Risk Sharing and Trade in World Food Markets: The Case of Rice, Wheat and Maize

Digvijay Singh Negi and Bharat Ramaswami
Indian Statistical Institute, New Delhi, India

July 2016

Abstract

It is claimed that world food supplies are more stable than the domestic supplies, and therefore free trade should achieve a higher degree of stability in prices and consumption than autarkic policies. The risk sharing implicit in such an argument, has, however never been formally examined.

In this paper we study the patterns of risk sharing in the global markets of rice, wheat and maize and quantify the contribution of trade and stocks towards risk sharing. We adopt the predictions of efficient risk sharing hypothesis as a benchmark and generalize the canonical single composite good model.

While the data rejects the efficient risk sharing hypothesis, the wheat market is closest to the efficient risk sharing allocation. Trade is more important than storage in smoothing domestic production shocks. Further we find that the degree of risk sharing is positively associated with income levels of the countries.

Key words: Risk sharing, Trade, Global Food Markets

JEL codes: F01, F10, F14, Q02, Q17, Q18

*Corresponding Author: Bharat Ramaswami, Indian Statistical Institute, 7 SJS sansanwal Marg, New Delhi 110016, India, 91-11-41493947, isid.bharat@gmail.com

Risk Sharing and Trade in World Food Markets: The Case of Rice, Wheat and Maize

1. Introduction

The sharp surge in global food prices in the years 2006-08 has led to concerns about the functioning of global food markets. The concern has been most manifest in the case of rice markets where it is believed that government actions of panic buying (by importers) and export prohibitions (by exporters) contributed to the price spikes. Rising food prices and high volatility, as witnessed in 2008 pose a threat to food security of the poor especially in developing countries who spends a significant part of their income on food (Ivanic and Martin, 2008; Ivanic et al., 2012; Ivanic and Martin, 2014).

Trade and storage are two principal means by which countries have sought to align unstable output with the need to smooth consumption. However, public stocks are considered to be a costly option, as they tie up scarce resources, are vulnerable to deterioration, corruption and theft; and may crowd out private sector from holding food stocks (Gilbert, 2011). Knudsen and Nash (1990), from a review of experiences on domestic price stabilization programs across the world, concluded that stabilization schemes should "avoid handling the commodity when possible".

On the other hand, several studies have indicated that in comparison to public stocks holdings, international trade is an economical means of stabilizing food supplies (Valdes, 1981; Krishna and Chhibber, 1983; Jha and Srinivasan, 1999 and 2001, Dorosh (2001)). The idea that trade can stabilize consumption has long been recognized in the literature. Timmer

(1996) argued for a move away from national food security stocks towards food security via trade and production based on comparative advantage.

In general, global food production is more stable than the regional or national production, and thus free trade should be able to achieve greater stability in prices and consumption. In the words of Gilbert (2011), "If supply (harvest) shocks are largely uncorrelated across countries, governments can import when they need to do so without, on average paying high prices". The caveat introduced by Gilbert acknowledges that the contribution of trade would depend on the correlation of production shocks across countries. For this reason, the contribution of trade was refined by Gouel (2013) when he stated the following: "In a world without trade costs and trade policies, trade would perfectly alleviate the idiosyncratic supply shocks. All countries would share the same price, determined by the aggregate shock to world yield and existing stocks, and stocks would help to reduce the volatility caused by the aggregate shocks. The respective ideal contributions of trade and storage in smoothing shocks in a laissez-faire world are for trade to smooth idiosyncratic shocks and for stocks to smooth aggregate shocks."

Although the literature assigns risk sharing to be the primary contribution of international trade to food security, this has not been tested or quantified in the literature. The primary objective of this paper is to examine the performance of world markets for grains (maize, rice and wheat) in a risk sharing framework. The paper is related to the optimal risk-sharing hypotheses that have been formulated and tested in finance, macro-economics and in development economics. In this literature, the risk sharing hypothesis has been formulated in the context of one composite good (for instance, household income or country GDP). We extend it to the case where endowments are multi-good (specifically, food and non-food) and are stochastic.

A finding that world food markets do not achieve full risk sharing would not, however, be surprising. Countries often use trade policies to insulate their domestic markets from price volatility in the global market. During price spikes, use of trade-restrictive policies is common, and when all countries attempt to insulate their domestic markets simultaneously, these render global food markets extremely thin and can magnify volatility in global food prices (Abbot 2011; Martin and Anderson 2011; Giordani, Rocha, and Ruta, 2012; Gilbert and Morgan 2010; Mitra and Josling, 2009; Headey, 2011, Slayton, 2009). The unreliability in world food markets, when needed most, would lead to serious doubts on their efficiency in providing insurance against adverse production shocks.

What is less obvious, however, is the extent of risk pooling that is achieved by each of these three grains markets. Equally, what is also of interest is the contribution of trade and national stocks to the observed risk sharing. This paper answers both of these questions. The contribution of this paper is, therefore, two fold. First, it asks questions not posed before. Second, it provides answers to questions that are at the heart of the global governance of trade and food security.

A preview of our findings is as follows. We adopt the predictions of efficient risk sharing hypothesis as a benchmark. A necessary condition for efficient risk sharing is that consumption growth rates should be perfectly correlated with aggregate shocks and independent of domestic production growth rates. We find that the efficient risk sharing hypothesis is rejected for the global food markets. However, the global wheat market is closest to the efficient risk sharing allocation. On average, trade and stocks jointly provide insurance against production shocks to the extent of 87% in case of wheat, followed by rice (66%) and maize (57%). However, the contribution of trade here is dominant. Of the insurance that is achieved, trade is responsible for more than 80% of it in each of the three markets. Further, by allowing the degree of risk sharing to vary by low income, lower middle income, upper middle income and high income country groups we find that the degree of risk sharing is positively associated with income levels of countries.

The paper is organized as follows. The next section discusses briefly the theory of efficient risk-sharing. Section 3 describes empirical methodology to test risk sharing and quantify the contribution of trade and stocks to consumption smoothing. Section 4 describes the sources and type of data used and the descriptive statistics. In section 5 we present the results. Main findings and are summarized in the last section.

2. Theory of efficient risk sharing

To illustrate the main idea of the theory of efficient risk sharing we set up a simple exchange world economy with N agents and 2 tradable goods, food and non-food denoted by x and y respectively.[1] To highlight the necessity nature of food consumption we assume that in times of an endowment shock an individual will adjust food consumption relatively less compared to non-food consumption. This implies that the elasticity of the marginal utility is higher for food than for non-food consumption. A convenient way of formalizing this is by using the quasi-linear utility function to define agents' preferences over the two goods.

$$U_i = u_i(x_i) + b_i y_i, u_i'(.) > 0, u_i''(.) < 0 , \tag{1}$$

[1] The standard risk sharing framework usually deals with a single composite commodity.

