Trade Impact on Food Security: Analysis on Farm Households in Rural China

By

Min Chang and Daniel A. Sumner

Selected paper presented at the
American Agricultural Economics Association Annual Meetings
Denver, CO-August 1-4, 2004

TRADE IMPACT ON FOOD SECURITY: ANALYSIS ON FARM HOUSEHOLDS IN RURAL CHINA

MIN CHANG AND DANIEL A. SUMNER[†]

Abstract. We simulate several alternative scenarios to access the impact of border liberalization on household food security in rural China. We find that most Chinese farmers derive most their income from sources other than grain marketing and buy a significant amount of staple grain. Opening the border to more import of grain resulting in lower the domestic price is likely to improve the general level of food security for rural farm households in China.

No topic is more important than food security and in recent years the linkage between food security and trade liberalization has been often discussed. Many countries, including China, have policies to pursue trade barriers and stimulants to domestic production in the name of food security. The WTO negotiation positions of several countries list food security among concerns that may justify additional farm trade barriers. Against this policy background, this paper examines how changes in distributions of prices of staple food crops caused by more open borders through trade liberalization are likely to affect food security in rural China.

Opening the border to more imports lowers the market price and may raise market price variation over time. If there is sufficient price transmission from the border to internal rural markets, the price distribution result to small farm is likewise affected

Date: May, 2004.

[†]Min Chang is a Ph.D. candidate in the Department of Agricultural and Resource Economics, University of California, Davis. Daniel A. Sumner is director of the University of California Agricultural issue Center, the Frank H. Buck Jr. Professor in the Department of Agricultural and Resource Economics, University of California, Davis, and a member Gianinni Foundation. Contact email: chang@primal.ucdavis.edu .

(Huang et al., forthcoming) . The price distribution affects farm household consumption and production decisions. We model these two decisions and use this previous result as the basis for simulating the impact on grain consumption pattern. We analyze the food security implication by simulating impact on the probability that household staple consumption would fall below some adequate consumption threshold.

This study employs time-series econometric analysis, empirical analysis of household survey data, derivation of food demand from a microeconomic farm household model and the development of a simulation model at the household level in order to track the effects of more open border on rural food security.

1. Backgound

Food security has been recognized as a demand-side issue at least since Sen's work (1979) , and accepted definitions and measures of food security are based on adequate consumption of food (World Bank 1986, Sumner 2000, Barret 2002) . Among poor rural households in China, food security is based on the potential consumption of staple food products, especially grain. Staple grain has been protected at the border by Chinese government such that its import is limited and domestic price is higher than world market.

As the border liberalized, studies show that price distributions of most staple grains in China will shift down (Anderson et al. 2004, Huang et al., forthcoming) . Prices may also become more variable if global markets face larger shocks than within country markets, or if national government has less scope to moderate price variability through national policies.

Low prices of staple grains that are transmitted to villages have two offsetting effects on food consumption. Farmers may consume more grain as the relative price falls, but they may also experience lower income and consume less grain given a positive income elasticity. This is because they are both sellers and buyers of staple food; and data from our household survey shows that most of the farmers indeed participate both sides of the grain market. The net impact will depend on income and substitution effect in grain demand, the share of farm household income from each source and the responsiveness of other income sources to grain price shifts.

A simulation model examining the net impact under alternative policy scenarios is built on these household parameters from survey data in 2000 and a market-level price data set of staple grain from 1991 to 2000.

2. Data

For this paper we draw prior work for the effect of opening the border to more import of basic staple grains (Wu and Findlay 1997, Li and Wang 2002, Huang et al. 2003, Anderson et al. 2004) . We also draw upon Huang et al. (forthcoming) for results on market integration and price transmission. Given these starting points, we then estimate the parameters from two main data sets to build the simulation model. First one is a grain market price data from 1991 to 2000, and the second one is a household survey data collected in 2000.

The market-level price data set from 1991 to 2000 is used to estimate the variability of grain prices in rural China over time. It is a unique set of price data collected by China's State Market Administration Bureau (SMAB) and assembled by the Research Center for Rural Economy (RCRE) of the Ministry of Agriculture (MOA). Prices are the average transaction prices of different agricultural commodities (including staple grains) in the local periodic markets from 50 sample sites of 15 provinces every 10 days. Among them 6 are selected, corresponding to the 6 provinces in the survey data, and their descriptive statistics are in Table 1.

