% (Kung and Lin 2007). In fact, households rarely permanently move out of their communities and relocate in areas with more off-farm work opportunities in the 1990s. Part of the reason is that if farmers permanently leave agriculture, they have to return the land to local authorities, and consequently, give up future income from the land. It is easier to attend to farms if farmers live at least some time in the communities where their allocated land is located.

We separately control for access to market in our model, which is likely correlated with both household food security and distance to township center. Thus the distance to township center is likely to affect household food security only through off-farm income and indirectly through agricultural production value. As a robustness test, we use the number of migrant workers[17] in the community in the previous year, and Hukou status in 1989 interacted with province-year dummy variables as alternate instruments for off-farm income (see appendix C, tables C1 and

[17] Migrants in this article are household members between age 18 and 45 that are out of home for at least one month.

C2).[18]

One might be concerned that liberalization affects tastes and improves nutritional knowledge, and that may be the true driver of increased SCNS instead of income. To disentangle this effect, we include the liberalization index in the household food security regression (include liberalization index in Z_{vt} in equation 4) and control for other observable mechanisms through which liberalization could affect household food security such as community access to markets and information, food retail prices (included in Z_{vt}), land and household demographics (X_{hvt}). We assume that the liberalization index as an explanatory variable in the household food security regression captures the residual changes induced by market liberalization such as changes in tastes, nutrition knowledge or greater access to a wider variety of foods.

In the 1990s, the barriers of rural to urban migration were gradually relaxed. One might be concerned that our market liberalization index is capturing the increasing ease of migration that affects household food security through off-farm income. To address this concern, we conduct two robustness tests. First, we run regressions on a sample of communities where there is less migration, i.e. the shares of migrants among all households are below 8.3%, or the 25th percentile of the sample. Results are shown in in appendix table C3 and C4. Second, Mu and de Brauw (2015) employ the CHNS data and identify the impact of migration using the interaction

[18] Hukou is the household registration system implemented in China. The hukou system differentiates opportunity structures for the entire population on the basis of position within a clearly defined spatial hierarchy, i.e., urban above rural and well-developed above less-developed cities. Rural hukou holders must pay fees and tuitions that are substantially higher than those paid by local residents. Many local governments continue to require business firms, both state-owned and privately-owned, to hire only local residents.

between wage growth (by gender) in provincial capital cities and initial village migrant networks as instruments of migration selection. The initial migrant network is measured as the share of men and women between ages of 18 and 45 who had migrated in 1989. In our second robustness test, we construct and control for the Mu-de Brauw instruments in all regressions (shown in appendix tables C5 and C6). Thus we attempt to control for the migration that might affect household food security through its association with market liberalization index.

In addition, one might be concerned that improvement in infrastructure and industrial development that may be affected by market liberalization are the true contributors of household food security. Therefore in the robustness tests, we include distance to the nearest paved road, train station and the number of township and village enterprises (TVEs) and private enterprises in the model to examine changes in market liberalization that are orthogonal to changes in community's access to railways, roads and number of enterprises. The regression results are presented in appendix tables C7 and C8. Furthermore, to mitigate the concern that our liberalization index is driven primarily by local commodity-specific shocks, we explore the correlation between the liberalization index and individual commodity price in the community and find little effect (appendix table C9). Additionally, to control for time-invariant household heterogeneity we include household fixed effects. We also use county by year dummy variables to capture agro-climatic and changes in infrastructure and economic conditions that vary over time in a county. After controlling for various variables that affect household food security and

are potentially correlated with market liberalization, our measure of market liberalization is treated as exogenous. All standard errors are bootstrap estimates clustered at the community level.

Last, we test the robustness of our results against possible measurement errors in the agricultural production value and off-farm income that may be correlated with errors in the measurement of the food security indicators in equation 5. In appendix table C10, we follow Woodridge (2003) and Giles and Yoo (2007) and control for the potential endogeneity introduced by correlated measurement errors by using period t-1 and t-2 values of agricultural production value and off-farm income as instruments.

We find that the Hansen J statistics is 69.68 with p-value of 0.1840, which suggests that there is no direct evidence against the validity of instruments. When testing the weak identification of instruments, because we cluster standard errors at the community level, we use a correspondingly robust Kleibergen-Paap Wald F statistics. Cameron and Miller (2011, 2015) note that with clustering, there is no appropriate rule of thumb and that instruments may be weak for F statistics at levels above 10 or sufficiently strong well below 10. Consequently, we use a Stata program developed by Finlay and Magnusson (2009) to perform overidentification tests that are robust against weak instruments as well as the hypothesis testing of our regression results. We find no direct evidence against the validity of instruments even when the instruments are weak.

Heterogeneous Effect of Liberalization

To see how market liberalization affects households with varying food security status, we divide the sample into food secure and food insecure households and then run separate OLS regressions of equations 2 and 3 for these two subsamples.[19] Following Jensen and Miller (2010), we define food insecure households as those with less than 16% SCNS.[20] Additionally, we split our sample into food secure import and export producers, food insecure import and export producers.[21],[22] Then we run first stage regressions for each of these four groups to see how the effect of liberalization differs by food security status and by production type. Last, we connect the heterogeneous effects of liberalization on income to changes in household food security using second stage regressions (equation 4).

We recognize that systematically subsampling on the dependent variable inherently introduces sample-selection bias (Heckman 1979). This concern is one motivation to use the IVUQR to examine effects at different parts of the distribution rather than for different

[19] Using interaction terms between liberalization and food security status gives us similar results.

[20] This SCNS level is calculated from a minimum cost diet for an active man 67 inches tall and weighting 121 pounds, which is average for China. It also corresponds to the 40th percentile of SCNS in our sample.

[21] We define field crops producers as farmers who receive more than 50% of their agricultural production value from field crops. Import producers are then defined as field crops producers in the northern provinces in China (Liaoning, Shandong and Henan), because we do not observe the specific crops farmers grow, and wheat, maize and soybeans production makes up the largest portion of the total field crops production in these provinces (about 92% on average from 1989 to 2000 based on China's Statistical Yearbooks in various years).

[22] Export producers include producers of rice, horticulture and livestock where China has a comparative advantage, and mixed producers. Field crops producers in southern provinces of China, namely Jiangsu, Hubei, Hunan, Guangxi and Guizhou are defined as rice producers because in these provinces, rice production makes up the biggest portion of total field crops production. Horticulture and livestock producers are farmers who have over 50% of their agricultural production value from horticulture and livestock respectively. Mixed producers are farmers who are neither horticulture nor livestock producers but have more than 50% of agricultural production value from livestock and horticulture combined. Mixed producers are considered to be more diversified agricultural producers than farmers who specialize in one type of production.

sub-samples of the dependent variable. Nonetheless, to provide a more detailed description, even if potentially biased, we also present findings from the sub-sample approach. It would be infeasible if we use a UQR in the first stage since a household who has little agricultural production value/off-farm income may not necessarily be a food insecure household. Thus we split the sample by food security status in the first stage to be able to connect it with the second stage estimation.

Results

We first estimate simple unconditional quantile regressions measuring the overall association between agricultural market liberalization and the distribution of household food security when treating agricultural production value and off-farm income as exogenous. The results in table 4 show that the correlations between both income sources and log SCNS decline from significantly positive to nearly zero as the households become more food secure (Wald test with a p-value of 0.0003). This result highlights the decreasing income elasticity of calories as households get more food secure.

These results may be biased because agricultural production value and off-farm income are potentially correlated with unobserved factors that also affect the SCNS. Thus we use the IVUQR to identify the effects of liberalization on SCNS when addressing the endogeneity of both incomes. In the first stage regressions, we find that liberalization insignificantly affects farmers' average agricultural production value while significantly increasing their average

off-farm income (table 5). A one unit increase in liberalization index, which amounts to a 3 percentage point decrease in the difference between regional and world prices, will lead farmers to increase off-farm income by 7.0%.[23] Given that the average liberalization index increased by about 4.3 units in the 1990s, the change in market liberalization left the value of the average rural household's agricultural production intact while increasing off-farm income by 30.1%. This result suggests that off-farm income is the dominant income channel through which market liberalization affects the average food security levels of households.