Quasi-linear preferences offer a way in which the two goods can be classified into a necessity and a luxury. Food consumption enters non linearly in the utility function hence the demand for food consumption is independent of income. We assume that there are $s^t \in S^t$, states of the world in each time period t, where each state occurs with a probability π_{s^t} and $\sum_{s^t \in S^t} \pi_{s^t} = 1$. Household i owns a stochastic endowment of food and non food consumption goods, $w_{is^t}^x$ and $w_{is^t}^y$ that depends on the realization of state. The expected lifetime utility function of household i is expressed as

$$E(U)_i^{lifetime} = \sum_{t=1}^{\infty} \rho_i^t \sum_{s^t \in S^t} \pi_{s^t} [u_i(x_{is^t}) + b_i y_{is^t}] \quad (2)$$

Where $\rho_i \in (0,1)$ is the discount factor for household i. Ex ante efficiency requires, that the allocation of resources across states is efficient such that no state-contingent exchange can improve both agents' expected utilities. The ex-ante efficient risk sharing allocation is the solution of the following program.

$$\text{Max} \sum_{i=1}^{N} \omega_i E(U)_i^{lifetime} \quad (3)$$

where, ω_i is the weight of consumer i in the Planner's problem ($0 < \omega_i < 1$, $\sum_{i=1}^{N} \omega_i = 1$). Subject to aggregate resource constraints.

$$\sum_{i=1}^{N} x_{is^t} = \sum_{i=1}^{N} w_{is^t}^x = X_{s^t}, \qquad \text{for each } s^t \quad (4)$$

$$\sum_{i=1}^{N} y_{is^t} = \sum_{i=1}^{N} w_{is^t}^{y} = Y_{s^t}, \qquad \text{for each } s^t \tag{5}$$

The first order condition with respect to food is

$$\rho_i^t \omega_i u_i'(x_{is^t}) = \mu_{s^t}^x, \quad \text{for each } s^t \tag{6}$$

Where $\mu_{s^t}^x$ is the Lagrangian multiplier of the aggregate resource constraint divided by the probability of state s^t. Note that individual household's endowment do not enter in the determination of the household's consumption allocation. The first order condition can be further simplified to

$$\rho_i \frac{u_i'(x_{it})}{u_i'(x_{it-1})} = \frac{\mu_t^x}{\mu_{t-1}^x} \tag{3}$$

This version of the first order condition presents an interesting implication of efficient risk sharing hypothesis. Given aggregate resources, the discounted growth in marginal utility is independent of individual household's endowment and is constant across households (Cochrane, 1991).

3. Empirical Framework

The theory of risk sharing establishes a benchmark against which the efficiency of world food markets can be compared. This benchmark has been tested in the literature under various contexts. At household level, Mace (1991) and Cochrane (1991) for the United States, and Townsend (1994) and Morduch (2002) for India utilized the efficient risk sharing hypotheses to examine households' insurance against idiosyncratic and aggregate shocks. The main argument in these studies is that in absence of insurance against idiosyncratic shocks, consumption will fluctuate adversely affecting the household welfare. Recently, Mazzocco and Saini (2012) also tested this hypothesis using household-level data from India. There is also substantial literature examining the patterns of consumption risk sharing at aggregate level using panel of industrialized countries (Obstfeld, 1994; Canova and Ravn, 1995; Lewis, 1996).

There are two ways in which the efficient risk sharing hypothesis can be tested. A direct test is to look at the correlation between country consumption growth and world consumption growth. Under efficient risk sharing, the country specific and aggregate consumption growth should be perfectly correlated. An indirect test is based on the premise that nothing else other than aggregate resources matter in explaining variation in domestic consumption growth. Therefore, for empirical validity of the efficient risk sharing hypothesis, ex post domestic consumption should be independent of shocks to domestic production (Cochrane, 1991). Asdrubali, Sorensen and Yosha (1996) propose a framework to test the efficient risk sharing hypothesis, to assess the degree of risk sharing and to quantify the contribution of trade and stocks in the risk shared. Consider the following identity,

$$Y_{it} = \frac{Y_{it}}{Y_{it}^{NX}} \times \frac{Y_{it}^{NX}}{S_{it}} \times S_{it} \tag{84}$$

where Y_{it} and S_{it} are the per capita production and supply in country i at time period t respectively. Y_{it}^{NX} is defined as the production left after net exports. Then the domestic supply will be equal to the sum of production left after trade and change in stocks. If we assume that domestic supply (S) equals consumption (C) then the variance in per capita production can be decomposed as.

$$\mathrm{Var}[y_{it}] = \mathrm{Cov}[y_{it}, y_{it} - y_{it}^{NX}] + \mathrm{Cov}[y_{it}, y_{it}^{NX} - c_{it}] + \mathrm{Cov}[y_{it}, c_{it}] \tag{9}$$

Where $y_{it} = \Delta \mathrm{Ln} Y_{it}$, $y_{it}^{NX} = \Delta \mathrm{Ln} Y_{it}^{NX}$ and $c_{it} = \Delta \mathrm{Ln} C_{it}$. Dividing by the variance of y_{it} we get

$$1 = \frac{\mathrm{Cov}[y_{it}, y_{it} - y_{it}^{NX}]}{\mathrm{Var}[y_{it}]} + \frac{\mathrm{Cov}[y_{it}, y_{it}^{NX} - c_{it}]}{\mathrm{Var}[y_{it}]} + \frac{\mathrm{Cov}[y_{it}, c_{it}]}{\mathrm{Var}[y_{it}]} \tag{10}$$

$$1 = \gamma^T + \gamma^S + \gamma \tag{51}$$

$$1 - \gamma = \gamma^T + \gamma^S \tag{62}$$

Under full risk sharing, after controlling for aggregate shocks, consumption should be independent of idiosyncratic production shocks, i.e., the optimal risk sharing hypothesis is $\gamma = 0$. Rejection of the hypothesis implies that agents are not able to fully insure themselves from idiosyncratic production shocks, hence consumption will be correlated with production. In that case, $(1 - \gamma)$ can be interpreted as a measure of the degree of insurance or risk sharing (Asdrubali et al., 1996; Crucini, 1999; Grimard, 1997; Jalan and Ravallion, 1999). The above identity decomposes the degree of risk sharing $(1-\gamma)$ into risk sharing due to trade (γ^T) and change in stocks (γ^S).

To quantify the contributions of trade, changes in stocks and the residual, we estimate the following regressions.

$$y_{it} - y_{it}^{NX} = \alpha^T + \beta^T \text{Aggregate shocks}_t + \gamma^T y_{it} + \epsilon_{it}^T \tag{73}$$

$$y_{it}^{NX} - c_{it} = \alpha^S + \beta^S \text{Aggregate shocks}_t + \gamma^S y_{it} + \epsilon_{it}^S \tag{84}$$

$$c_{it} = \alpha + \beta \text{Aggregate shocks}_t + \gamma y_{it} + \epsilon_{it} \tag{95}$$

Aggregate shocks are unobserved in the data but literature provides ways in which these can be controlled while testing for risk sharing. One way, which was followed by Mace (1991) and Townsend (1994), is to use the cross-sectional averages of the variables as a proxy for aggregate shocks. Another way is to use time dummies to remove the common component in growth of both the consumption and production so that γ is interpreted as the effect of idiosyncratic production growth on idiosyncratic consumption growth (Asdrubali et al., 1996; Sorensen and Yosha, 1998, Sorensen et al., 2007; Kose et al., 2009).

4. Data and Descriptive Statistics

To test the risk sharing hypothesis we make use of the 'Production, Supply and Distribution' database of the United States Department of Agriculture (USDA). The data-set includes time series (1961-2013) of production, consumption, stocks and trade of major agricultural commodities for a number of countries. This enables us to construct large unbalanced panels. Our analysis focuses on three important staple food commodities, viz., wheat, rice and maize. There are two types of consumption aggregates in this data-set; (1) total consumption including food and feed, and (2) food, seed and industrial consumption. We use total consumption in this analysis.

The aggregates of consumption and production are converted into their per capita equivalents dividing by the population as provided in the World Development Indicators (World Bank). Further the data are log transformed and then first differenced to get year-on-year growth rates.

One limitation of the dataset is that it does not provide information on the different varieties of a commodity. For example, maize is of two types, yellow and white, but the available data does not distinguish maize by its type. In such a situation, our estimated degree of risk sharing will be representative of the aggregate and not of the types.

