Courant Research Centre
‘Poverty, Equity and Growth in Developing and Transition Countries: Statistical Methods and Empirical Analysis’

Georg-August-Universität Göttingen
(founded in 1737)

Discussion Papers

No. 66

World Food Prices after WTO Foundation: Deterministic and Non-deterministic Factors in Production

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January 2011

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Abstract:

This paper develops a two-step method to estimate the influence of non-deterministic factors in production on subsequent food prices, and finds that non-deterministic factors of wheat production do significantly affect both wheat and corn prices in the world and, however, those of corn do not.

Key words: Non-Deterministic Factors, World Food Prices, WTO

1. Introduction

A huge spike in world food prices from 2006 to 2008, a so-called food crisis, triggered a lot of research in this field. Many institutes, such as FAO (2008), OECD (2008), USDA (Trostle 2008), the World Bank (Mitchell 2008) and IFPRI (von Braun 2007) published many research papers with which they tried to give reasons for such a price "explosion".

Many factors can influence food prices. On the one hand, supply events, such as weather effects, reduced stocks or changes in input prices could be responsible. On the other hand, demand-side factors can also be influential. For instance, rising biofuel production, rapid urbanization and fast income growth in transition countries (especially China and India) could increase the demand for agricultural products. Other explanations include the speculations in commodity markets and political interventions into food markets, such as subsidies and export embargoes.

Most of the current literature on food price analysis assumes that prices of inputs and outputs are certain, which in fact for farmers (and for economists as well) is not true. In particular, the price of output is often uncertain and not deterministic. Lags exist between the decision to produce and realization and sale of the output (Tomek and Robinson 2003, p.61). Any uncertainties during the process of realization, such as bad weather, diseases, or a financial crisis, can subsequently affect the market price systematically and are very difficult to predict by farmers or to capture by economists. Therefore it is very important to decompose the total quantity effects, which can affect the final food price, into deterministic (predicted) and non-determinitic (unpredicted) parts.

This article will develop a two-step method to fulfill the above-mentioned objective, to decompose the total effects of production into two parts: a deterministic part and a non-deterministic part. If there are no uncertainties (non-deterministic factors) and we assume that farmers know the production function and the demand function (more precisely, inverse demand function) as economists do, farmers can predict the output price based on their inputs (deterministic factors). However the non-deterministic factors during the process of food production may undermine the predictability. Non-deterministic factors in this study include all the uncertainties which are not observed by farmers or economists at the beginning of the production and can affect the production, as well as final market prices. The agricultural production processes are exposed to weather risks, political risks and financial market uncertainties. For instance, good weather may increase the output and lowers the output price, and vice versa. The weather effects are the most important non-deterministic factors, because they take place regularly. Studies, like Schnepf (2008) and Trostle (2008) summarize the bad weather events for the largest grain producing countries.

It has important policy implications to distinguish the deterministic and non-deterministic factors in food price analysis. If the non-deterministic factors are not significant, governments can coordinate the food production before the production to stabilize the food price. Otherwise, the government should provide more counter-risk measures to stabilize the food price, such as increasing government stocks, to increase the welfare of both farmers and consumers.

Using a two-step model and a panel dataset of almost 100 countries with the years between 1995 and 2007, we will study the deterministic and non-deterministic factors in world corn and wheat price variations after the foundation of WTO, given the fact that corn and wheat are two most important food products.

The rest of the article is organized as follows: first, we introduce the two-step model; second, introduce the data sources; then give the empirical results; and finally, give policy implications and conclusions.

2. The Model

In the first step, we separate the non-deterministic factors (the random components) from the deterministic factors in the production function. In the current literature, weather shock is considered one of the most important non-deterministic factors in agricultural production. Most studies use the deviation of the yield to measure it. For instance, a seminal work by Wright (1928) calculated the deviation from the yield with a trend and used it as an instrument variable for weather shock; and the recent analysis by Roberts and Schlenker (2009) estimated the impact of weather by a non-parametric time trend for the yield. However, these studies did not think too much over other possible inputs, as called the deterministic factors in this study, which also influence the yield.

After dividing the total quantity effect into deterministic factors and non-deterministic factors, we plug them into the inverse demand function to estimate their impacts on prices respectively. The model is set as follows.

2.1 The production function

We assume the production is

(1) $$Y_{it} = F(X_{it}, t_{it}, e_{it}),$$

where Y_{it} is the total output for country i at time t; X_{it} is a vector of inputs and t_{it} is the technology, and they are deterministic factors; e_{it} is the non-deterministic factor including weather, diseases and other factors which can affect the production but can not be observed or predicted.