The second stage regressions on SCNS show that the marginal effects of agricultural production value and off-farm income decrease as households become more food secure (results are presented in table 6). As shown in figures 6 and 7, the off-farm income coefficients demonstrate a clear decreasing trend over the quantiles, suggesting decreasing income elasticities of non-staples.[24] Although some of the coefficients of agricultural production value and off-farm income are not statistically significant, we argue that they are economically meaningful in terms of non-staples calories, which we will discuss at the end of the results section.

[23] The average liberalization index is 21.1 in 1989, which means the total price differences between farm-gate and regional markets plus the price difference between regional and world markets for seven products that compose the liberalization index are 1/21.3%. The average price difference for each agricultural product is 1/(21.1%*7), or 68%. One unit increase in liberalization index means the liberalization index increases to 22.1 and the average price difference for each agricultural product is 1/(22.1%*7) or 65%. Therefore, a one unit increase in our liberalization index amounts to a 68%-67%, or a decrease of 3 percentage points in the average difference between local and regional plus regional and world prices.

[24] The results are similar when we include separate liberalization indices (grains market liberalization, horticulture market liberalization and meat market liberalization) as opposed to one composite liberalization index in the regression.

Effects of Agricultural Market Liberalization on Income by Food Security Status

Market liberalization might affect income differently depending on the initial state of household food security and the type of household production. We first look at the effects of liberalization on import producers (table 7). Both food secure and insecure import producers see their agricultural production value significantly decrease while food secure import producers mitigate this income loss with increased off-farm income (29.2%, 4.3 times 6.8%). On the other hand, food insecure import producers see their value of agricultural production decrease by 14.6% (4.3 times 3.4%) without earning more off-farm income.

Liberalization appears to increase off-farm income for all types of producers except for food insecure import producers but the coefficient is only statistically significant for food secure export producers. Our results indicate that food insecure import producers at best do not benefit from liberalization, while all other producers appear to benefit, largely from improved off-farm income. This finding is consistent with studies that find poor farmers who have little economic links with the outside world are the most vulnerable to agricultural market liberalization while rich or food secure farmers are capable of capturing off-farm work opportunities given better human capital and access to credit (Chen and Ravallion 2004; Anderson, Huang and Ianchovichina 2004; Huang and Rozelle 2009; Wang et al. 2009).

To further explore possible reasons why liberalization affects off-farm income differently for food-secure versus food-insecure farmers, we interact liberalization with education. All

producers with at least middle school education appear to be better able to capture the opportunities induced by market liberalization and improve their agricultural production value and off-farm income compared to their counterparts without middle school education (table 8).[25] Even for the most vulnerable group, food insecure import producers, having at least middle school education leads market liberalization to increase their off-farm income.

What do these results imply in terms of calories?

To gauge the economic significance of our results, we simulate the predicted changes in a household's non-staple calories intake as a result of market liberalization in table 9. Combining both the distributional effects of liberalization on income and the distributional effects of income on household food security, we obtain an estimate of the total effects on household food security from liberalization.

We first estimate the predicted value of logSCNS with the 2000 liberalization index and the counterfactual value of logSCNS with the 1989 liberalization index. To estimate logSCNS at both levels of liberalization, we use coefficients from table 7 and the 10^{th} and 90^{th} percentile coefficients from table 6 while holding all other explanatory variables at the values of 2000. Then we calculate the actual change in SCNS using exp(logSCNS with 2000 liberalization index)-exp(logSCNS with 1989 liberalization index).

To back out the non-staple calories, we multiply the daily average caloric intake per person

[25] The shares of households whose head has at least middle school education are 29.3%, 31%, 33.8%, 34.8% and 39% in 1989, 1991, 1993, 1997 and 2000 respectively.

of the food insecure (1976.87 Kcal) and food secure households (2110.6 Kcal) in 2000 with 365 days and the respective changes in SCNS. Finally, to convert non-staple calories to pounds of pork, we divide the change in calories by 760, the average calories in one pound of pork estimated from the Food Composition Table provided by the CHNS data. We chose pork as a non-staple example because of its importance in the Chinese diet (Larsen 2012).

We find that an average food insecure import producer's consumption *decreases* by 2,129 calories per person per year, the same calories provided by 2.8 pounds of pork, an equivalent of 28.2% decrease based on average meat consumption of 9.9 pounds for food insecure import producers in 1989. The reason behind this result is that liberalization reduces food insecure import producers' agricultural production value without increasing off-farm income. In contrast, both food secure export and import producers benefit from liberalization and *increase* their non-staple consumption by 9,633 and 6,179 calories per person per year, an equivalent consumption of 12.7 (13.6%) and 8.1 pounds (11.4%) of pork respectively, because they can grab the lucrative off-farm work opportunities introduced by market liberalization, and increase their off-farm income substantially.

Robustness Tests

The results of all robustness tests are presented in appendix C. As noted in the methods section, we test our identification strategy against different sets of IVs (appendix tables C1, C2 and C10) and other possible mechanisms that could make our market liberalization index

endogenous (appendix tables C3-C9). The results remain substantially the same.

We find that our results are consistent across different definitions of farmers (appendix table C11) and rural sample (appendix table C12). Furthermore, we compare our measure of household food security against other commonly used measures (appendix table C13). The off-farm income does not significantly affect average caloric intake per person per day at each quantile while we observe that off-farm income affect food insecure households (10^{th} quantile) significantly when using SCNS. Although none of the coefficients are significant, the income elasticities of protein intake per person per day demonstrate similar decreasing patterns as those of SCNS. Furthermore, we evaluate the income elasticities of food diversity for households with different levels of food security where dietary diversity is quantified by the number of food groups consumed by a household per day.[26] Both agricultural production value and off-farm income seem to have bigger impact on dietary diversity for highly food insecure and food secure households while the effect is negligible for the households with median food security levels.

One might be worried that our sample declines from 1641 in 1989 to 1105 in 2000. The attrition rates are 8 percent in 1991, 17 percent in 1993, 30 percent in 1997 and 33 percent in 2000 compared to 1989. This would be of concern if the attrition in the paper might be systematically related to our outcome variables and other features. To test for this concern, in appendix table C14, we keep only households in 1989 and count the number of years each

[26] There are 12 food groups, which are cereals, legumes, roots and stems, vegetables, mushrooms, fruits, nuts and seeds, meats, milk, eggs, fish and other foods. The average dietary diversity scores are 4.73, 4.99, 4.94, 5.25 and 5.38 for year 1989, 1991, 1993, 1997 and 2000 in our sample.

household was surveyed. Then we run a linear regression of logSCNS on the number of years surveyed for each household. We do not find a systematic difference across households who are surveyed by different number of rounds. Thus it suggests that the attrition of households is not systematically related to our outcome variable.

In our main analysis, we drop non-farmers in the sample (i.e. rural households with less than 10 percent of their gross income from agriculture), which could introduce bias if we drop households as they earn more off-farm income. We only drop 4% of rural sample because they do not meet our definition of being a farmer. We then keep those observations in the sample and run our main regressions again; results are shown in appendix table C15 and C16. Our results do not change substantially.

Last, we test the robustness of our results when dropping the household fixed effects in appendix table C17 and C18. Other than a small increase in significance, our results do not change substantially.

Conclusion

We analyze the effects of China's agricultural market liberalization on rural household food security through agricultural production value and off-farm income. We find that market liberalization primarily affects households' food security through off-farm income. Further, the small average effect of liberalization on food security masks a great deal of heterogeneity across producers.