Full risk sharing is achieved if each country is allocated a fixed proportion of the world production. Then domestic consumption will depend on world production and will be independent of domestic production. The efficiency of risk sharing in minimizing consumption variance is directly related to the correlation between the idiosyncratic production shocks across countries. Therefore, it is useful to start the discussion on international risk sharing with the relationship between world and national production shocks. Following Martin et. al, (2012) we define world production growth as production share weighted average of country specific production growth rates.

$$y_t^w = \sum_{i=1}^{N} s_i y_{it} \qquad (106)$$

Multiplying both sides by y_t^w and taking expectations, the variance of the world production growth can be written as

$$\mathrm{Var}(y_t^w) = \sum_{i=1}^{N} s_i \mathrm{Cov}(y_{it}, y_t^w) \quad (117)$$

or

$$1 = \sum_{i=1}^{N} s_i\, b_i \quad (18)$$

where $b_i = \mathrm{Cov}(y_{it}, y_t^w)/\mathrm{Var}(y_t^w)$ is the slope coefficient estimated regressing the domestic production growth on world production growth.

Figure 1 panel (a) plots the variance in growth of world and domestic production of rice, wheat and maize. There is considerable variation in country-specific production growth rates, but in comparison the growth in world production is incredibly stable. This implies that, while a country may face significant variability in its production, the idiosyncratic shocks at global level are averaged out.

Figure 1 panel (b), (c) and (d) show variance decomposition of the world production growth for rice, wheat and maize, respectively. India accounts for 21% of the world rice production but contributes 56% to the variance in its growth. China, on the other hand, produces 35% of the world rice, contributing only 22% to the growth variance. In case of wheat, Australia, Canada, United States and China together contribute 80% to the variance in world production growth as against their share of 57% in production. United States is the main producer of maize and contributes 94% to the variance in growth.

Figure 2 shows distribution of $b_i = \mathrm{Cov}(y_{it}, y_t^w)/\mathrm{Var}(y_t^w)$ for rice, wheat and maize. We observe significant dispersion of b_i around unity. This suggests existence of a scope for risk sharing through trade. Figure 3 plots trends in world exports of rice, wheat and maize as proportion of their respective production. In terms of volume, wheat has been the most traded food commodity-- about 20% of its production enters the international market, followed by maize (13%) and rice (4%). Exports of rice were almost stagnant until the early 1990s and started rising afterwards mainly due to trade liberalization in India and Viet Nam. Exports of wheat have been volatile, declining until early 1990s and rising thereafter. Maize exports show an increasing trend in 1970s and 1980s.

5. Results

(a) Correlations

As a step towards testing the predictions of efficient risk sharing hypothesis, first we examine the correlation of growth in domestic consumption with the growth in domestic production and with the growth in world consumption each of rice, wheat and maize. Figure 4 (a) summarizes these correlations. The solid lines show the trend in median decadal moving average correlations of domestic and world consumption growth and the dashed lines show the trend in correlations of domestic consumption with domestic production. The estimated correlation coefficients between domestic consumption and world consumption have always been less than unity, while domestic consumption is found to be highly correlated with domestic production for the entire period. This indicates low degree of consumption smoothing across countries. Further, there is no clear trend in correlations of domestic consumption with world consumption but the correlation of domestic consumption with domestic production for all the commodities declines overtime, implying an improvement in the degree of consumption smoothing.

Further we estimate these correlations by income levels of the countries, which have been grouped into four as low income, lower middle income, upper middle income and high income following the World Bank classification. In figure 4 (b) for sake of brevity we present results only for low income and high income countries. There is considerable heterogeneity in the estimated correlations. For all the commodities, the correlation between domestic consumption and production (dashed line) is higher for low income countries compared to the high income countries. For maize, the difference is stark between low and high income countries indicating that low-income countries are unable to insure domestic consumption against domestic production shocks.

(b) Formal tests of risk sharing

Though the correlation based analysis provides a preliminary idea of the degree to which a commodity market abides by the predictions of the optimal risk sharing hypothesis, it is not a substitute for a formal regression based test of risk sharing. The correlations are also highly variable across countries, and this heterogeneity needs to be taken care of in regressions.

Table 1 presents the regression results of the test of efficient risk sharing hypothesis and also the estimates of the contributions of trade and stocks to consumption smoothing. The estimates of γ (panel C of table 1) are significantly different from zero for rice, wheat and maize, and therefore, the full risk sharing hypothesis is rejected. These results reinforce our earlier observation that commodity markets are unable to completely insulate domestic consumption from idiosyncratic production shocks.

(c) Extent of Risk Sharing

Comparing the degree of risk sharing across food markets (Table 1), we find that wheat market performs the best providing 87% insurance against domestic production shocks. This is followed by rice (66%) and maize (57%) markets. The decomposition analysis shows trade as the principal means of insurance against domestic production shocks contributing to more than 80% of the total insurance that is achieved against domestic production shocks. These results are robust to inclusion of the country fixed effects, income groups, region specific time dummies and controls for aggregate shocks.

The absolute contribution of trade to smoothing domestic production shocks is higher in the case of wheat (71%) than rice (54%) and maize (50%). This is expected, as wheat is one of the most traded food commodities in the global food market. Also distortions in global food market are less for wheat than for rice. Croser et al. (2010) have reported that, amongst grains, rice trade has been taxed most since the 1970s, and India has been the main contributor to this distortion. Note that rice production is concentrated in Asia and different countries in the continent specialize in production of different varieties or types of rice. India is one of the largest producers and consumers of *indica* rice, while in east and Southeast Asia, populations have a strong preference for glutinous rice. This difference in consumer preferences contributes to thin international rice markets. In case of shortfall in domestic production, it is difficult for India to source the required type of rice from the international market.

In the case of maize, trade could insure domestic consumption against 50% of the fluctuation in its domestic production, an estimate closer to that for rice. This is contrary to our expectation as the total volume of maize exports far exceeds that for rice. A possible explanation for this could be the difference in types/varieties of maize being traded in the international market. Dawe et al. (2015) while studying price behavior of staple food commodities in low- and middle-income countries find that domestic maize prices are more volatile than the prices of rice and wheat because of the thin global market for white maize which is primarily used for human consumption more so in sub Saharan Africa where maize staple food crop and accounts for 30-50% of the total household consumption expenditure. The US and China are major producers of yellow maize, which is largely used as livestock feed and as a raw material for industrial products.

(d) Heterogeneity in degree of risk sharing

Having tested the optimal risk sharing hypothesis, we now explore the patterns of risk sharing across countries and overtime. The observed heterogeneity in correlation trends across country-groups based on their income levels suggest that the degree of risk sharing is heterogeneous across countries and overtime. To evaluate the relationship between the degree of risk sharing and the income level we allow γ to vary across income groups of countries (INC_g) with country-group specific linear time trend. Mathematically, this can be expressed as:

$$\gamma = \delta_1 + \sum_{g=2}^{4} \delta_g INC_g + \theta_1 T + \sum_{g=2}^{4} \theta_g (T \times INC_g) \tag{19}$$

Where INC_g is dummy variable for each income group g, and T is the linear time trend. The results are presented in table 2. The degree of risk sharing is the lowest (γ highest) for low income countries (base category) and increases with income. For example, rice consumption in low income countries is insured only against 25% of the shocks to production whereas high income countries domestic consumption is insured to the extent of 75% of the shocks to production (Table 2 panel C). A similar situation is observed in the case of maize. The difference in the degree of risk sharing between low income and the high income countries for both rice and maize is statistically significant. Trade seems to be the reason for this difference in degree of risk sharing between low and high income countries especially in the case of maize where trade insulates low income countries from only 15% of the production shocks as compared to 73% in high income countries.

(e) Robustness checks

We conduct multiple tests to check the robustness of these results. Since rice, wheat and maize are the main staple foods across the world, we expect some substitution among them in the consumption basket. Therefore, the shocks in market for one of these will affect the consumption of others. Our estimates of the degree of risk sharing may be biased due to omitted idiosyncratic and aggregate shocks of other substitutable commodities. Therefore, we test the robustness of the γ^T, γ^S and γ in each market by adding controls for aggregate and idiosyncratic shocks to rice, wheat and maize for the subsample of countries that produce and consume all the three commodities. The results (table 3) indicate that estimates of γ are not sensitive to additional controls i.e. aggregate and idiosyncratic shocks to the substitutable commodities.