Dividing Equation (1) by land input L_{it} in both sides, we have

(2) $$y_{it} = f(X_{it}, t_{it}, e_{it}),$$

where $y_{it} = Y_{it} / L_{it}$ which is the yield and $f(X_{it}, t_{it}, e_{it}) = F(X_{it}, t_{it}, e_{it}) / L_{it}$.

If we specify the production function of Equation (2) as a Cobb-Douglas form, and labor, land, and fertilizers are used as the inputs, we have

(3) $$\ln y_{it} = \beta_0 + \beta_1 \ln l_{it} + \beta_2 \ln c_{it} + \beta_3 \ln L_{it} + \gamma_1 t + \gamma_2 t^2 + e_{it}$$

where l_{it} and c_{it} respectively are the labor and fertilizer chemicals per unit of harvest area for country i at time t; L_{it} is the harvested land; and we use a quadratic form of time trend.

With the additional assumption of constant returns to scale for harvest area we can exclude the variable L_{it} from equation (3). In the empirical part, we estimate models both with and without the assumption of constant returns to scale for the sake of comparison.

Suppose the parameters in equation (3) can be observed by historical data. We estimate equation (3) for each country separately to obtain the production function for each country. If the production functions are known and there are no uncertainties, farmers can predict their outputs based on their inputs used. Suppose the predicted yield is $\hat{y}_{it}$, and the non-deterministic factor $e_{it} = \ln y_{it} - \ln \hat{y}_{it}$.

We can define $YSI_{it} \equiv \exp(e_{it}) = y_{it} / \hat{y}_{it} = Y_{it} / \hat{Y}_{it}$ as the Yield Shock Index. YSI_{it} is positive and measures the impact of non-deterministic factors. If YSI_{it} equals to one, there is no uncertainty and farmers (and economists as well) can predict the output perfectly; if YSI_{it} is less than one, the real output is less than the predicted output and the non-deterministic factors are unfavorable; and if the YSI_{it} is greater than one, the real output is greater than the predicted output and the non-deterministic factors are favorable.

Now, we have

$$Y_{it} = \hat{Y}_{it} * YSI_{it} \tag{4}$$

which decomposes the real outputs into deterministic and non-deterministic factors for wheat and corn respectively, which will be substituted into the inverse demand function in the second step to predict the output prices.

2.2 The inverse demand function

We also assume that farmers know the demand function in the world, so that the price is

$$P_{it} = \tilde{G}(Q_{it}, Pop_{it}, t) \tag{5}$$

where P_{it}, Q_{it} and Pop_{it} respectively are price, food quantity and population size in country i at time t. Food quantity in the market may be determined by country i's production Y_{it}, stock change ΔS_{it} and net import ΔT_{it}, so that

(6) $$Q_{it} = Y_{it} + \Delta S_{it} + \Delta T_{it}$$

We can also assume that the stock is determined by the current production Y_{it}, agricultural land size $\tilde{L}_{it}$, and population Pop_{it}, because governments and farmers may adjust their stocks based on these factors. For instance, when the Yield Shock Index is below one, governments may decrease their stocks to increase supply, while farmers may increase their stocks in order to make more profits, and therefore the aggregate effects could be ambiguous. That is

(7) $$\Delta S_{it} = S(Y_{it}, \tilde{L}_{it}, Pop_{it}) .$$

The net import of food for country i, ΔT_{it}, is assumed to be determined by the current production Y_{it}, agricultural land size $\tilde{L}_{it}$, population Pop_{it}, income per capita GNI_{it}, and possibly the stock change ΔS_{it}. In particular, land size and population are resource endowments for food production, and the income per capita shows the food purchase ability for a country in the world market. We have

(8) $$\Delta T_{it} = T(Y_{it}, \tilde{L}_{it}, Pop_{it}, GNI_{it}, \Delta S_{it})$$

Substituting Equation (4), (6) ,(7) and (8) into Equation (5) gives

(9) $$P_{it} \approx G(\hat{Y}_{it}, YSI_{it}, \tilde{L}_{it}, Pop_{it}, GNI_{it}, t)$$

Then equation (9) can be specified a log-linear form which can be seen as a first-order approximation for equation (9),

(10) $$\ln P_{it} = \alpha_0 + \alpha_1 \ln \hat{Y}_{it} + \alpha_2 \ln \tilde{L}_{it} + \alpha_3 \ln Pop_{it} + \alpha_4 \ln GNI_{it} + \theta * YSI_{it} + \lambda_1 t + \lambda_2 t^2$$

In equation (10) we add a linear and a quadratic trend to capture the price changes over time. θ captures the effects of non-deterministic factors on food prices.