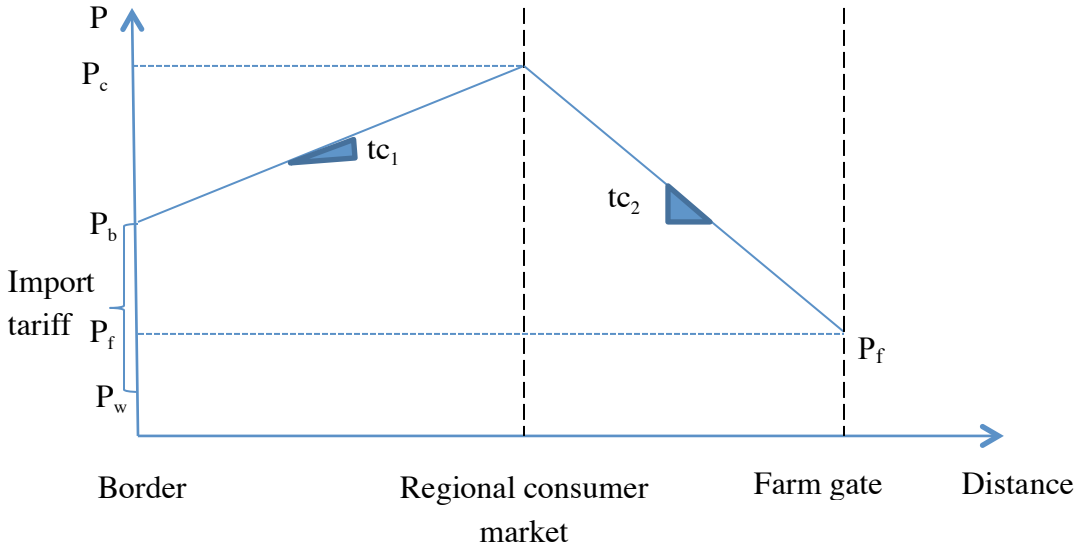
One might worry that food insecure households will suffer because of agricultural market liberalization. They may be constrained by credit and/or human capital, and not able to switch to production that is more comparatively advantageous, or get jobs to increase their off-farm incomes. We study the effects of market liberalization on the distribution of food security. Using a novel empirical method, we find that food insecure import-producing households decrease their agricultural production value without earning more off-farm income. Specifically, agricultural market liberalization causes food insecure import producers to decrease their caloric intake by 2,129 calories per person per year; the same calories provided by 2.8 pounds of pork (28.2% decrease). Food secure producers benefit the most from liberalization because they can grab lucrative off-farm opportunities as a result of market liberalization. An average food secure export and import household increases their consumption of calories from non-staples by 9,633 and 6,179 calories per person per year, a consumption equivalent to 12.7 and 8.1 pounds of pork (13.6% and 11.4% increase) respectively. Education appears to be important to allow producers to capture opportunities afforded by market liberalization and increase their food security. Our results are robust to different definitions of the rural sample, farmers and various model specifications.

We find that liberalization primarily improves household food security by increasing off-farm income. There are at least two mechanisms through which the reduction in grains quotas and trade barriers could have increased off-farm income for farmers. On one hand, the

relaxation of grains quota gives farmers more freedom to work off-farm and earn more income. To meet the grains quota, Chinese farmers needed to stay on farm to grow enough grains to fulfill this mandatory quantity requirement. When the quota was gradually reduced, farmers could pay money in lieu of grains. Eventually during our time period, the quota was ended. With the end of the grains quota, farmers have discretion to work in a more profitable sector and increase their off-farm income. On the other hand, market liberalization may encourage farmers and local processors to specialize in producing those crops or livestock in which they have a comparative advantage, which may increase farm scale and demand for farm labor.. Although we do not have the data to directly disentangle these two mechanisms, we believe they could both explain how market liberalization increases rural household food security through more off-farm income.

In conclusion, the effects of market liberalization are heterogeneous depending on producer type and initial food security status. Although market liberalization is generally beneficial for food secure households, it is not as beneficial for food insecure households, particularly food insecure import producers. Therefore, Chinese policy makers may wish to take extra steps to protect food insecure farmers from the negative effects of liberalization by alleviating their human capital, credit and technology constraints. In this way, agricultural market liberalization may enhance food security for all farmers.

Figures and Tables



P_c: regional consumer market price P_b: border price P_f: farm gate price P_w: world price
tc_1: transactions cost from border to regional consumer market
tc_2: transactions cost from farm gate to regional consumer market