Another concern relates to the robustness of the results to measurement error in the dependent as well independent variables. Errors in aggregation of domestic production and consumption may cause past production shocks to be correlated with current consumption, and thus their omission may introduce bias in the estimates. To check the robustness of our estimates we estimate the regressions including lags of domestic production growth rate as an additional regressor. The results do not change with their inclusion (Table 4).

6. Conclusions

Greater stability in the growth of global food production as compared to that in the national or regional production theoretically implies tremendous potential for trade to share risk across countries. However, this idea of risk sharing has not been formally tested in the world food markets. In this paper, we try to fill this gap in literature using efficient risk sharing hypothesis as a benchmark to look at the potential of trade in insulating domestic consumption against domestic production shocks, and its importance in relation to domestic food stocks.

For observers of world food markets, the rejection of the efficient risk sharing hypothesis is probably not surprising. Similarly, the superior performance of the wheat market in providing insurance is also possibly an expected finding. However, the finding that the maize market performs just as poorly as the rice market is unexpected. Both these markets are characterized by horizontal and vertical differentiation of varieties (which in turn, is a reflection of imperfect substitutability) and that possibly limits the ability of the market to provide insurance. Another noteworthy finding is the dominant role of trade in providing insurance for all of the markets. Countries have been following the prescription of economists that trade is, in most cases, a cheaper way of stabilizing consumption than storage.

While global governance would have to be concerned by the limited risk sharing achieved by maize and rice markets, there is also an additional concern that such risk sharing is even lower for poorer countries. In the case of rice, for example, low-income countries are able to achieve only 25% of full insurance relative to 75% attained by high-income countries. A similar situation is observed in the case of maize. Improving the insurance for poor countries would be vital to achieve food security. This paper provides the tools for such a discussion.

References

Abbot, P. C. (2011) Export Restrictions as Stabilization Responses to Food Crisis. American Journal of Agricultural Economics, 94(2). 428–434.

Asdrubali, P., Sorensen, B. E., and Yosha, O. (1996) Channels of Interstate Risk Sharing: United States 1963-90. Quarterly Journal of Economics, 111(4), 1081-1110.

Cochrane, J. H. (1991) A Simple Test of Consumption Insurance. Journal of Political Economy, 99(5), 957-976.

Cole, H. L, and Obstfeld, M. (1991) Commodity Trade and International Risk Sharing: How Much do Financial Markets Matter? Journal of Monetary Economics, 28(1991), 3-24.

Croser, J. L., Lloyd, P. J., and Anderson, K. (2010) How do Agricultural Policy Restrictions on Global Trade and Welfare Differ Across Commodities? American Journal of Agricultural Economics, 92(3), 698–712.

Crucini, M. J. (2000) on international and national dimensions of risk sharing. The review of economics and statistics, 81(1), 73-84.

Dorosh, P. A. (2001) Trade Liberalization and National Food Security: Rice Trade between Bangladesh and India. World Development, 39(4), 673-689.

Dawe, D., Morales-Opazo, C., Balie, J., and Pierre, G. (2015) How Much Have Domestic Food Prices Increased in the New Era of Higher Food Prices? Global Food Security. 5(2015), 1–10.

Gilbert, C. L. (2011) Food Reserves in Developing Countries: Trade Policy Options for Improved Food Security, ICTSD Issue Paper No 37.

Gilbert, C. L., and Morgan, C. W. (2010) Food Price Volatility. Philosophical Transactions of the Royal Society, B. 365(1554), 3023-3034.

Giordani, P. E., Rocha, N., and Ruta, M. (2012) Food Prices and the Multiplier Effect of Export Policy. Staff Working Paper ERSD 2012-08. World Trade Organization Economic Research and Statistics Division.

Gouel, C. (2013) Food Price Volatility and Domestic Stabilization Policies in Developing Countries. Working Paper 18934, National Bureau of Economic Research, Cambridge, MA.

Grimard, F. (1997) Household Consumption Smoothing through Ethnic Ties: Evidence from Cote d'Ivoire. Journal of Development Economics, 53(2), 391-422.

Headey, D. (2011). Rethinking the Global Food Crisis: The Role of Trade Shocks. Food Policy, 36(2), 136–146.

Ivanic, M., and Martin, W. (2008) Implications of Higher Global Food Prices for Poverty in Low-income Countries. Agricultural Economics, 39 (1), 405-416.

Ivanic, M., and Martin, Will. (2104) Short and Long-Run Impacts of Food Price Changes on Poverty. World Bank Policy Research Working Paper No. 7011.

Ivanic, M., Martin, W., and Zaman. H. (2012) Estimating the Short-Run Poverty Impacts of the 2010–11 Surge in Food Prices. World Development, 40(11), 2302–2317.

Jalan, J., and Ravallion, M. (1999) Are the Poor Less Well Insured? Evidence on Vulnerability to Income Risk in Rural China. Journal of Development Economics, 58(1), 61-81.

Jha, S., and Srinivasan, P. V. (1999) Grain Price Stabilization in India: Evaluation of Policy Alternatives. Agricultural Economics, 21(1), 93–108.

Knudsen, O., and Nash, J. (1990) Domestic price stabilization schemes in developing countries, Economic Development and Cultural Change, 38(3), 539-58.

Krishna, R., and Chhibber, A. (1983) Policy Modelling of a Dual Grain Market: The Case of Wheat in India. Research report No. 38, International Food Policy Research Institute.

Kose, M. A., Prasad, E. S., and Terrones, M. E. (2009) Does Financial Globalization Promote Risk Sharing? Journal of Development Economics, 89(2), 258-270.

Lewis, K. K. (1996) What Can Explain the Apparent Lack of International Consumption Risk Sharing? Journal of Political Economy, 104(2), 267-297.

Mace, B. J. (1991) Full Insurance in the Presence of Aggregate Uncertainty. Journal of Political Economy, 99(5), 928-956.

Martin, B., Crucini, M. J., and Wang, C. (2012) International Risk Sharing and Commodity Prices. Canadian Journal of Economics. 45(2), 417–447.

Martin, W., and Anderson. K. (2011) Export Restrictions and Price Insulation during Commodity Price Booms. American Journal of Agricultural Economics. 94 (2), 422-427.

Mazzocco, M., and Saini, S. (2012) Testing Efficient Risk Sharing with Heterogeneous Risk Preferences. American Economic Review, 102(1), 428-468.

Mitra, S. and Josling, T. (2009). Agricultural Export Restrictions: Welfare Implications and Trade Disciplines. Position paper agricultural and rural development policy, IPC.

Morduch, J. (2001) Consumption Smoothing Across Space: Tests for Village-Level Responses to Risk. WIDER Working Paper DP 2002/55.

Obstfeld, M. (1994) Are Industrial-Country Consumption Risks Globally Diversified? In: Leiderman, L., Razin, A. (Eds.), Capital Mobility: The Impact of Consumption, Investment and Growth Cambridge University Press, New York, 13-47.

Slayton, T. (2009). Rice Crisis Forensics: How Asian Governments Carelessly Set the World Rice Market on Fire. Working Paper 163, Center for Global Development.

Sorensen, B. E., and Yosha, O. (1998) International risk sharing and European monetary unification. Journal of International Economics, 45, 211–238.

Sorensen, B. E., Yosha, O., Wu, Yi-T., and Zhu, Y. (2007). Home Bias and International Risk Sharing: Twin Puzzles Separated at Birth. Journal of International Money and Finance, 26(4), 587–605.

Srinivasan, P. V. and Jha, S. (2001). Liberalized Trade and Domestic Price Stability. The Case of Rice and Wheat in India. Journal of Development Economics, 65(2), 417–441.