We use a panel dataset consisting of almost 100 countries. The price units of the currencies are different. In order to overcome this difficulty, we take first-order differences of equation (10),

(11) $$d\ln P_{it} = \alpha_1 d\ln \hat{Y}_{it} + \alpha_2 d\ln \tilde{L}_{it} + \alpha_3 d\ln Pop_{it} + \alpha_4 d\ln GNI_{it} + \theta * dYSI_{it} + \lambda_1 + \lambda_2 dt^2$$

In equation (11), the dependent variable $d\ln P_{it} = \ln(P_{it} / P_{i,t-1})$ becomes the log of price index which is consistent in units cross countries.

Furthermore, this paper studies the two important agricultural products: wheat and corn. Because of the substitution effects between them, we should include both quantities in each price function. The final functions for world corn and wheat respectively are

(12a) $$d\ln P_{it}^{w} = \alpha_1^{w} d\ln \hat{Y}_{it} + \alpha_1^{c} d\ln Y_{it}^{c} + \alpha_2 d\ln \tilde{L}_{it} + \alpha_3 d\ln Pop_{it} + \alpha_4 d\ln GNI_{it}$$

$$+\theta^{w} * dYSI_{it}^{w} + \theta^{c} * dYSI_{it}^{c} + \lambda_1 + \lambda_2 dt^2$$

(12b) $$d\ln P_{it}^{c} = \alpha_1^{c} d\ln \hat{Y}_{it} + \alpha_1^{w} d\ln Y_{it}^{w} + \alpha_2 d\ln \tilde{L}_{it} + \alpha_3 d\ln Pop_{it} + \alpha_4 d\ln GNI_{it}$$

$$+\theta^{c} * dYSI_{it}^{c} + \theta^{w} * dYSI_{it}^{w} + \lambda_1 + \lambda_2 dt^2 .$$

Here the superscripts w and c respectively are indicating wheat and corn.

In the rest of the paper, we will use a panel dataset with almost 100 countries from 1995 through 2007 from FAO to empirically study the determinants of food price after the foundation of WTO.

3. The Dataset

In the first step, we assume that the production function for each country is different, so that, in order to construct the Yield Shock Index for each country, we estimate the equation (3) by OLS for each country separately. The Productions and harvest areas for wheat and corn respectively are directly obtained from the FAOStat database. Because FAO does not have labor input and fertilizer input for each product, we use the rural population as a proxy for labor input, and per hectare fertilizer inputs as a proxy for fertilizer input for corn and wheat respectively. Fertilizer chemicals include Nitrogen (N), Phosphate (P) and Potash (K), which together are included in the production function. In order to obtain more degrees of freedom for each country, we use the data after 1990 rather than after 1995 for each country to get the predicted production and the Yield Shock Index.[1]

In the second step, the variables of agricultural land size $\tilde{L}_{it}$, corn price P_{it}^{c}, and wheat price P_{it}^{w} are also obtained from FAOStat. The prices in FAOStat are the farm-gate prices, which are the mean price of all "grades, kinds and varieties" (FAOStat 2009) for a particular crop in a country.

However, FAO only reports the price for each country using the current value of that country's currency. Some countries changed their currencies during this period, some EU countries for example, and we integrate the old currencies into the new ones. Inflation also affects the real prices, so that we also use the CPI for each country to adjust the current price to the price in 2007.

The variables of CPI, and population Pop_{it}, and income per capita GNI_{it} are obtained from the World Development Index of the World Bank.

The WTO was founded in 1995, hence the data used in the second step dates from 1995 onwards. The food price in each country would be more relevant because of less-barrier trade under WTO. The countries used in this study are producers of wheat or corn. The number of countries for the two commodity datasets are different, and more countries produce corn than wheat. The distribution of the countries is shown in table 1.