Figure 1. Import competing good with high transaction costs from farm

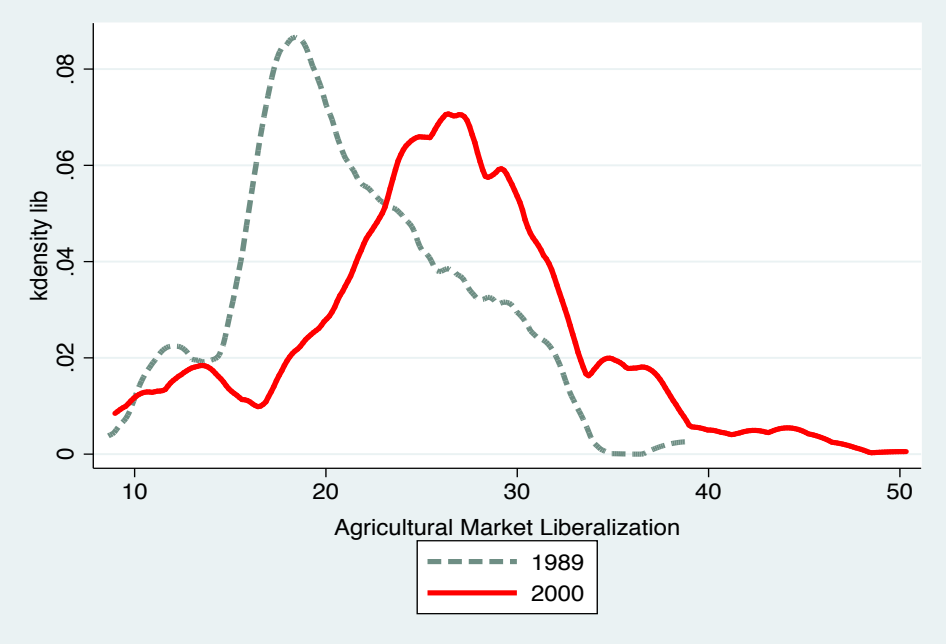


Figure 2. Agricultural market liberalization in 1989 and 2000

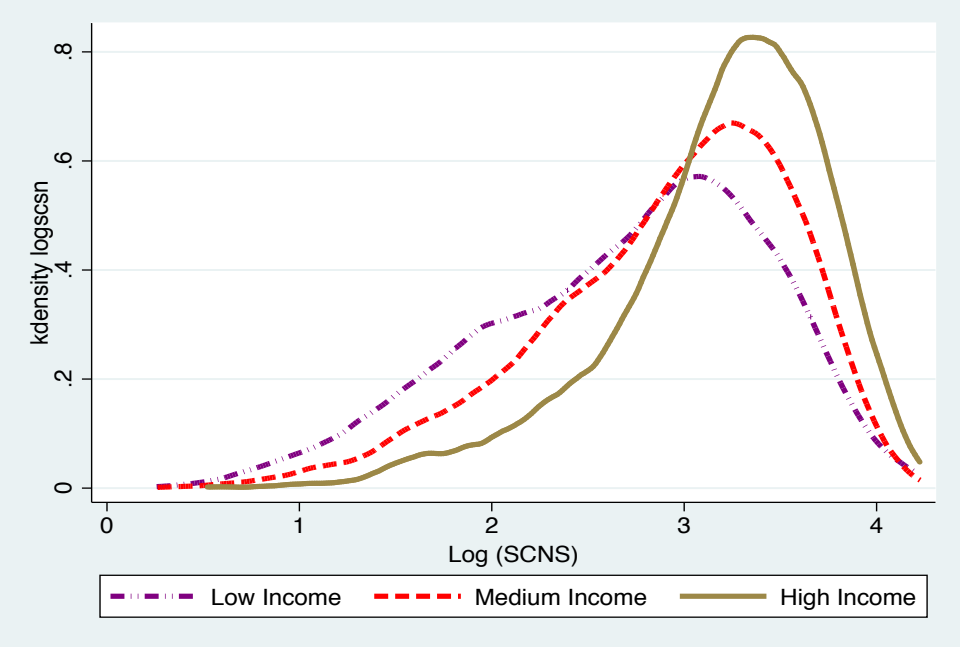
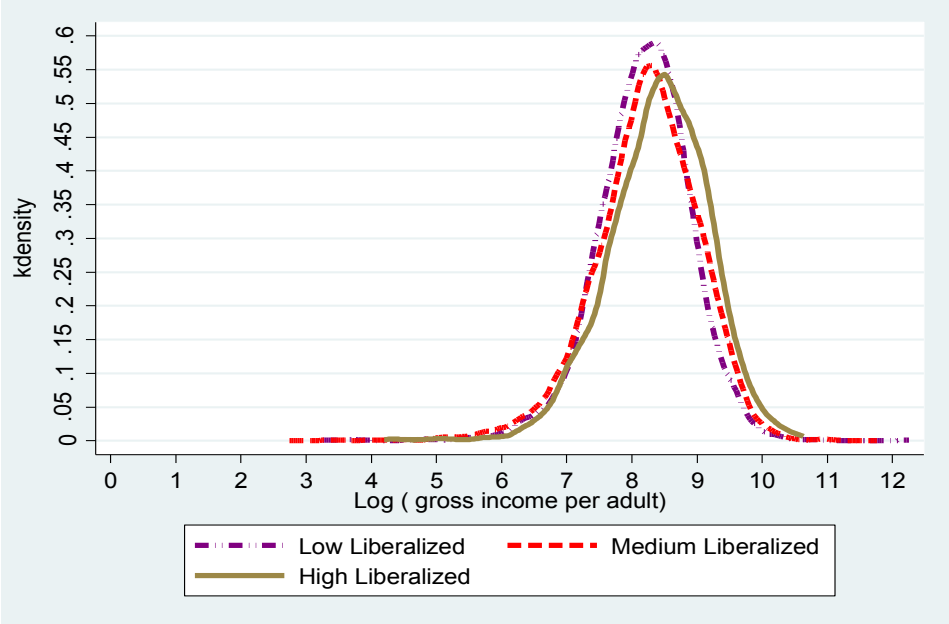
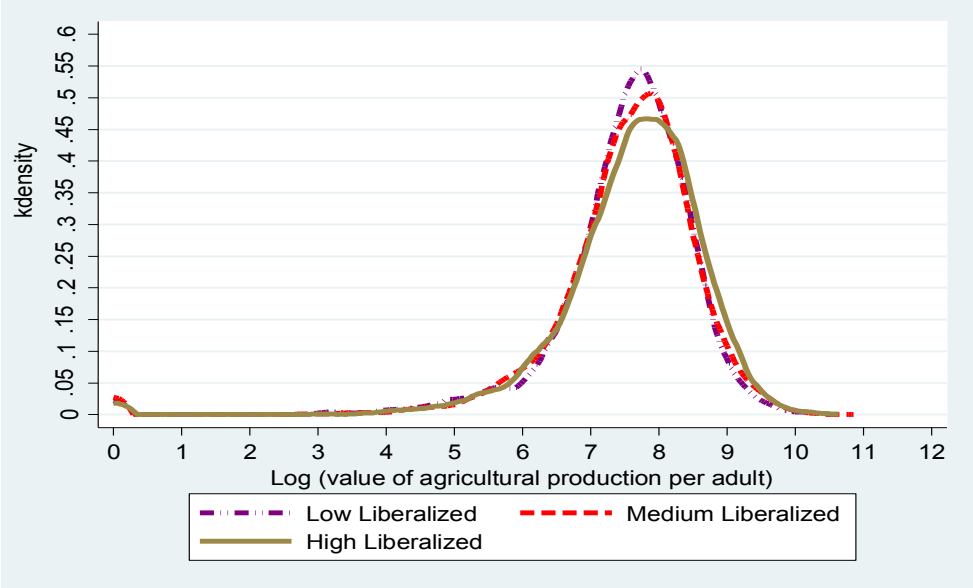


Figure 3. Log SCNS kernel density distributions for different income groups





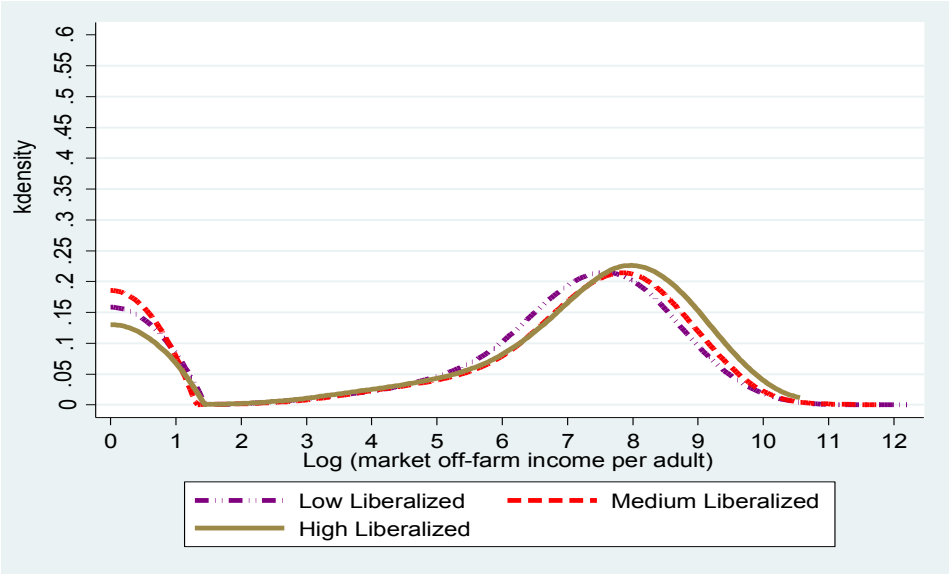


Figure 4. Log gross income, agricultural production value and off-farm income per adult for differently liberalized communities