The pre-WTO parameters in the simulation model are estimated from the household survey data in 2000. The survey covered 6 provinces across rural China: Hebei, Shaanxi, Liaoning, Zhangjiang, Sichuan, and Hubei. Within each income quintile in each province, one county and then two villages (i.e. total 1200 households) were randomly chosen to ensure the coverage of the household information. The summary statistics of the households are in Table 2.

3. Farm Household's Grain Consumption and the Price

The impact of trade liberalization on agricultural market in China is the downward shifting in the price distribution (Anderson et al. 2004, Huang et al., forthcoming). We are particularly interested in such impact on rural farm household's food security. We focus on rice farmers for now. The impact on the consumption due to the change of the price can be analyzed by decomposing the income effect and substation effect.

$$(1)\qquad \frac{\partial C}{\partial P_g} = \overbrace{\left.\frac{\partial C}{\partial P_g}\right|_{\overline{Y}}}^{\text{price effect}} + \overbrace{\frac{\partial C}{\partial Y}\frac{\partial Y}{\partial P_g}}^{\text{income effect}} .$$

When grain price falls, grain consumption will clearly increase for a consumer. However, it is ambiguous if a farmer's grain consumption will increase as grain price change, for he is both a consumer and a producer. The direct price effect is negative, but the income effect is positive. It is shown that if the share of a income from grain marketing is relatively bigger than the share of other off-farm incomes, grain price has bigger effect on total farm household income, and it is more likely that household total income effect due to grain price change is relatively more influential. Nevertheless, household's grain marketing income is often price inelastic for the production relies more heavily on factors other than price, and we show that household income effect due to grain price change is further "mitigated" by the reallocation of household resources responding to the price change.

Farm household's income comprises farm income(F), off-farm wage income (O), and any other transfer income (T).

$$Y = F + O + T.$$

Decomposing each source of income we estimate the income effect of a farm household due to grain (rice) price change.

We assume household allocations of resources between farming and off farm work are represented solely by labor allocation. Household's labor allocation and consumption decision can be depicted in two stages. In the first stage before knowing the price, the household decides how much to work on farm (L_F). The amount of time work off-farm (L_o) is just the total time endowment minus labor on farm (assume leisure is constant). After all the prices are realized and its income is known, household makes its consumption decision in the second stage.

Farm income (F) is valued by the price of grain (P_g) times the quantity of grain output (Q_g). Note that grain production is a function of grain price and household labor input, which is also a function of grain price

$$Q_g = Q_g(L_F(P_g)).$$

Household's off-farm income (O) is wage rate (w) multiplies by the amount of labor time it provides (L_o). For simplicity, we assume other transfer income (T) is a constant for now.

Household farm income is

$$F = P_g Q_g = P_g Q_g(L_F(P_g)), \tag{2}$$

and its off-farm income

$$O = wL_o = w(P_g)L_o(P_g) = w(P_g)(1 - L_F(P_g)). \tag{3}$$

Household farm production is a concave function of labor input, because land and other resources are fixed, and therefore, the relationship between labor input and production is

$$\frac{\partial Q_g}{\partial L_F} > 0, \frac{\partial^2 Q_g}{\partial L_F^2} < 0.$$

Given the negative relation in the second derivative and the equilibrium condition (i.e. value of marginal product of labor on farm equals to the wage rate), labor demand of a household farm is a downward sloping function: the more labor the lower the wage. As grain price increases, if the wage rate is fixed, the farm labor demand curve will be pushed outward, and naturally household will work more on farm than outside to return to equilibrium. The increment of labor due to grain price increase is also at a decreasing rate, given the decreasing marginal production of labor. Thus the relationship between grain price and household labor on farm

$$\frac{\partial L_F}{\partial P_g} > 0, \frac{\partial^2 L_F}{\partial P_g^2} < 0.$$

The farming labor is concave in grain price.