Townsend, R. M. (1994) Risk and Insurance in Village India. Econometrica, 62(3), 539-591.

Valdes, A. (Ed,) (1981) Food Security for Developing Countries. Westview Press, Boulder, CO.

Figures

Figure 1: Variance decomposition of world production growth

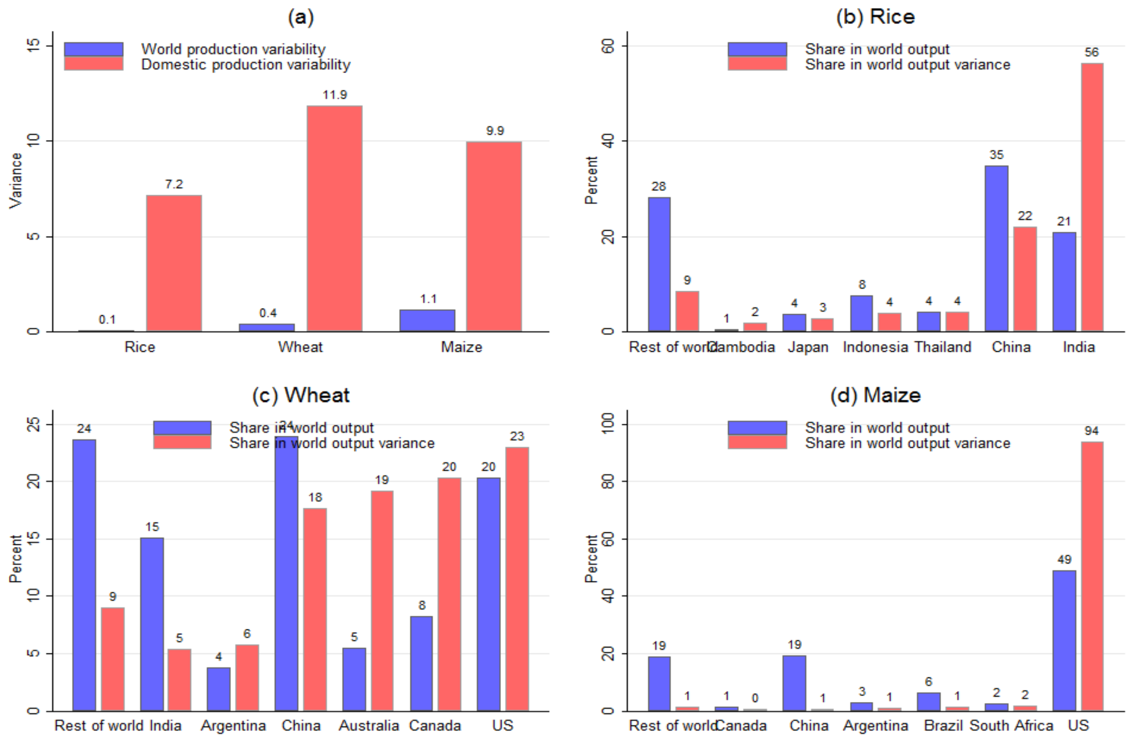


Figure 2: Commodity wise distribution of b_i

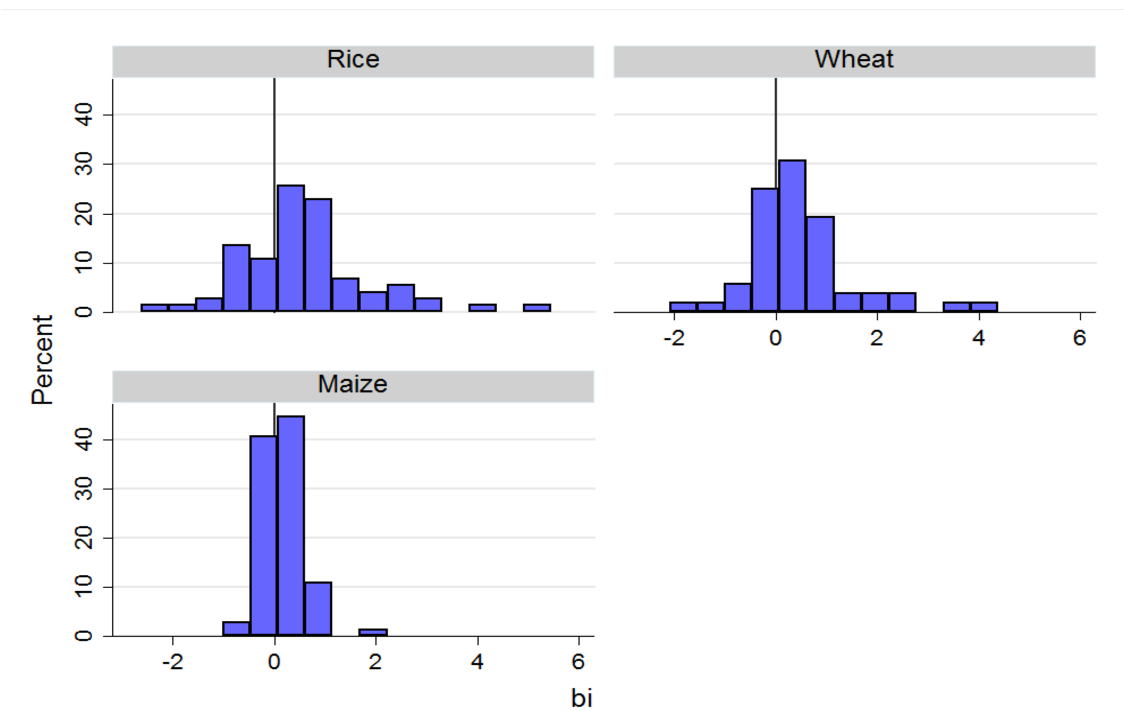


Figure 3: Trends in world exports as a share of world production (%)