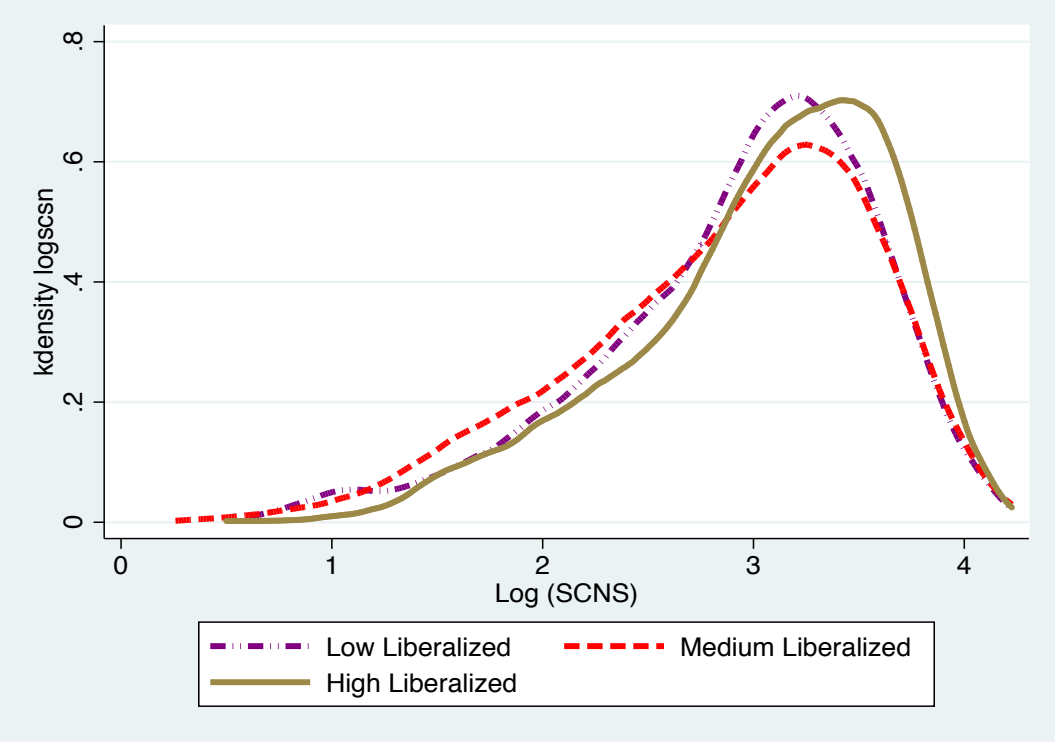


Figure 5. Log SCNS for differently liberalized communities

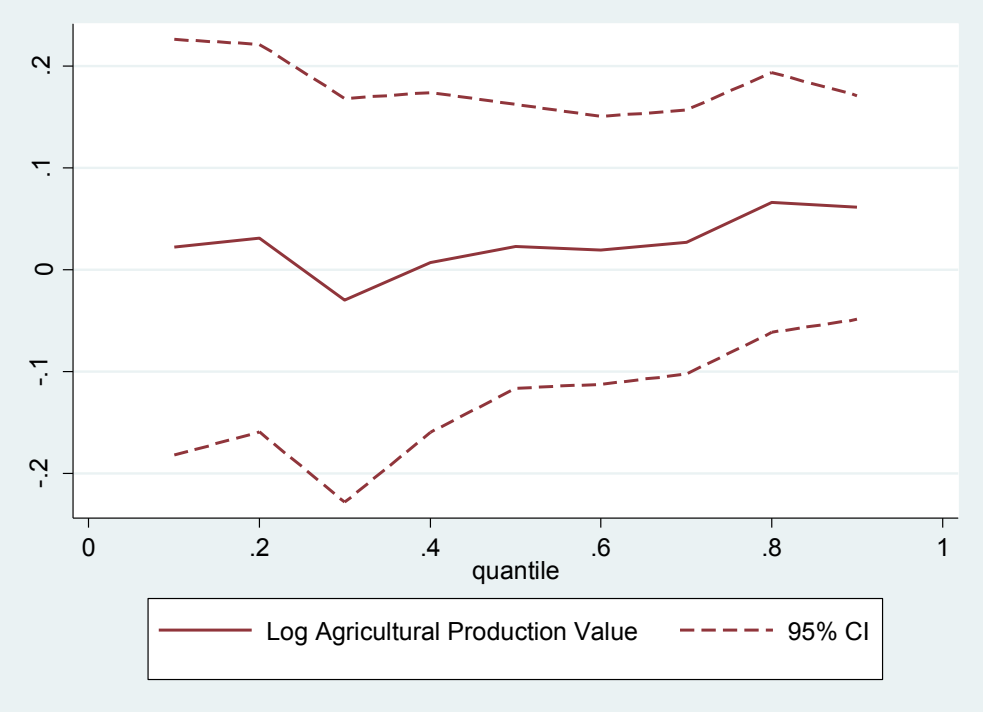


Figure 6. The agricultural production value elasticity of SCNS

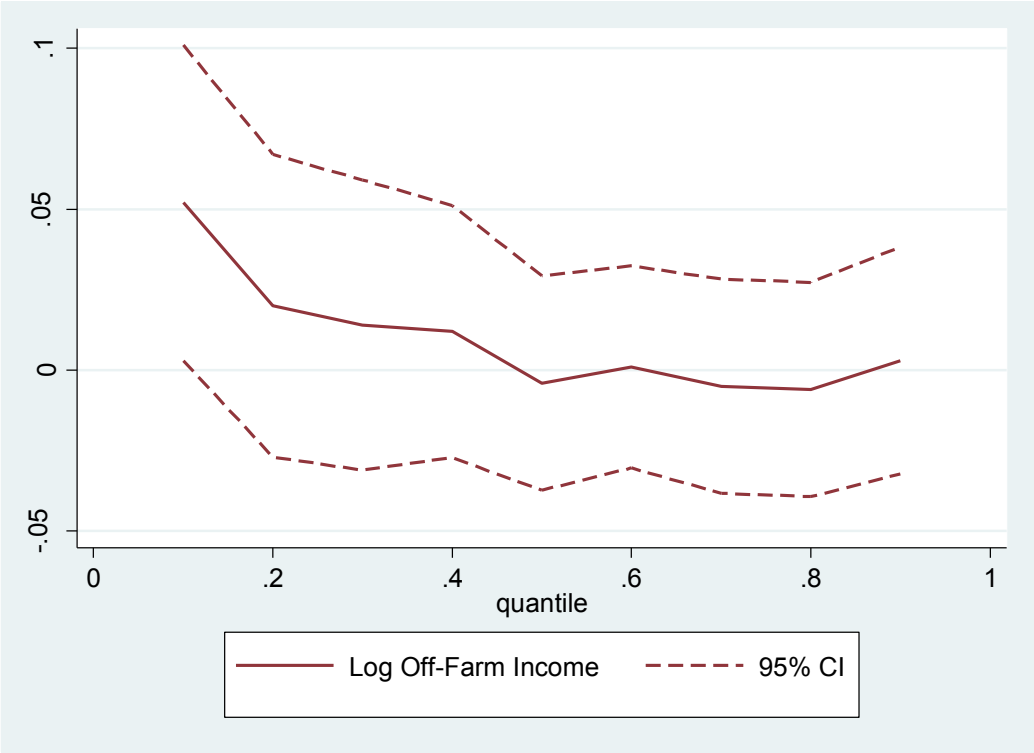


Figure 7. The off-farm income elasticity of SCNS

Table 1. NRAf (%) for Selected Agricultural Products and Agricultural 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
Agricultural market liberalization	21.07	19.78	21.66	26.94	25.35

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

Table 2. Summary Statistics by Year

Variables	1989	1991	1993	1997	2000
Share of calories from	20.67	18.84	18.79	20.66	24.30
non-staples (SCNS, %)	(13.68)	(12.26)	(11.13)	(12.11)	(13.66)
Agricultural production	8139.78	7560.05	6953.87	8464.84	8655.95
value (2009 Yuan)	(6675.01)	(5587.16)	(5128.66)	(5797.96)	(7551.56)
Market off-farm income	3500.70	3451.58	4401.28	6154.00	8710.08
(2009 Yuan)	(6138.17)	(5138.00)	(6696.08)	(8504.12)	(10473.6)
Grains quota (kg) per mu	96.17	99.49	50.17	75.09	0.00
	(145.72)	(147.62)	(92.31)	(143.20)	(0.00)
Number of adults in the	2.60	2.58	2.67	2.71	2.78
household	(1.01)	(0.98)	(1.08)	(1.10)	(1.10)
Household size	4.02	4.06	4.26	4.11	3.97
	(1.51)	(1.37)	(1.30)	(1.25)	(1.27)
Community distance to	2.05	2.07	2.00	2.06	2.03
township center (km)	(2.07)	(2.07)	(2.01)	(1.88)	(2.02)
Community market	2.94	2.73	3.00	2.86	3.07
access score	(2.94)	(3.04)	(2.90)	(2.73)	(2.96)
Community	2.07	3.27	3.43	3.96	4.12

communication score	(1.49)	(1.34)	(1.46)	(1.31)	(1.09)
Agricultural market	21.07	19.78	21.66	26.94	25.35
liberalization	(5.42)	(5.17)	(4.37)	(4.55)	(7.22)
Rice retail price (2009	4.15	3.14	2.94	2.80	2.35
Yuan/kg)	(1.07)	(0.94)	(0.88)	(0.80)	(0.53)
Chicken retail price (2009	18.13	17.78	18.22	17.32	15.71
Yuan/kg)	(6.51)	(5.49)	(6.11)	(5.06)	(5.73)
Vegetables retail price	1.44	1.44	1.44	1.37	1.42
(2009 Yuan/kg)	(1.05)	(1.03)	(0.97)	(0.62)	(0.90)
Soybeans oil retail price	13.09	12.68	12.19	11.67	10.43
(2009 Yuan/kg)	(3.54)	(3.06)	(2.79)	(2.41)	(2.67)
Number of observations	1641	1509	1369	1146	1105

Note: Standard deviations are in parentheses.

Table 3. Unconditional Quantile Regressions of Household Food Security Measures on Log Gross Income Per Adult

Percentiles	10th	20th	50th	80th	90th
SCNS	0.249[a]	0.263[a]	0.196[a]	0.134[a]	0.101[a]
	(0.051)	(0.043)	(0.026)	(0.023)	(0.023)
Calories	0.001	-0.001	-0.018[b]	-0.023[b]	-0.025[b]
	(0.014)	(0.009)	(0.008)	(0.010)	(0.012)
Protein	0.037[a]	0.031[a]	0.025[b]	0.017	0.005
	(0.013)	(0.012)	(0.011)	(0.012)	(0.015)

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses. Standard errors are bootstrap estimates clustered at the community level. All household food security measures are in logs. The calories and protein are daily caloric and protein intake per capita. Results using daily caloric intake per adult equivalent are similar to those with caloric intake per capita.