The relationship between local wage rate and grain price in farming communities is more complicated. It is observed that a village with lower grain price tends to have lower wage rate at the same time, while higher wage rate and higher grain price may occurred together in another village. A possible explanation for such phenomenon is that wage rate and grain price are both highly correlated to the transaction cost of the village to the major city. Such cost is a function of the distance from the city, the market infrastructure, and the development of transportation facilities, etc. From the household survey data that, across households, wage rate (w) is positively correlated with the grain price (P_g):

$$\mathrm{Cov}(w, P_g) > 0.$$

Though it does not necessarily imply that one causes the other, it is shown that wage rate moves in accordance with grain price to sustain household's means of living (Ricardo 1819, *Principal of Political Economy and Taxation*, deduced from *Law of Population*, Malthus 1798). In This study, we assume increase in grain price causes wage rate to increase

$$\frac{\partial w}{\partial P_g} > 0.$$

If wage rate changes the same direction as grain price changes, the impact on off-farm income due to grain price change is

$$\frac{\partial O}{\partial P_g} = \overbrace{\frac{\partial w}{\partial P_g} L_o}^{+} + \overbrace{w \left(\frac{\partial L_o}{\partial P_g} \right)}^{-},$$

and then

$$\frac{\partial Y}{\partial P_g} > 0 \iff \left| \frac{\partial F}{\partial P_g} \right| > \left| \frac{\partial O}{\partial P_g} \right|.$$

The off-farm income effect due to the grain price change may be smaller since the change of wage rate and labor reallocation wash out each other. The total income effect due to grain price change is therefore "positive": when grain price falls, in a farming community, the direct farm income effect due to grain price change is bigger than the indirect off-farm income effect, and household total income will fall with grain price.

However, after applying the income and price elasticity of the household's staple demand in China from previous studies (Huang and Rozelle 1995, Wu and Wu 1997, Wu and Findaly 1997, Hsu et al. 2002) to the simulation model, we show that the first-order substitution effect is almost always bigger than the second-order income effect. That is to say farm household's staple consumption would increase as grain price falls, and it is less likely to fall below some threshold of inadequate staple consumption to become food insecure.

4. Simulating a Two-Stage Farm Household Model

For simplicity, household allocations of resources between farming and off farm work are represented solely by labor allocation. Household's labor allocation and consumption decisions can be depicted in two stages. In the first stage before knowing the price, the household decides how much to work on farm (L_F). The amount of time work off-farm (L_o) is just the total time endowment minus labor on farm (assuming leisure is constant). After all the prices are realized and its income is known, household makes its consumption decision in the second stage.

For definitiveness we assume Cobb-Douglas utility function, $U = U(C_g, C_n) = C_g^{\theta} C_n^{1-\theta}$; a quadratic production function with diminishing return in labor, $Q = q(L_F) = \alpha L_F + \beta L_F^2$, where$\beta < 0$; and prices are normally distributed and truncated above zeros ($P's > 0$, where P_g is the grain price, P_n is the price of non-grain good).

Moreover, for analysis purpose, we assume that retail price is a compound of farm-gate (wholesale) price, such that $P_g^r = AP_g^f$, where $A > 1$, i.e. margin exists between these two levels of grain price.

A representative farm household consumes food bundles consist of grain (rice for now) and non-grain goods. Solving backwardly we get the consumption functions for the two goods in time 2 first, and plug them back to solve for the labor allocation in time 1 that maximizes the expected utility.

In time 2, the optimal demand functions are

$$C_g^* = \frac{\theta}{P_g} \overbrace{(P_g q(L_F) + wL_o)}^{Y} \tag{4}$$

$$C_n^* = \frac{(1-\theta)}{P_n} \overbrace{(P_g q(L_F) + wL_o)}^{Y}. \tag{5}$$

The first order condition of labor allocation decision in time 1 is

$$(\alpha + \beta L_F)\, E\left[\left(\frac{P_g}{P_n}\right)^{1-\theta}\right] - E\left[\left(\frac{P_g}{P_n}\right)^{-\theta}\left(\frac{w}{P_n}\right)\right] = 0$$

Labor on farm (L_F) is then solved as follows

$$\Rightarrow L_F = \frac{\mu_x}{\mu_y \beta} - \frac{\alpha}{\beta}. \tag{6}$$

Where $x = \left(\frac{P_g}{P_n}\right)^{1-\theta}$ and $y = \left[\left(\frac{P_g}{P_n}\right)^{-\theta}\left(\frac{w}{P_n}\right)\right]$, and therefore $\mu_x = E_x = E\left[\left(\frac{P_g}{P_n}\right)^{1-\theta}\right]$ and $\mu_y = E_y = E\left[\left(\frac{P_g}{P_n}\right)^{-\theta}\left(\frac{w}{P_n}\right)\right]$.

Note that labor allocation function, eq(6), is a concave function of real prices, since it consists of two concave random variables of the real prices x and y.