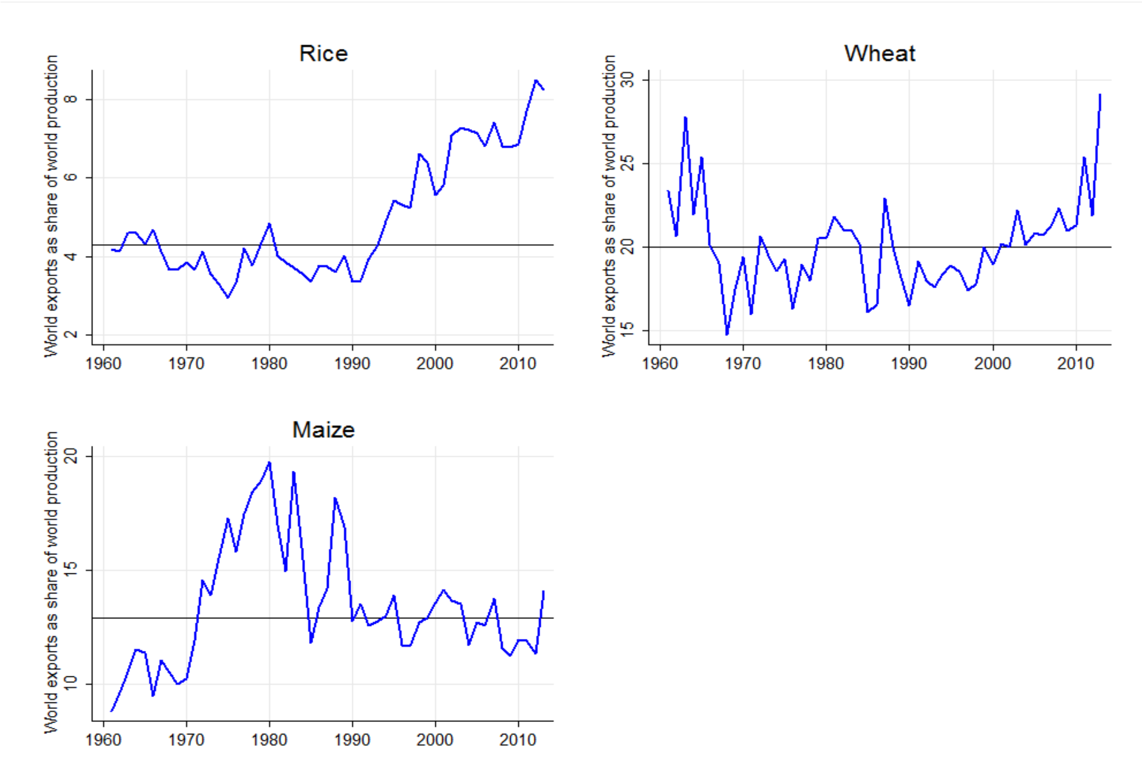
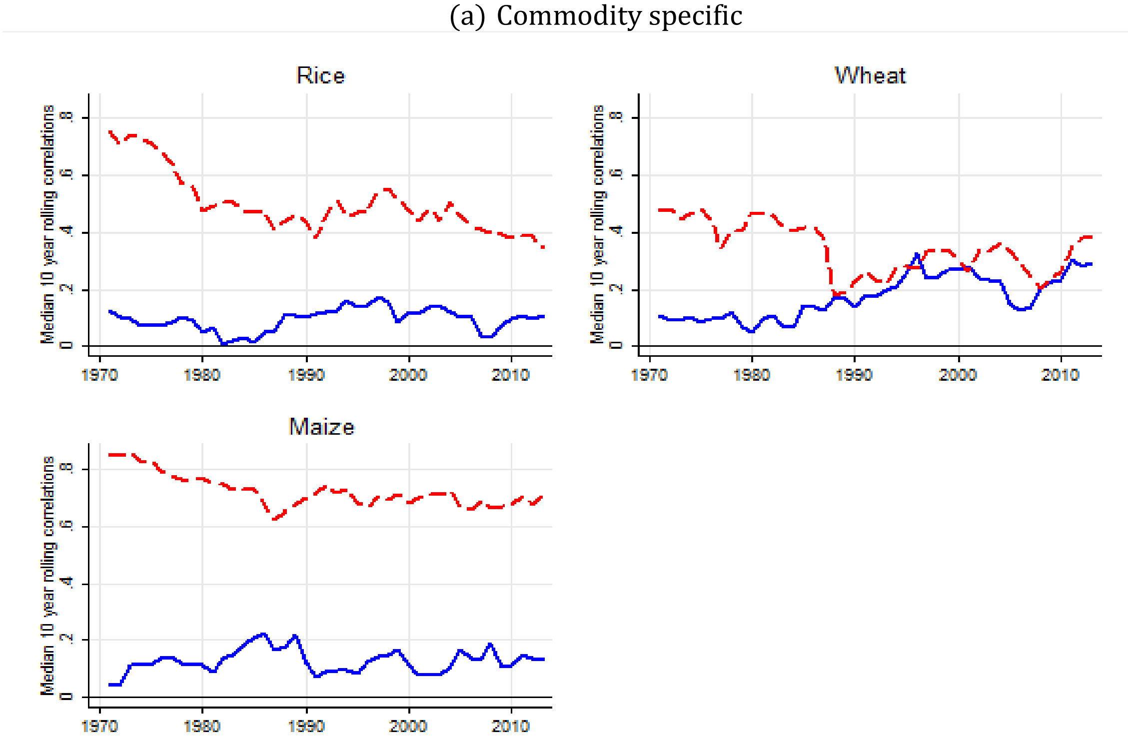
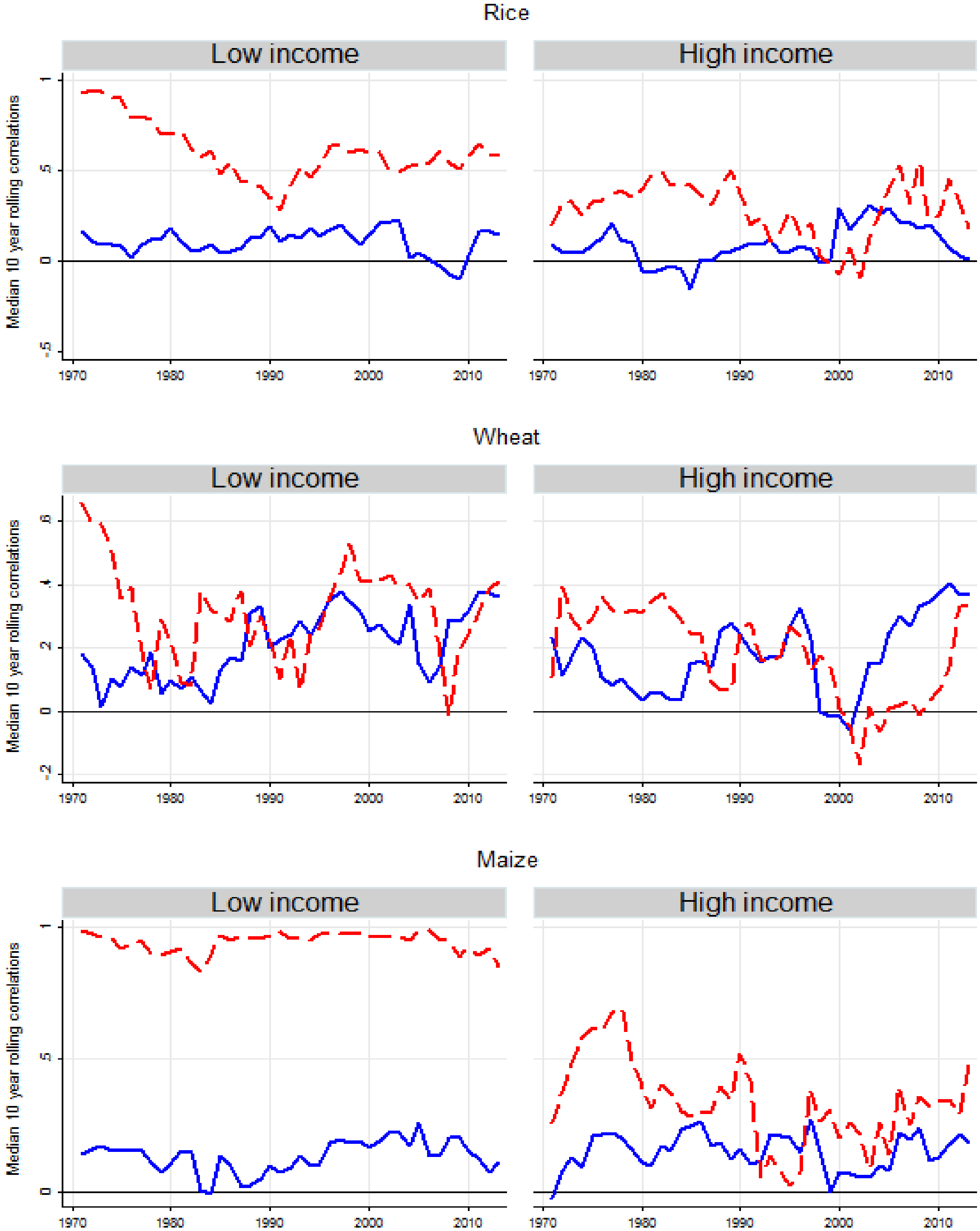


Figure 4. Median country wise decadal rolling correlations

(a) Commodity specific



(b) Country group specific



Note: Dashed line shows the correlations of domestic per capita consumption growth with domestic per capita production growth $corr(c_{it}, y_{it})$ and the solid line shows the correlations of domestic per capita consumption growth with its cross sectional average $corr(c_{it}, \bar{c}_t)$.