"Insert Table 1"

4. Empirical Results

Because the separation of production into a deterministic and a non-deterministic factor cannot be reported here in detail for all countries, figure 1 documents the averages of the two harvest indices for each time period. The graphs reveal the years, which are most influenced by weather effects, diseases, financial or political crises. The wheat production for example was negatively influenced by non-deterministic factors in the years 2006 and 2007. Trostle (2008) finds that this unexpected output decrease of wheat in some important countries is caused by droughts. Besides, we can ascertain that the harvest indices of wheat and corn are, as expected, uncorrelated ($\rho = 0.05$). Additionally, figure 1 documents the average prices relative to the previous year.

"Insert Figure 1"

In the second step of the method, a panel of countries is used. Variables like expected production ($\hat{Y}_{it}$) and income (GNI_{it}) are adjusted for population size to make their effects comparable on the state level. The development over time of the averages of all variables used is displayed in tables 2 and 3 for the inverse demand functions of wheat and corn, respectively. The tables show the difference between the wheat and corn producing countries in terms of population, income and acreage.

"Insert Tables 2 and 3"

The estimated results of Equation (12a) for wheat and (12b) for corn are reported in table 4 and table 5 respectively. In particular, Model 1.1 and Model 2.1, which assume non-constant returns to scale in the first step, are the full models which we are interested in, and on which the following discussion will be based. In order for comparison and robustness check, we also reported the results of different models for either product. For instance, Model 1.2 and 2.2 assume constant returns to scale in the first stage.

"Insert Tables 4 and 5"

First, the results of the estimation reveal a clear and consistent picture about impacts of non-deterministic factors on food prices. The Yield Shock Index of wheat is statistically significant both for wheat and corn prices, while the Yield Shock Index of corn is not statistically significant either for wheat or for corn prices. This implies that the non-deterministic factors in wheat production can significantly influence both prices in the inverse demand function, while those in corn production can not. For instance, an unexpected negative shock in wheat harvest, (e.g. caused by bad weather) can push up both commodity prices, while shocks on corn production have no impacts on both prices. It implies that wheat is a strong substitute for corn and not vice versa. Furthermore, the cross price elasticity in terms of the non-deterministic factors of wheat is

(13) $$\frac{d\ln(P^w)}{d\ln(P^c)} = \left.\frac{d\ln(P^w)\big/dYSI^w}{d\ln(P^c)\big/dYSI^w}\right|_w = \frac{-0.0909}{-0.1365} = 0.67$$

Interestingly, the impact of non-deterministic factors of wheat on corn is larger than those on wheat.

The findings of the importance of non-deterministic factors in wheat production are consistent with some recent research. For instance, Saunders, Kaye-Blake, and Cagatay (2009) use a partial equilibrium model and find that wheat prices react on a stronger level to weather effects, while the corn price does not; and Headey and Fan (2008) also propose weather effects in wheat production as an explanation for price movements.

In addition, the predicted output of wheat has a significantly negative influence on its own price, but not a cross effect on corn. As expected, a higher expected output of wheat results in falling prices. However, the impact of expected output of corn is not significant either on wheat prices or on corn prices itself.

Second, the coefficients for per capita income are negative and statistically significant at 1% level both in wheat price function and in corn price function. The elasticity of wheat prices with respect to per capita income is -0.315, and the elasticity of corn prices with respect to per capita income is -0.717. It implies that food prices within a country can decrease when a country is richer, which is consistent with our prediction. As predicted in our theory, per capita income is a proxy for the purchase power in the world market, so that a richer country can purchase more food in the world when the domestic supply is not sufficient.

Third, other input factors, like population size and agricultural land are not statistically significant, which indicates those factors are not so important in determining food prices.

Furthermore, the time trends are statistically highly significant both in first and in second order, either in corn equation or in wheat equation. In particular, the coefficients for the time trend are 0.005 and -0.111 respective for the second-order and the first-order term in the wheat equation. It implies that the world wheat prices move in a U-shape after 1995 and reaches the lowest point between 2005 and 2006. The coefficients for the time trend are 0.008 and -0.203 for the second-order and the first-order term in the corn equation respectively. It implies that the world corn prices also move in a U-shape after 1995 and reaches the lowest point between 2006 and 2007.

For each of the two models the R^2 is low, which means that there are also other factors which could influence the prices.

Tables 4 and 5 also report the results of other models with different specifications and different time periods, and we find that the results are quite consistent with those in Model 1.1 and Model 2.1. For instance, even though we put a constraint of constant return to scale in the production functions, the results in the second stage reported as the results of Models 1.2 and 2.2 are quite close to those in Model 1.1 and 2.1, respectively. This implies that our econometric models are quite robust.