Table 4. The Distributional Effects of Income on Log SCNS with No Instrumental Variables

Percentiles	10th	20th	50th	80th	90th
Log agricultural	0.039	0.036	0.026	0.012	0.018
production value	(0.042)	(0.028)	(0.019)	(0.020)	(0.020)
Log off-farm income	0.017[b]	0.016[a]	0.007[c]	0.009[b]	0.008[b]
	(0.007)	(0.006)	(0.004)	(0.004)	(0.004)
Agricultural market	0.001	0.008	0.004	0.012[b]	0.008
liberalization	(0.010)	(0.010)	(0.006)	(0.006)	(0.007)
Household FE	X	X	X	X	X
County by Year FE	X	X	X	X	X
Number of observations	6770	6770	6770	6770	6770

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household size, number of adults in the household, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. In this regression, log agricultural production value and off-farm income are treated as exogenous.

Table 5. The Effects of Market Liberalization on Agricultural Production Value and Off-farm Income (Equations 2 and 3)

	Log Agricultural Production Value	Log Off-farm Income
Agricultural market liberalization	0.001	0.070[a]
	(0.005)	(0.024)
Household size	0.072[a]	-0.094[c]
	(0.010)	(0.057)
Number of adults in the household	0.045[a]	0.521[a]
	(0.013)	(0.065)
Community market score	-0.003	-0.005
	(0.007)	(0.031)
Community communication score	-0.006	0.035
	(0.014)	(0.095)
Household FE	X	X
County by Year FE	X	X
Number of observations	6770	6770

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are clustered at the community level. The IVs, average retail prices of rice, chicken, vegetables and soybeans oil in the community are included.

Table 6. The Distributional Effects of Agricultural Production Value and Off-farm Income on Log SCNS (Equation 4)

Percentiles	10th	20th	50th	80th	90th	Mean
Log agricultural	0.022	0.031	0.023	0.066	0.061	-0.010
production value	(0.104)	(0.097)	(0.071)	(0.065)	(0.056)	(0.085)
Log off-farm income	0.052[b]	0.020	-0.004	-0.006	0.003	0.041
	(0.025)	(0.024)	(0.017)	(0.017)	(0.018)	(0.018)
Agricultural market	-0.0007	0.008	0.005	0.013[b]	0.008	-0.001
liberalization	(0.011)	(0.010)	(0.006)	(0.006)	(0.007)	(0.006)
Household FE	X	X	X	X	X	X
County by Year FE	X	X	X	X	X	X
Number of observations	6770	6770	6770	6770	6770	6770

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household size, number of adults in the household, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. Then mean column presents the results of 2SLS regressions. The IVs for log agricultural production value and off-farm income are log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables.

Table 7. The Effects of Market Liberalization on Income for Food Insecure and Food Secure Producers

	Export Producers		Import Producers	
	Log Ag Production Value	Log Off-farm Income	Log Ag Production Value	Log Off-farm Income
Food Insecure				
Liberalization	-0.002	0.049	-0.034[a]	-0.009
	(0.010)	(0.063)	(0.013)	(0.069)
Number of observations	1983	1983	846	846
Food Secure				
Liberalization	-0.002	0.121[a]	-0.050[a]	0.068
	(0.007)	(0.044)	(0.015)	(0.116)
Number of observations	3350	3350	591	591

Note: : [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables, distance to township center interacted with province-year dummy variables, household size, number of adults in the household, community market and communication score, food retail prices, household fixed effects and county by year dummy variables are also included.

Table 8. The Effects of Market Liberalization on Income for Food Insecure and Secure Producers with Different Education Levels

	Export Producers		Import Producers	
	Log Ag Production Value	Log Off-farm Income	Log Ag Production Value	Log Off-farm Income
Food Insecure				
Liberalization	-0.004	0.056	-0.036[a]	-0.004
	(0.011)	(0.064)	(0.013)	(0.069)
Liberalization *Middle School	0.006	0.021	0.012[b]	0.028
	(0.004)	(0.022)	(0.005)	(0.025)
Number of observations	1983	1983	846	846
Food Secure				
Liberalization	-0.003	0.114[a]	-0.051[a]	0.044
	(0.006)	(0.043)	(0.015)	(0.111)
Liberalization *Middle School	0.002	0.017	0.005	0.082
	(0.002)	(0.011)	(0.006)	(0.052)
Number of observations	3350	3350	591	591

Note: : [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables, distance to township center interacted with province-year dummy variables, household size, number of adults in the household, community market and communication score, food retail prices, household fixed effects and county by year

dummy variables are also included.

Table 9. The Effects of Liberalization on Non-staple Caloric Intake Per Person Per Year by Food Security Status

	Non-staple Calories	Pounds of Pork
Food Insecure		
Export Producers	2,350	3.1
Import Producers	-2,129	-2.8
Food Secure		
Export Producers	9,633	12.7
Import Producers	6,179	8.1

Note: The detailed calculation methods are discussed in the results section.

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Online Appendix: Not For Publication

Agricultural Market Liberalization and Household Food Security in Rural China

APPENDIX A: FACTORS ASSOCIATED WITH MARKET LIBERALIZATION

Because our market liberalization measure is novel and constructed using coarse data, we test the validity of our measure by regressing market liberalization on local access to communication facilities and markets, transportation scores and community population density.

The regression results are shown in table A1. The first column reports the regression results with year dummy variables only and the second column reports results with year and province dummy variables. The regression results do not change much when using different dummy variables. Communication, availability of modern markets and local transportation are positively associated with agricultural market liberalization.

Table A1. Agricultural Market Liberalization Regression Results

Variables	(1)	(2)
Community transportation score	0.0334	0.220
	(0.107)	(0.106)
Community communication score	0.845[a]	0.624[a]
	(0.210)	(0.214)
Community market score	0.142	0.186[b]
	(0.089)	(0.086)
Community population density	0.124	0.002
	(0.175)	(0.170)
Constant	22.36[a]	20.87[a]
	(1.183)	(1.271)
Year dummy variables	X	X
Province dummy variables		X
Observations	977	977

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses.

APPENDIX B. TECHNICAL DETAILS OF INSTRUMENTAL VARIABLE UNCONDITIONAL QUANTILE REGRESSIONS (IVUQR)

Firpo, Fortin and Lemieux (2009) first introduce the UQR estimator in which all regressors are exogenous. Imbens and Newey (2009) and Rothe (2010) provide methods to identify the partial effects of the UQR with endogenous regressors via a control variable approach. The UQR estimator without endogeneity builds on the concept of an influence function (IF). Using notation largely from Firpo, Fortin, and Lemieux (2009), consider some distributional statistic q_τ (e.g. 20th percentile) of the dependent variable Y (e.g. food security indicator), and F_Y as the cumulative distribution function (CDF) of Y. As its name suggests, the influence function IF(Y; q_τ , F_Y) of a distributional statistic q_τ captures the influence of an individual observation on that distributional statistic. Adding back the statistic q_τ to the influence function obtains the recentered influence function (RIF) i.e. RIF(Y; q_τ , F_Y) = IF(Y; q_τ , F_Y) + q_τ . Firpo, Fortin and Lemieux (2009) show that the expectation of RIF(Y; q_τ , F_Y) is equal to the distributional statistic q_τ . In the example of 20th percentile as the distributional statistic, this means the expectation of the RIF (*food security*; q_τ , $F_{food\ securit}$) is equal to the 20th percentile of the unconditional distribution of the food security indicators. The conditional expectation of the RIF(Y; q_τ , F_Y) is modeled as a function of explanatory variables, i.e. E[RIF(Y; q_τ , F_Y) | X] = $m_{q_\tau}(X)$. The RIF regression parameter estimates, or the partial derivative of the RIF with respect to the explanatory variables, are the unconditional quantile marginal effects of the explanatory variables.