Tables

Table 1: Estimates of contribution of trade and change in stocks to consumption smoothing

	Rice				Wheat				Maize			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Contribution of trade to consumption smoothing (γ^T)												
Yit	**0.541*** (0.046)**	**0.543*** (0.045)**	**0.537*** (0.047)**	**0.539*** (0.047)**	**0.713*** (0.043)**	**0.717*** (0.045)**	**0.713*** (0.040)**	**0.714*** (0.042)**	**0.491*** (0.052)**	**0.493*** (0.053)**	**0.489*** (0.051)**	**0.497*** (0.053)**
$\bar{y}$t		-0.119 (0.118)				-0.130 (0.085)				-0.130 (0.115)		
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Time×Income groups	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Time×Regions	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Observations	4382	4382	4382	4382	3475	3475	3475	3475	5002	5002	5002	5002
R2-adjusted	0.232	0.232	0.228	0.215	0.444	0.444	0.447	0.478	0.287	0.287	0.283	0.286
B. Contribution of change in stocks to consumption smoothing (γ^S)												
Yit	**0.124*** (0.031)**	**0.122*** (0.031)**	**0.123*** (0.031)**	**0.123*** (0.033)**	**0.161*** (0.038)**	**0.161*** (0.038)**	**0.160*** (0.034)**	**0.160*** (0.037)**	**0.077*** (0.018)**	**0.077*** (0.018)**	**0.076*** (0.017)**	**0.075*** (0.018)**
$\bar{y}$t		0.0901 (0.066)				0.0246 (0.062)				0.0373 (0.045)		
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Time×Income groups	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Time×Regions	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Observations	4382	4382	4382	4382	3475	3475	3475	3475	5002	5002	5002	5002
R2-adjusted	0.0316	0.0317	0.0461	0.0199	0.0691	0.0689	0.0600	0.156	0.0472	0.0472	0.0240	0.0463
C. Residual (γ)												
Yit	**0.335*** (0.036)**	**0.335*** (0.036)**	**0.340*** (0.035)**	**0.338*** (0.037)**	**0.126*** (0.021)**	**0.123*** (0.022)**	**0.127*** (0.020)**	**0.126*** (0.021)**	**0.432*** (0.047)**	**0.431*** (0.048)**	**0.434*** (0.047)**	**0.428*** (0.049)**
$\bar{y}$t		0.0285 (0.099)				0.105 (0.065)				0.0932 (0.107)		
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Time×Income groups	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Time×Regions	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Observations	4382	4382	4382	4382	3475	3475	3475	3475	5002	5002	5002	5002
R2-adjusted	0.155	0.155	0.143	0.130	0.0493	0.0500	0.0669	0.0514	0.260	0.260	0.254	0.254

Figures in parenthesis are standard errors robust to heteroscedasticity and within-country serial correlation. Bar over variables denote cross sectional averages.

Income groups are low income, lower middle income, upper middle income and high income countries and are defined following the World Bank classification. Regions are East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia and Sub-Saharan Africa.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 2: Heterogeneity in γ^T, γ^S and γ

	A. Heterogeneity in γ^T			B. Heterogeneity in γ^S			C. Heterogeneity in γ		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Yit	0.221**	0.657***	0.150**	0.0259	0.0320	0.0615	0.754***	0.311***	0.789***
	(0.0872)	(0.0985)	(0.0579)	(0.0205)	(0.0296)	(0.0845)	(0.0808)	(0.111)	(0.123)
yit × Lower middle income	0.203	-0.0442	-0.0773	0.107	0.0315	-0.0105	-0.310**	0.0128	0.0877
	(0.177)	(0.140)	(0.123)	(0.0912)	(0.0640)	(0.0995)	(0.137)	(0.146)	(0.155)
yit × Upper middle income	0.190	0.0667	0.591***	0.225	0.0999	-0.0611	-0.415***	-0.167	-0.530***
	(0.198)	(0.126)	(0.106)	(0.158)	(0.0808)	(0.0903)	(0.124)	(0.116)	(0.147)
yit × High income	0.397	0.0265	0.580***	0.108	0.115	-0.0341	-0.505***	-0.142	-0.546***
	(0.247)	(0.163)	(0.121)	(0.169)	(0.161)	(0.0898)	(0.153)	(0.143)	(0.159)
yit × T	0.00977***	0.00511**	0.000182	-0.000208	0.000702	0.000197	-0.00956***	-0.00581**	-0.000379
	(0.00323)	(0.00220)	(0.00193)	(0.000434)	(0.00102)	(0.00210)	(0.00307)	(0.00242)	(0.00262)
yit × T × Lower middle income	-0.00227	-0.00390	0.00938**	-0.00112	0.00279	0.00128	0.00339	0.00111	-0.0107***
	(0.00601)	(0.00370)	(0.00429)	(0.00303)	(0.00199)	(0.00304)	(0.00477)	(0.00337)	(0.00384)
yit × T × Upper middle income	-0.0103*	-0.00564	-0.00241	0.00106	0.000495	0.00250	0.00920*	0.00515*	-0.0000892
	(0.00551)	(0.00414)	(0.00309)	(0.00311)	(0.00326)	(0.00238)	(0.00472)	(0.00263)	(0.00327)
yit × T × High income	-0.00921	-0.00509	0.00324	0.00300	0.00380	0.00118	0.00621	0.00129	-0.00442
	(0.00613)	(0.00507)	(0.00490)	(0.00293)	(0.00480)	(0.00276)	(0.00442)	(0.00331)	(0.00480)
Constant	-0.0123***	-0.00815***	-0.0140***	0.000552	0.000174	-0.000838**	0.0117***	0.00797***	0.0148***
	(0.00165)	(0.00223)	(0.00243)	(0.000664)	(0.000910)	(0.000352)	(0.00157)	(0.00188)	(0.00244)
Observations	4382	3475	5002	4382	3475	5002	4382	3475	5002
R2-adjusted	0.244	0.447	0.358	0.0502	0.0821	0.0525	0.179	0.0628	0.343
F-statistic	59.32	89.07	40.71	11.53	6.899	3.611	35.00	8.365	27.28

Base category is low income countries. T denotes a linear trend.
Figure in parenthesis are standard errors robust to heteroscedasticity and within-country serial correlation. Country groups are defined following the World Bank classification.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Robustness to additional controls