5. Variance Decomposition

In order to measure the importance of the non-deterministic factors, we apply a variation analysis to decompose the total variances of food prices into different factors. Usually, adding a explanation variable in a regression model can decrease the variance of residuals due to the explanation power, so that we can decompose the total variance into different factors. The results of variances analysis are reported in table 6.

"Insert Table 6"

The benchmark models are Model 1.1 and 1.2 in Tables 2 and 3, respectively. First we exclude YSI^{w} to reveal its explanation power. Then, we remove all other quantity variables (YSI, $\hat{Y}$) to obtain the explanation power of total quantitative effects. The numbers of observation are kept constant in order for compatibility.

We find that the non-deterministic factors in production function can explain 18.7% and 15.4% respectively for wheat and corn in total quantity effect. Surprisingly, the numbers are not so high. It implies that farmers can predict more than 80% of the price changes caused by production.

Furthermore, we also find that non-deterministic factors in production function only explain 3.2% and 1.6% respectively for wheat and corn in total explained effects for price functions. It implies that non-deterministic factors in wheat production have significant but small effects on world food prices.

6. Conclusions

Agricultural production involves a lot of uncertainties, comprising natural risks and market risks, and resulting from time lags between the planning, realization and sale of output. A shock during the production can, of course, affect the outputs of agricultural products, which in turn may impact the final market price in a region or a country. As many scholars argued, the recent food crisis might be partially caused by the non-deterministic factors in agricultural production, such as bad weather in some agricultural countries. However, few studies have been conducted for quantitatively studying the impacts of uncertainties in production on final market prices in the world.

This study develops a two-step method to study the impacts of uncertainties in production on world food prices, and then empirically analyze the prices of wheat and corn, the two most important staple foods, for almost 100 countries from 1995 to 2007.

The results of our econometric model show that non-deterministic factors of wheat, denoted by the Yield Shock Index, have significant impacts on both wheat and corn prices, while that of corn is not significant either for wheat or for corn prices. It may be explained by the fact that wheat is a strong substitute for corn, but not vice versa. The results also indicate that food prices can decrease as per capita incomes increase in a country, mainly due to higher purchase power in the world market.

Finally, we also use variance analysis to decompose the total quantity effects in production into deterministic and non-deterministic factors, and we find that more than 80% of the total quantity effects can be explained by deterministic factors. However, this study also concludes that the non-deterministic factors in wheat production have significant but small impacts on world food prices, and the non-deterministic factors in corn production have even much smaller effects.

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Table 1. Distribution of the Wheat and Corn Production by Continents

Commodity	Africa	America	Asia	Oceania	Europe	total
wheat	18	14	30	1	34	97
corn	27	23	28	2	22	102

Table 2. Average Data of Equation (12a)

Year	$\hat{Y}^w$	YSI^w	GNI	Pop	$\tilde{L}$	$\hat{Y}^c$	YSI^c
	hg/1000 people		$/1000 people	1000 people	1000 ha	hg/1000 people	
1995	291463	1.013	6916	50653	44699	217860	0.9886
1996	307721	1.019	7345	51328	44699	255723	1.010
1997	328640	0.9897	7537	52092	44676	250820	1.055
1998	312631	1.021	7278	52753	44755	236876	0.9948
1999	321293	0.9968	7223	53411	44834	227938	1.029
2000	304200	0.9872	7329	54063	44893	239354	0.9870
2001	302489	1.031	7208	54712	44947	244588	1.012
2002	316963	1.020	7185	55357	44761	267087	1.038
2003	306401	0.9980	7991	56000	44573	301918	0.9886
2004	314601	1.034	9537	56640	44609	327227	1.034
2005	310659	1.005	10977	57280	44723	341461	0.9941
2006	309369	0.9957	12004	57919	44981	321329	1.040
2007	271099	0.9949	13022	58557	44585	301731	0.9889

Table 3. Average Data of Equation (12b)

Year	$\hat{Y}^c$	YSI^c	GNI	Pop	$\tilde{L}$	$\hat{Y}^w$	YSI^w
	hg/1000 people		$/1000 people	1000 people	1000 ha	hg/1000 people	
1995	183164	0.9885	5132	47918	41505	225704	1.010
1996	207663	1.011	5423	48593	41513	236437	1.013
1997	208043	1.045	5480	49323	41505	247813	0.9823
1998	206064	0.9807	5257	49984	41587	237570	1.029
1999	195740	1.026	5197	50639	41550	248706	1.006
2000	201523	1.007	5204	51290	41610	230374	0.9842
2001	206053	1.019	5119	51937	41677	231084	1.030
2002	225539	1.030	5171	52581	41510	243477	1.017
2003	244722	1.000	5651	53221	41492	223764	0.9961
2004	259162	1.038	6657	53861	41534	226889	1.042
2005	272973	1.006	7596	54499	41543	226409	1.001
2006	263150	1.037	8283	55137	41465	229495	0.9997
2007	247256	0.9744	8962	55775	41426	196679	0.9920