To build the simulation model we need the following parameters: mean and variance of grain price over time, wage rate at 2000 level (wage rate is fixed for now, not a random variable), the production function parameters, α and β, and the income and price elasticities of farm household staple consumption.

The starting point of these parameters are estimated from the data set, except the income and price elasticities of staple consumption are drawn from previous studies (Wu and Wu 1997, Hsu et al. 2002). Grain price variability over time is calculated from a time-series price data, and parameters such as mean of grain price and the wage rate and the parameters of production are estimated from the household survey data. We apply the procedures in Zhao et al. 2000 to generate data and analyze alternative scenarios in the simulation model.

4.1. **Price Variance from Market Data.** The variance of the rice price distribution is calculated from a time-series price data, 1991-2000. The locations of the markets are corresponding to those in the survey data. There is one market in each of the province matching the household survey data (Hebei, Shaanxi, Liaoning, Zhejiang, Sichuan, and Hubei), and they are all rural markets.

In 1995 and 1996, rice price spiked up to almost double in all the markets in the sample, and year 1994 had the highest price variation. In late 1994, governor's grain bag responsibility system announced followed this food price inflation and the apprehension of food shortage. This policy assigned ultimate responsibility for securing grain needed in a province to the provincial leadership. However, it has been evaluated as a barrier to the inter-provincial grain movement and the impediment to market development (Fang and Beghin 2003) . Thus, this may be an explanation for the price spike in the following years.

Two methods are applied to de-trend the price series. First is applying OLS regression on regional and period dummies to de-trend. We stack all 6 market price series and regress the price on 6 regional dummies, 36 period dummies and time trend variables, and the variance of the deviated price series are in the following table.

Aggregate Price (μ)	De-trend σ
1.811	0.585

Second, Lowess smoothing method (a weighted regression of price on time trend) is applied to filter the price fluctuation in each market and extract out the effect of inflation on price variation. The variance of the deviation-from-trend price series is then estimated. Results are in the table below.

market	Mean Price (μ)	De-trend σ
m76	2.04	0.474
m158	1.60	0.402
m88	1.90	0.449
m105	1.66	0.432
m146	1.69	0.415
m131	1.67	0.476

The de-trended price variances are no difference in all markets and an F test on the null hypothesis that all estimates of the variances are the same is not rejected at 5% significant level. Therefore, the mean value, 0.44, is applied in the simulation model.

4.2. **Parameters from Household Survey Data.** The mean of grain price and wage rate are estimated from the household survey data in 2000. Along with the variance of price they are used to generate the variables of μ_x and μ_y, in eq(6).

Production function parameters, α and β, are drawn from a bivariate normal with mean and variance estimated from the regression using the survey data.

After obtaining all the parameters, labor allocation can be calculated from equation (6). We simulate different means and/or variances of grain price distribution as alternative scenarios and examine how labor is reallocated, and furthermore, how grain consumption is affected by these different price distributions. Each alternative scenario contains 900 simulated observations.

5. Discussion on the Results and Concluding Remarks

Parameters of the simulation model are based on the 2000 survey data and the time-series retail price data set from 1991 to 2000. Sensitivity analyses are conducted to examine possible impacts on farm household grain consumption when grain price distribution changes due to trade liberalization.

The baseline price distribution is drawn at 2000. Three scenarios of trade liberalization are simulated for analysis of the change of grain consumption distribution after liberalizing the border. First scenario is when the mean of the price distribution shifts downward and no change in the spread, and the second and third are when the spread also changes.

In Huang et al. (forthcoming), prices of most staple grains (indica and jasmine rice, wheat, maize and soybean) are falling as China fully implements its WTO agreement on agriculture in 2007. Grain price transmission is estimated to be 10 to 25 percent from border to inland for rice, and 20 to 50 percent for corn. The de-trended CIF rice price variation is 0.24 , which is smaller than the domestic price variation[1]. Though more recent CIF price data will be needed to make further conclusion on the comparison between the variation of domestic price and the border price, we believe that the fluctuation of the rice price distribution should not become too much bigger after trade liberalized[2].

Based on these findings, we experiment a 15 percent fall in rice price and two alternative increments in the spread of rice price distribution (+5% and +10%) in this study.

Note that nominal wage rates in China, both non-farm skilled and unskilled labor are shown to increase after trade liberalized (Anderson et al. 2004), household's total income effect will be further mitigated by the increase of real wage rate, and food *insecurity* will be less likely to occur. In our analysis, the nominal wage rate is set at 2000 level as the initial value for all alternative scenarios to obtain the conservative estimation.