To implement the UQR without endogeneity, the dependent variable in the regression is RIF(Y; q_τ , F_Y) = $\left(\tau - 1\{Y \le q_\tau\}\right) / f_Y(q_\tau) + q_\tau$. The dependent variable is easily computed by estimating the sample quantile q_τ , estimating the empirical density $f_Y(q_\tau)$ at that point q_τ using the kernel (or other) methods, and creating a dummy variable $1\{Y \le q_\tau\}$, showing whether the value of the outcome variable is below q_τ . Then we can run an OLS regression of this new dependent variable on the covariates. Firpo, Fortin and Lemieux (2009) have shown that this estimation approach is not coming off of non-linearities or functional form assumptions. Therefore, we follow their method and use RIF-OLS as our estimation technique.

Firpo, Fortin and Lemieux (2009) show that when all covariates are exogenous the RIF-OLS regression coefficients are the consistent estimates of unconditional quantile marginal effects (UQME), i.e. the marginal effects of a small location shift in the distribution of covariates on the unconditional quantile of the dependent variable, holding everything else constant. However, under endogeneity, the RIF-OLS regression coefficients are no longer consistent estimates of UQME. Rothe (2010) and Imbens and Newey (2009) demonstrate that one can consistently estimate the regression coefficients and thus UQME through a control variable approach. The empirical CDFs of residuals from the first stage regressions are included in the second stage as control variables. Similar to a two-stage least squares approach, for the control variable approach to be valid, the instruments should be exogenous and correlated with the endogenous variable.

Specifically, we use IVUQR for this model where both agricultural production value (A_{hvt})

and off-farm income (O_{hvt}) are endogenous in the food security regression. First, we obtain the residuals from the first stage regressions (equation 2 and 3). Second, we estimate the empirical CDFs of the residuals from the first stage regressions ($\widehat{F}_{\eta}(\eta_{ivt})$ and $\widehat{F}_{v}(v_{ivt})$). Third, we regress $RIF(FS_{ivt};q_t,F_{FS})$ against $\widehat{F}_{\eta}(\eta_{ivt})$, $\widehat{F}_{v}(v_{ivt})$ and all other explanatory variables. For our analysis, we estimate the marginal effects of liberalization at all deciles (10^{th}, 20^{th},…, 90^{th}) of the food security indicator distributions.

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APPENDIX C. ROBUSTNESS TESTS

Table C1. The Effects of Market Liberalization on Income Using Other IVs

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	-0.019	0.032	-0.112[a]	0.039
	(0.012)	(0.090)	(0.014)	(0.157)
Number of observations	1504	1504	610	610
Food Secure				
Liberalization	0.001	0.070	-0.058	0.338
	(0.008)	(0.051)	(0.041)	(0.302)
Number of observations	2539	2539	430	430

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas in 1989 interacted with province-year dummy variables, number of migrants in the community in the previous year, the number of migrants in the community in the previous year interacted with Hukou status in 1989, household size, community market and communication score, food retail prices, household and county by year dummy variables are also included.

Table C2. The Distributional Effects of Income on Log SCNS Using Other IVs

Percentiles	10th	20th	50th	80th	90th
Log agricultural	0.018	0.037	0.026	0.077	0.054
production value	(0.162)	(0.119)	(0.059)	(0.047)	(0.055)
Log off-farm income	0.041	0.032	0.014	0.021	0.026[a]
	(0.026)	(0.022)	(0.016)	(0.013)	(0.013)
Agricultural market	0.015	-0.004	-0.001	-0.004	0.001
liberalization	(0.015)	(0.011)	(0.009)	(0.007)	(0.006)
Number of observations	5083	5083	5083	5083	5083

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household, year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. We use log of grains quotas in 1989 interacted with province-year dummy variables, number of migrant in the community in the previous year, the number of migrants in the community in the previous year interacted with Hukou status in 1989 as IVs.

Table C3. The Effects of Market Liberalization on Income among Communities with Little Migration

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	0.451[a]	2.613[a]	0.438[b]	-2.851[a]
	(0.060)	(0.562)	(0.144)	(0.217)
Number of observations	500	500	275	275
Food Secure				
Liberalization	-0.073[a]	0.107	-0.030	2.163
	(0.016)	(0.214)	(0.254)	(1.374)
Number of observations	691	691	143	143

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. The data only include communities with less than 8.3% (25 percentile) of migrant households. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables, household size, community market and communication score, food retail prices, household and county by year dummy variables are also included.

Table C4. The Distributional Effects of Income on Log SCNS among Communities with Little Migration

Percentiles	10th	20th	50th	80th	90th
Log agricultural	-0.084	-0.016	-0.023	0.028	0.094
production value	(0.347)	(0.220)	(0.218)	(0.151)	(0.139)
Log off-farm income	-0.008	0.035	0.022	0.050	0.012
	(0.068)	(0.061)	(0.039)	(0.032)	(0.043)
Agricultural market	0.023	0.030	-0.011	-0.025[a]	-0.031[c]
liberalization	(0.021)	(0.028)	(0.010)	(0.008)	(0.017)
Number of observations	1609	1609	1609	1609	1609

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. The data only include communities with less than 8.3% (25 percentile) of migrant households. Household, year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. We use Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables as IVs.

Table C5. The Effects of Market Liberalization on Income Controlling for Mu-de Brauw Instruments

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	-0.025[b]	0.052	-0.107[a]	0.021
	(0.012)	(0.122)	(0.015)	(0.194)
Number of observations	1500	1500	610	610
Food Secure				
Liberalization	-0.014	0.124[b]	-0.060	0.057
	(0.009)	(0.061)	(0.054)	(0.250)
Number of observations	2510	2510	432	432

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables, household size, community market and communication score, food retail prices, community migration networks x provincial capital city wage, household and county by year dummy variables are also included.

Table C6. The Distributional Effects of Income on Log SCNS Controlling for Mu-de Brauw Instruments

Percentiles	10th	20th	50th	80th	90th
Log agricultural	-0.063	0.095	-0.029	-0.007	0.051
production value	(0.162)	(0.131)	(0.076)	(0.066)	(0.084)
Log off-farm income	0.048	0.027	0.013	0.021	0.034[b]
	(0.034)	(0.026)	(0.018)	(0.015)	(0.013)
Agricultural market	0.016	0.005	-0.002	0.00003	-0.001
liberalization	(0.015)	(0.012)	(0.009)	(0.009)	(0.009)
Number of observations	5052	5052	5052	5052	5052

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household, year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community, community migration networks x provincial capital city wage are also included. We use Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables as IVs.

Table C7. The Effects of Market Liberalization on Income for Food Insecure and Food Secure Producers Controlling for Industrial Development and Infrastructure Improvement

	Export Producers		Import Producers	
	Log Ag Production Value	Log Off-farm Income	Log Ag Production Value	Log Off-farm Income
Food Insecure				
Liberalization	-0.017[c]	0.041	-0.028	0.115[b]
	(0.010)	(0.083)	(0.019)	(0.046)
Number of observations	1795	1795	789	789
Food Secure				
Liberalization	-0.003	-0.007	-0.044[b]	0.162
	(0.007)	(0.059)	(0.019)	(0.124)
Number of observations	2906	2906	516	516

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables, distance to township center interacted with province-year dummy variables, log distance to the nearest train station, log distance to the nearest paved road, log of the number of TVEs (township and village enterprises) and private enterprises, household size, number of adults in the household, community market and communication score, food retail prices, household and county by year dummy variables are also included.

Table C8. The Distributional Effects of Agricultural Production Value and Off-farm Income on Log SCNS Controlling for Industrial Development and Infrastructure Improvement

Percentiles	10th	20th	50th	80th	90th
Log agricultural	-0.008	0.003	-0.040	0.059	0.040
production value	(0.097)	(0.091)	(0.080)	(0.081)	(0.064)
Log off-farm income	0.049[c]	0.028	0.013	0.018	0.030
	(0.028)	(0.033)	(0.021)	(0.020)	(0.019)
Agricultural market	-0.002	0.010	0.009	0.016[b]	0.009
liberalization	(0.012)	(0.014)	(0.009)	(0.007)	(0.007)
Number of observations	6006	6006	6006	6006	6006

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household, year by county dummies, log distance to the nearest train station, log distance to the nearest paved road, log of the number of TVEs (township and village enterprises) and private enterprises, household size, number of adults in the household, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. Log of grains quotas per mu in 1989 interacted with province-year dummy variables, distance to township center interacted with province-year dummy variables are the IVs.