	Rice		Wheat		Maize	
	(1)	(2)	(3)	(4)	(5)	(6)
A. Contribution of trade to consumption smoothing (γ^T)						
yitRice	**0.500*** **	**0.497*** **	**0.0525**		**0.0109**	
	(0.0605)	**(0.0603)**	**(0.0460)**		**(0.0230)**	
yitWheat	**0.0136**		**0.670*** **	**0.673*** **	**0.0703*** **	
	(0.0227)		**(0.0779)**	**(0.0734)**	**(0.0215)**	
yitMaize	**0.0398**		**0.0356**		**0.512*** **	**0.522*** **
	(0.0275)		**(0.0393)**		**(0.0852)**	**(0.0857)**
ȳtRice	-0.157		-0.0683		-0.148	
	(0.228)		(0.170)		(0.132)	
ȳtWheat	0.0838		-0.0156		0.0157	
	(0.110)		(0.115)		(0.0918)	
ȳtMaize	-0.130		-0.0979		-0.168	
	(0.139)		(0.168)		(0.135)	
Constant	-0.00819***	-0.00926***	-0.00976***	-0.0105***	-0.0129**	-0.0146***
	(0.00287)	(0.00255)	(0.00356)	(0.00321)	(0.00484)	(0.00534)
Observations	2071	2071	2072	2072	2074	2074
R2-adjusted	0.187	0.186	0.347	0.345	0.324	0.318
F-statistic	17.07	67.87	39.54	83.99	14.97	36.99
B. Contribution of change in stocks to consumption smoothing (γ^S)						
yitRice	**0.187*** **	**0.190*** **	**-0.0528**		**-0.00602**	
	(0.0540)	**(0.0548)**	**(0.0437)**		**(0.00780)**	
yitWheat	**-0.0123**		**0.217*** **	**0.215*** **	**-0.00915**	
	(0.0200)		**(0.0739)**	**(0.0700)**	**(0.0117)**	
yitMaize	**0.00343**		**-0.0254**		**0.0962*** **	**0.0953*** **
	(0.0157)		**(0.0419)**		**(0.0232)**	**(0.0240)**
ȳtRice	0.0431		-0.0360		0.148*	
	(0.141)		(0.113)		(0.0757)	
ȳtWheat	-0.206**		-0.00973		-0.0576	
	(0.0829)		(0.0858)		(0.0448)	
ȳtMaize	0.314**		0.259**		0.0349	
	(0.134)		(0.105)		(0.0711)	
Constant	-0.00269	-0.000474	-0.00228	-0.000359	-0.000893	-0.000393
	(0.00173)	(0.00131)	(0.00181)	(0.00152)	(0.000857)	(0.000533)
Observations	2071	2071	2072	2072	2074	2074
R2-adjusted	0.0505	0.0470	0.0874	0.0826	0.0537	0.0518
F-statistic	3.212	12.09	4.312	9.446	3.728	15.75
C. Residual (γ)						
yitRice	**0.313*** **	**0.313*** **	**0.000289**		**-0.00484**	
	(0.0413)	**(0.0408)**	**(0.0148)**		**(0.0236)**	
yitWheat	**-0.00130**		**0.113*** **	**0.112*** **	**-0.0612** **	
	(0.0119)		**(0.0298)**	**(0.0286)**	**(0.0237)**	
yitMaize	**-0.0433** **		**-0.0102**		**0.392*** **	**0.383*** **
	(0.0211)		**(0.00974)**		**(0.0719)**	**(0.0719)**
ȳtRice	0.114		0.104		-0.000429	
	(0.169)		(0.113)		(0.116)	
ȳtWheat	0.122*		0.0253		0.0419	
	(0.0685)		(0.0860)		(0.0834)	
ȳtMaize	-0.185**		-0.161		0.133	
	(0.0895)		(0.120)		(0.124)	
Constant	0.0109***	0.00973***	0.0120***	0.0109***	0.0138***	0.0150***

	(0.00282)	(0.00250)	(0.00256)	(0.00245)	(0.00474)	(0.00526)
Observations	2071	2071	2072	2072	2074	2074
R2-adjusted	0.168	0.164	0.0309	0.0316	0.236	0.231
F-statistic	12.78	58.88	3.622	15.26	10.35	28.41

Figure in parenthesis are standard errors robust to heteroscedasticity and within-country serial correlation. Bar over variable denote cross sectional averages.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4: Robustness to lagged production shocks

	Rice				Wheat				Maize			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Contribution of trade to consumption smoothing (γ^T)												
Yit	**0.549*** **	**0.564*** **	**0.558*** **	**0.558*** **	**0.709*** **	**0.735*** **	**0.735*** **	**0.735*** **	**0.501*** **	**0.503*** **	**0.508*** **	**0.504*** **
	(0.0443)	**(0.0410)**	**(0.0406)**	**(0.0408)**	**(0.0460)**	**(0.0403)**	**(0.0399)**	**(0.0398)**	**(0.0504)**	**(0.0505)**	**(0.0525)**	**(0.0519)**
yit-1		0.0739***	0.0642**	0.0635**		0.0790***	0.0796***	0.0817***		0.00955	0.0187	0.00935
		(0.0280)	(0.0276)	(0.0271)		(0.0256)	(0.0276)	(0.0272)		(0.0176)	(0.0155)	(0.0153)
yit-2			-0.0426**	-0.0438**			0.00156	0.00711			0.0295	0.0139
			(0.0198)	(0.0195)			(0.0191)	(0.0187)			(0.0254)	(0.0209)
yit-3				-0.00536				0.0156				-0.0481***
				(0.0178)				(0.0181)				(0.0183)
Observations	4084	4084	4084	4084	3215	3215	3215	3215	4634	4634	4634	4634
R2-adjusted	0.240	0.244	0.246	0.245	0.432	0.437	0.437	0.437	0.308	0.308	0.309	0.311
F-statistic	153.7	170.0	117.1	88.18	237.4	309.3	209.7	185.7	98.72	49.74	38.86	32.32
B. Contribution of change in stocks to consumption smoothing (γ^S)												
Yit	**0.125*** **	**0.115*** **	**0.112*** **	**0.113*** **	**0.169*** **	**0.143*** **	**0.141*** **	**0.140*** **	**0.0820*** **	**0.0674*** **	**0.0674*** **	**0.0676*** **
	(0.0297)	**(0.0275)**	**(0.0273)**	**(0.0276)**	**(0.0400)**	**(0.0335)**	**(0.0333)**	**(0.0332)**	**(0.0186)**	**(0.0155)**	**(0.0153)**	**(0.0154)**
yit-1		-0.0538***	-0.0580***	-0.0567***		-0.0825***	-0.0885***	-0.0898***		-0.0532***	-0.0534***	-0.0527***
		(0.0169)	(0.0167)	(0.0163)		(0.0211)	(0.0216)	(0.0221)		(0.0125)	(0.0125)	(0.0122)
yit-2			-0.0183	-0.0161			-0.0166	-0.0200*			-0.000554	0.000574
			(0.0122)	(0.0115)			(0.0109)	(0.0105)			(0.00668)	(0.00595)
yit-3				0.00936				-0.00949				0.00347
				(0.00935)				(0.0108)				(0.00585)
Observations	4084	4084	4084	4084	3215	3215	3215	3215	4634	4634	4634	4634
R2-adjusted	0.0329	0.0385	0.0389	0.0389	0.0726	0.0881	0.0884	0.0883	0.0503	0.0701	0.0699	0.0698
F-statistic	17.84	8.872	5.911	4.581	17.97	9.242	6.446	5.575	19.54	10.23	6.876	5.182
C. Residual (γ)												
Yit	**0.326*** **	**0.322*** **	**0.329*** **	**0.329*** **	**0.122*** **	**0.123*** **	**0.125*** **	**0.125*** **	**0.417*** **	**0.429*** **	**0.425*** **	**0.428*** **
	(0.0353)	**(0.0335)**	**(0.0325)**	**(0.0329)**	**(0.0211)**	**(0.0199)**	**(0.0199)**	**(0.0199)**	**(0.0459)**	**(0.0469)**	**(0.0482)**	**(0.0479)**
yit-1		-0.0201	-0.00626	-0.00682		0.00347	0.00893	0.00808		0.0436***	0.0347**	0.0433***
		(0.0227)	(0.0220)	(0.0213)		(0.0149)	(0.0168)	(0.0160)		(0.0146)	(0.0168)	(0.0152)
yit-2			0.0609***	0.0600***			0.0151	0.0129			-0.0289	-0.0144
			(0.0207)	(0.0195)			(0.0139)	(0.0135)			(0.0260)	(0.0211)
yit-3				-0.00400				-0.00615				0.0446**
				(0.0203)				(0.0142)				(0.0193)
Observations	4084	4084	4084	4084	3215	3215	3215	3215	4634	4634	4634	4634
R2-adjusted	0.151	0.152	0.157	0.156	0.0454	0.0451	0.0454	0.0452	0.262	0.264	0.265	0.268
F-statistic	85.22	48.20	46.39	35.13	33.28	19.51	13.56	10.19	82.72	41.87	32.16	24.51

Figure in parenthesis are standard errors robust to heteroscedasticity and within-country serial correlation.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.