Household's rice consumptions per day in baseline and three scenarios are generated. When rice price distribution shifts down with no change in its spread, in scenario I, farm household rice consumption is shifting to the right (Figure 1), indicating an improvement of food security. The more spreading out the price distribution is, the more likely

[1]Data source: China Statistical Yearbook, SSB. Grain includes wheat, barley and corn, no data on rice import until 1997. We calculate the rice price variation using data from 1997-2001.

[2]The standard deviation of U.S. rice FOB to China is 0.1, from 1990-2000. Data sources: Foreign Agricultural Service (FAS) trade data set, USDA.

household becomes food insecure, comparing scenario II (Figure 2) and scenario III (Figure 3).

We show that farm households can reallocate resources between available jobs to mitigate the income effect due to grain price falls. Household survey data shows that most Chinese farmers derive income from resources other than grain marketing and buy a significant amount of staple grain (Table 2). Same evidence is found in Benjamin et al. (2004, Table 5) using a different survey data, showing that agricultural income share in rural China has decreased from 30% in 1987 to 15% in 1999. Thus we conclude that lower staple grain price raises consumption and reduces the probability that grain consumption falls below some unacceptable threshold. This result is aligned with Huang et al. (2003) that China's farmers will be benefit from trade liberalization as their income *increases* by switching to non-grain production when grain price falls.

From the simulation results, holding price stable, or keeping the variation increment smaller, will improve household's staple food consumption (Figure 1 and 3). From the potential benefit of keeping price stable, policy implications are enhancing households accessibility to more varieties of foods, such as improving infrastructure on transportation and developing the local market facilities, and education on basic nutrition and a more balance diet to general public as well as farm households.

References

[1] *Poverty and Hunger: Issues and Options for Food Security in Developing Countries.* World Bank, Washington D.C., 1986.

[2] *WTO Accession Will Increase China's Agricultural Import.* ERS/USDA, Washington D.C., 2002.

[3] Anderson, K., Huang, J., and Ianchovichina, E. Will china's wto accession worsen rural poverty? Working Paper 4196, Center of Economics Policy Research, 2004.

[4] Barrett, C. Food security and food assistance program. In *Handbook of Agricultural Economics*, B. L. Gardner and G. C. Rausser, Eds. Amsterdam: Elsevier Science, 2002, pp. 2–95.

[5] Benjamin, D., Brandt, L., and Giles, J. The evolution of income inequality in rural china. Working Paper 654, William Davidson Institute, 2004.

[6] Fang, C., and Beghin, J. Protection and comparative advantage of chinese agriculture: Implications for regional and national specialization. In *Agricultural Trade and Policy in China: Issues, Analysis and Implications.*, S. D. Rozelle and D. A. Sumner, Eds.

[7] Hsu, H.-H., Chern, W. S., and Gale, F. How will rising income affect the structure of food demand? In *China's Food and Agriculture: Issues for the 21st Century.* 2002, pp. 10–13.

[8] Huang, J., Li, N., and Rozelle, S. Trade reform, household effects, and poverty in rural china. *American Journal of Agricultural Economics 85*, 5 (2003), 1292–1298.

[9] Huang, J., and Rozelle, S. Market development and food demand in rural china. FCND Working Paper 4, International Food Policy Research Institute., 1995.

[10] Huang, J., Rozelle, S., and Chang, M. The nature of distortions to agricultural incentives in china and implications of wto accession. *World Bank Economic Review* (forthcoming).

[11] Li, C., and Wang, H. China's food security and international trade. *China and World Economy. 4* (2002), 28–31.

[12] Sen, A. Famine. *World Development 8* (1979), 613–621.

[13] Sumner, D. A. Agricultural trade policy and food security. *Quarterly Journal of International Agriculture 39*, 4 (2000), 395–409.

[14] Wu, H. X., and Findlay, C. China's grain demand and supply: Trade implications. Working Paper 97, Center of Economics Policy Research.

[15] Wu, Y., and Wu, H. X. Household grain consumption in china: Effectd of income, price and urbanization. *Asian Economic Journal 11*, 3 (1997), 325–342.

[16] Zhao, X., Griffiths, W. E., Griffith, G. R., and Mullen, J. D. Probability distributions for economic surplus changes: The case of technical change in the australian wool industry. *The Australian journal of Agricultural and Resource Economics 44*, 1 (2000), 83–106.