Table C9. The Correlation Coefficients between Market Liberalization and Commodity Prices

Prices	Liberalization
Rice	-0.18
Wheat	-0.15
Corn	0.001
Soybeans oil	-0.03
Pork	0.07
Chicken	-0.26
Vegetables	0.07

Table C10. The Distributional Effects of Income on Log SCNS Using Lagged Income as IVs

Percentiles	10th	20th	50th	80th	90th
Log agricultural	0.010	-0.056	0.044	0.078[c]	0.048
production value	(0.105)	(0.085)	(0.054)	(0.044)	(0.046)
Log off-farm income	0.034	0.017	0.001	0.019[b]	0.021
	(0.028)	(0.023)	(0.015)	(0.010)	(0.013)
Agricultural market	0.007	0.012	0.005	0.008	0.003
liberalization	(0.011)	(0.009)	(0.006)	(0.005)	(0.006)
Number of observations	4195	4195	4195	4195	4195

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household, year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. The instruments are the predicted log agricultural production value and log off-farm income from the 1st stage regressions where the period t-1 and t-2 log agricultural production value and log off-farm income are included as instruments following Giles and Yoo (2007).

Table C11. The Effects of Market Liberalization on Income Using Alternative Farmers Definition

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	0.004	0.103	-0.031[b]	0.046
	(0.008)	(0.066)	(0.015)	(0.097)
Number of observations	1857	1857	770	770
Food Secure				
Liberalization	0.005	0.161[a]	-0.058[a]	0.515[a]
	(0.006)	(0.046)	(0.014)	(0.168)
Number of observations	2954	2954	502	502

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quota in 1989 interacted with province-year dummy variables, distance to the township center interacted with province-year dummy variables, number of adults, household size, community market and communication score, food retail prices, household and county by year dummy variables are also included. Households are defined as farmers who have over 25% of their total income from agriculture instead of 10% in the main results.

Table C12. The Effects of Market Liberalization on Income Using Alternative Rural Sample Definition

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	0.001	0.094	-0.049	0.222
	(0.010)	(0.068)	(0.030)	(0.149)
Number of observations	1819	1819	718	718
Food Secure				
Liberalization	-0.001	0.210[a]	0.102	2.720[a]
	(0.008)	(0.050)	(0.072)	(0.665)
Number of observations	2816	2816	479	479

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quota per mu in 1989 interacted with province-year dummy variables, distance to the township center interacted with province-year dummy variables, number of adults, household size, community market and communication score, food retail prices, household and county by year dummy variables are also included. Communities with over 35% instead of 25% total income from agriculture are defined as rural.

Table C13. The Distributional Effects of Income on Log SCNS with Different Household Food Security Measures

	10th	50th	90th
Average Caloric Intake			
Log agricultural production value	0.106[b]	0.046[b]	0.066
	(0.050)	(0.021)	(0.043)
Log off-farm income	-0.00001	-0.001	0.006
	(0.015)	(0.007)	(0.008)
Agricultural market liberalization	-0.004	-0.002	-0.001
	(0.004)	(0.002)	(0.003)
Average Protein Intake			
Log agricultural production value	0.063	0.054[b]	0.046
	(0.041)	(0.027)	(0.051)
Log off-farm income	0.022	0.010	0.006
	(0.014)	(0.007)	(0.009)
Agricultural market liberalization	-0.002	-0.003	-0.002
	(0.005)	(0.002)	(0.003)
Dietary Diversity			
Log agricultural production value	0.027	0.015	0.034

	(0.060)	(0.036)	(0.084)
Log off-farm income	0.019	0.010	0.023
	(0.015)	(0.008)	(0.018)
Agricultural market liberalization	0.001	0.003	0.006
	(0.004)	(0.003)	(0.006)
Number of observations	6770	6770	6770

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Household, year by county dummies, household size, number of adults in the household, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. The dependent variable is log average caloric intake and protein per person per day. Dietary diversity is measured as the number of food groups consumed per day for all household members. The IVs are log grains quota per mu in 1989 interacted with province-year dummy variables and distance to nearest township center interacted with province-year dummy variables.

Table C14. Attrition Analysis: Do Log SCNS and Liberalization Index Vary with the Number of Years Surveyed?

Variables	logSCNS	Liberalization Index
Surveyed in 2 years	-0.162	-0.813
	(0.115)	(0.892)
Surveyed in 3 years	-0.143	-0.456
	(0.103)	(0.822)
Surveyed in 4 years	-0.128	1.750[b]
	(0.098)	(0.801)
Surveyed in 5 years	-0.150	1.291
	(0.095)	(0.794)
Observations	1641	1641

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses. The data only include observations in 1989.

Table C15. The Effects of Market Liberalization on Agricultural Production Value and Off-farm Income among All Rural Sample

	Log Agricultural Production Value	Log Off-farm Income
Agricultural market liberalization	-0.020	0.056[b]
	(0.015)	(0.027)
Household size	0.108[b]	-0.008
	(0.042)	(0.055)
Number of adults in the household	0.304[a]	0.374[a]
	(0.042)	(0.061)
Community market score	0.006	0.017
	(0.024)	(0.026)
Community communication score	-0.062	-0.004
	(0.043)	(0.087)
Number of observations	6925	6925

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are clustered at the community level. The sample contains all households surveyed in the rural communities defined by the CHNS team. The IVs, average retail prices of rice, chicken, vegetables and soybeans oil in the community are included. Household, and year by county dummy variables are also included.

Table C16. The Distributional Effects of Income on Log SCNS among All Rural Sample

Percentiles	10th	20th	50th	80th	90th
Log agricultural	-0.001	-0.003	-0.005	0.00003	0.00003
production value	(0.022)	(0.018)	(0.013)	(0.0002)	(0.0002)
Log off-farm income	0.020	-0.019	-0.028	0.00003	0.0003
	(0.031)	(0.024)	(0.018)	(0.0003)	(0.0003)
Agricultural market	0.004	-0.004	-0.011	0.00003	0.00003
liberalization	(0.013)	(0.014)	(0.010)	(0.00005)	(0.00005)
Number of observations	6925	6925	6925	6925	6925

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. The sample contains all households surveyed in the rural communities defined by the CHNS team. Household, year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community, are also included. We use Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables as IVs.

Table C17. The Effects of Market Liberalization on Income without Household dummy variables

	Export Producers		Import Producers	
	Log Ag Production Values	Log Off-farm Income	Log Ag Production Values	Log Off-farm Income
Food Insecure				
Liberalization	0.020	0.007	-0.037[b]	-0.050
	(0.014)	(0.071)	(0.014)	(0.058)
Number of observations	1983	1983	846	846
Food Secure				
Liberalization	0.002	0.042	-0.009	0.214[c]
	(0.006)	(0.036)	(0.018)	(0.108)
Number of observations	3350	3350	591	591

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and clustered at the community level. If the household has an SCNS higher than 16%, the household is defined as a food secure household. Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables, household size, community market and communication score, food retail prices, county by year dummy variables are also included.

Table C18. The Distributional Effects of Income on Log SCNS without Household dummy variables

Percentiles	10th	20th	50th	80th	90th
Log agricultural	0.097	0.038	-0.004	0.024	0.009
production value	(0.081)	(0.081)	(0.048)	(0.047)	(0.045)
Log off-farm income	0.059[b]	0.040	0.016	-0.0003	0.002
	(0.023)	(0.025)	(0.017)	(0.014)	(0.012)
Agricultural market	0.003	0.007	0.008	0.015[b]	0.011[b]
liberalization	(0.010)	(0.009)	(0.007)	(0.006)	(0.005)
Number of observations	6770	6770	6770	6770	6770

Note: [a], [b], and [c] denote significance levels at 1%, 5% and 10%. Standard errors are in parentheses and are bootstrap standard errors clustered at the community level. Year by county dummies, household size, community market score, communication score, and average retail prices of green vegetables, chicken, soybeans oil and rice in the community are also included. We use Log of grains quotas per mu in 1989 interacted with province-year dummy variables and the distance to township center interacted with province-year dummy variables as IVs.