TABLE 1. Summary Statistics of Market-Level Price Data Set, 1990-2000.

Market Code	Province (City)	Price (Yuan/kg)
NCP		
m76	Tianjing 2	1.904
m158	Shaanxi	1.4
Northeast		
m88	Liaoning	1.613
South		
m105	Zhejiang	1.71
m146	Sichun	1.75
m131	Hubei	1.53

NCP: North China Plain, mainly the yellow river regions.

TABLE 2. Summary Statistics of Household Survey Data Set, 2000.

Variable	N	Mean	Std. Dev	Min(#hhs)	Max
(jin)					
Total grain production	543	4220.16	3894.96	0	37000
Sold in market	543	879.76	2430.91	0(294)	31000
For own consumption(processed)	543	1166.2	742.1	0(8)	5652
Purchased from market	543	276.8	365.61	0(64)	2300
(RMB)					
Total income	543	8649.64	19437.43	-39951.62	300781.9
Grain income	543	542.32	1385.7	0	20460
Non-grain income	543	6796.24	19379.36	-40625	300000

Note: The 8 zero-self-consumed households purchased grain from market. Most grain production contributes to own consumption, small amount is sold in the market, therefore, grain income attributes small share to total income.

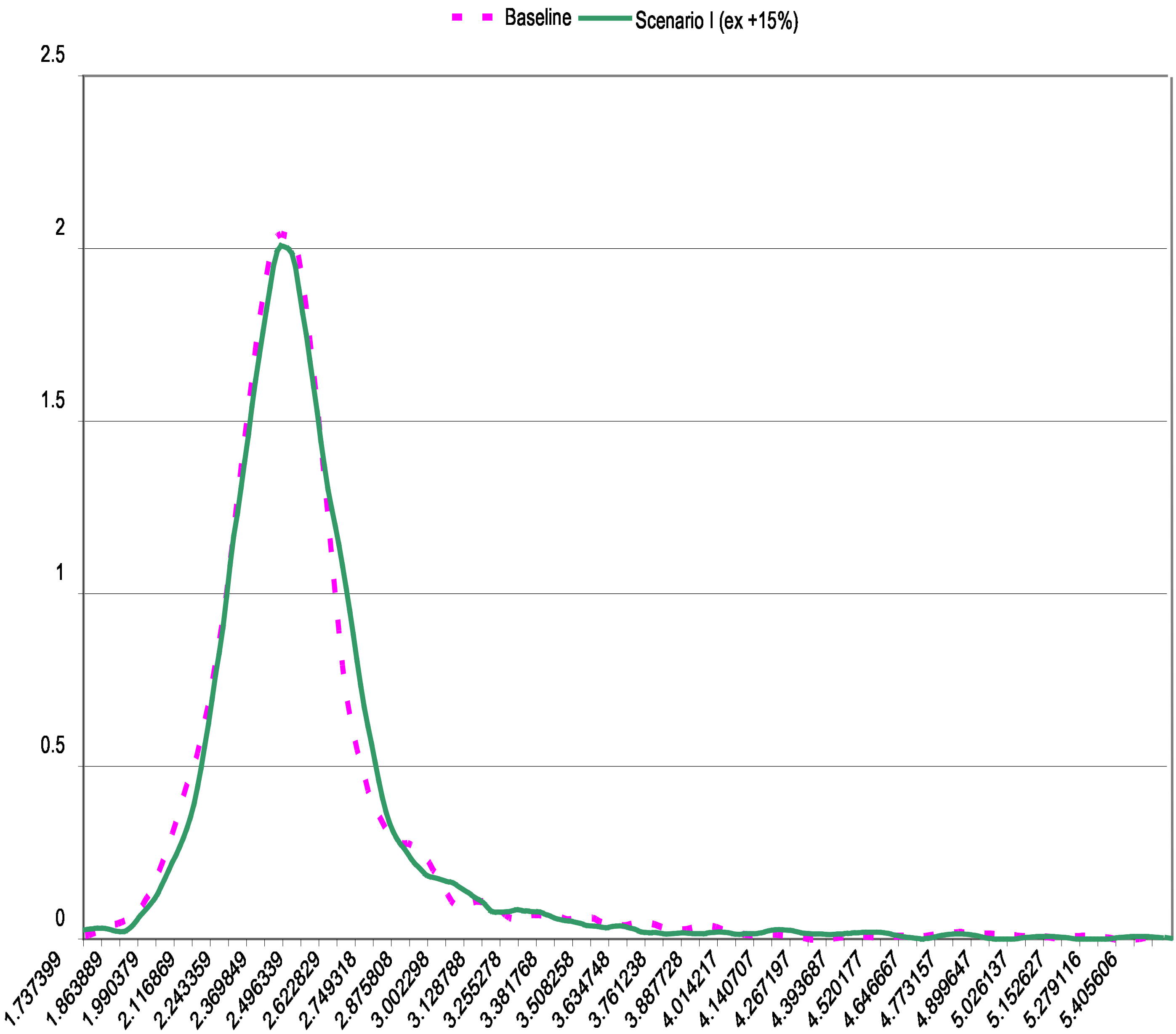

Figure 1. Figure 1– Rice Consumption Distribution in Baseline and Scenario I

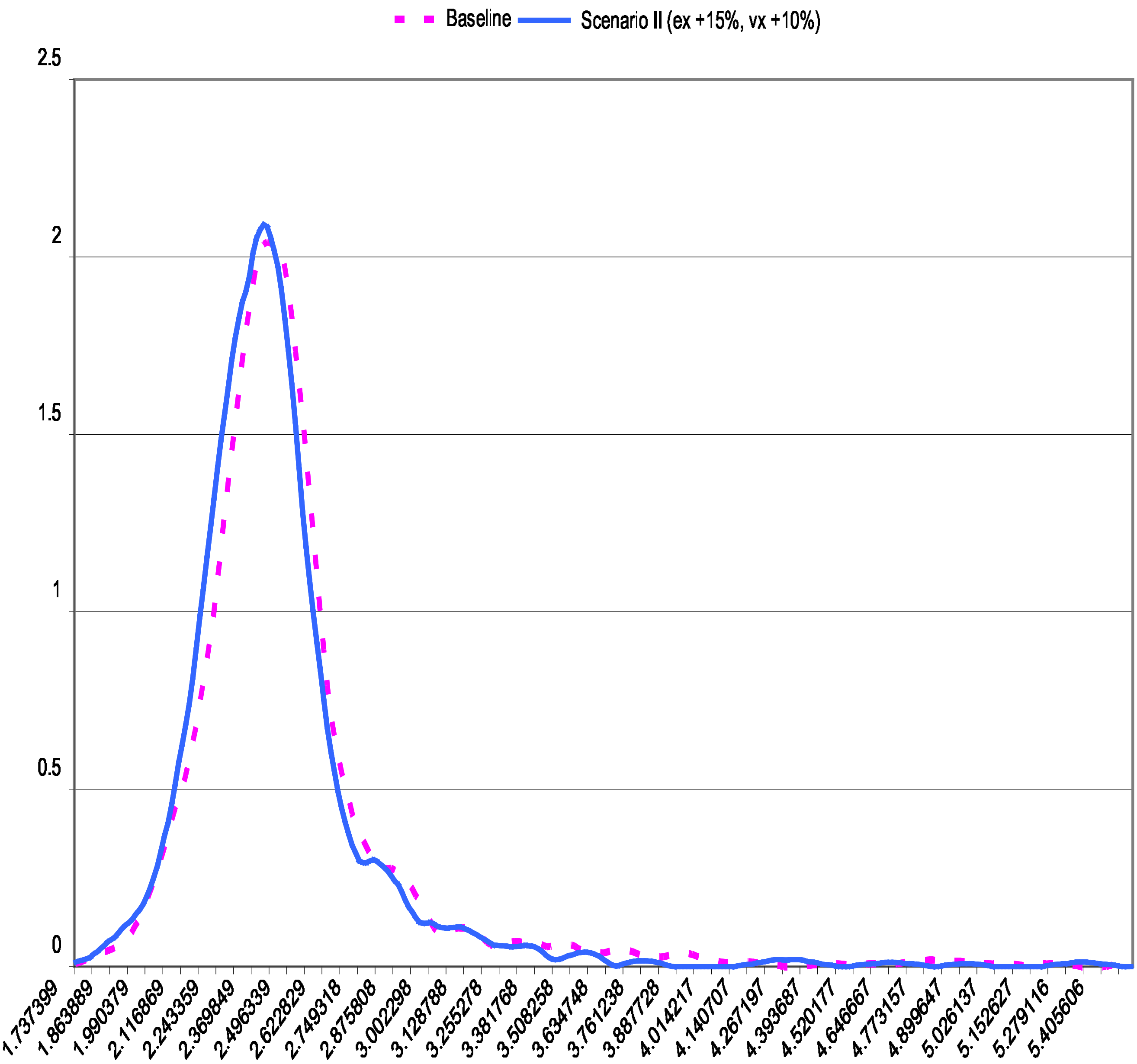

Figure 2. Figure 2– Rice Consumption Distribution in Baseline and Scenario II

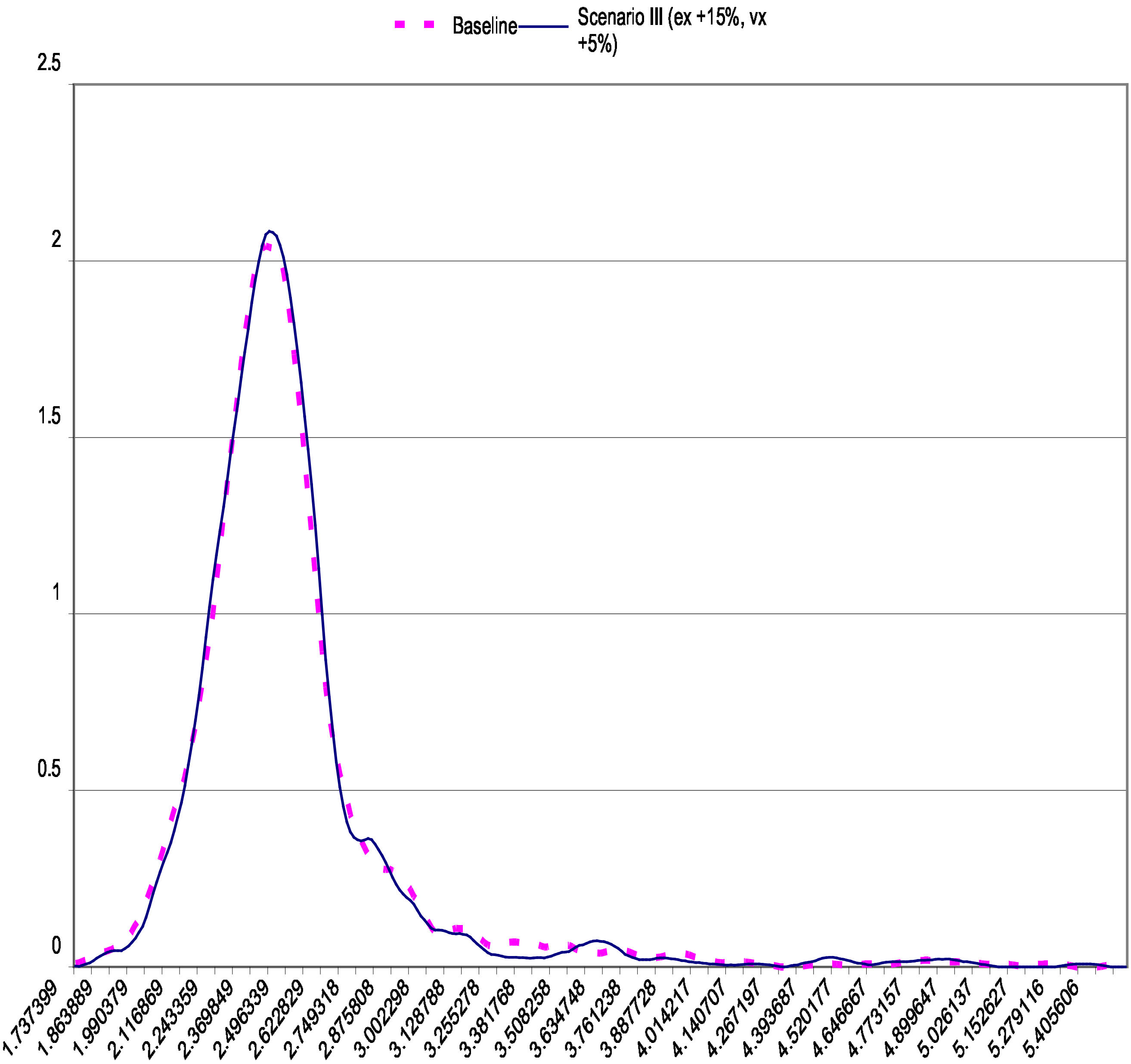

Figure 3. Figure 3– Rice Consumption Distribution in Baseline and Scenario III