Table 4. Results of the Estimation of the Demand Function for Wheat

Wheat	Model 1.1		Model 1.2		Model 1.3		Model 1.4		Model 1.5		Model 1.6	
	Non-Constant-Return-to- Scale		Constant-Return-to-Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale	
	coef	t-ratio	coef	t-ratio	coef	t-ratio	coef	t-ratio	coef	t-ratio	coef	t-ratio
YSI^w	-0.091	-2.57**	-0.095	-2.73**	—	—	-0.091	-2.53*	-0.067	-2.20**	-0.087	-2.29**
$\log(\hat{Y}^w)$	-0.065	-2.91**	-0.064	-2.86***	—	—	-0.071	-3.16***	-0.061	-3.06***	-0.079	-3.29***
$\log(Y^w)$	—	—	—	—	-0.003	-3.06***	—	—	—	—	—	—
YSI^c	0.014	0.48	0.003	0.10	-0.001	-0.05	0.006	0.21	—	—	0.004	0.14
$\log(\hat{Y}^c)$	-0.006	-0.22	0.002	0.06	-0.014	-0.58	-0.006	-0.24	—	—	0.025	0.83
$\log(GNI)$	-0.315	-4.12***	-0.315	-4.13***	-0.312	-4.07***	-0.179	-2.48**	-0.321	-4.56***	-0.319	-3.90***
$\log(Pop)$	-0.285	-0.48	-0.291	-0.50	-0.273	-0.47	-0.288	-0.49	0.239	0.46	0.845	1.35
$\log(\tilde{L})$	-0.173	-0.67	-0.173	-0.67	-0.187	-0.72	-0.202	-0.77	-0.006	-0.20	-0.259	-0.97
t^2	0.005	4.90***	0.005	4.89***	0.005	4.89***	—	—	0.005	5.46***	0.002	1.55
t	-0.111	-4.51***	-0.111	-4.50***	-0.111	-4.48***	-0.004	-0.38	-0.119	-5.47***	-0.072	-2.49**
R^2	0.0529		0.0533		0.0468		0.0272		0.0503		0.0486	
Sample Size	892		892		892		892		1076		747	
Time Period	1995-2007		1995-2007		1995-2007		1995-2007		1995-2007		1995-2005	

Note: *significant at 10%; **significant at 5%; ***significant at 1%.

Table 5. Results of the Estimation of the Demand Function for Corn

Corn	Model 2.1		Model 2.2		Model 2.3		Model 2.4		Model 2.5		Model 2.6	
	Non-Constant-Return-to- Scale		Constant-Return-to-Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale		Non-Constant-Return-to- Scale	
	coef	t-ratio	coef	t-ratio	Coef	t-ratio	coef	t-ratio	coef	t-ratio	coef	t-ratio
YSI^c	0.038	0.62	0.026	0.43	—	—	0.028	0.46	-0.002	-0.04	0.014	0.24
$\log(\hat{Y}^c)$	-0.042	-0.73	-0.025	-0.45	—	—	-0.037	-0.65	-0.015	-0.33	0.011	0.21
$\log(Y^c)$	—	—	—	—	-0.0006	-1.60	—	—	—	—	—	—
YSI^w	-0.137	-1.79*	-0.131	-1.76*	-0.082	-1.15	-0.139	-1.81*	—	—	-0.147	-2.22**
$\log(\hat{Y}^w)$	0.044	0.92	0.043	0.87	0.043	0.92	0.033	0.68	—	—	0.030	0.71
$\log(GNI)$	-0.717	-4.22***	-0.716	-4.22***	-0.683	-4.18***	-0.489	-3.06***	-0.586	-4.12***	-0.371	-2.47**
$\log(Pop)$	1.041	0.85	1.001	0.81	0.998	0.81	1.041	0.83	0.708	0.69	2.574	2.32**
$\log(\tilde{L})$	-0.202	-0.37	-0.205	-0.37	-0.084	-0.16	-0.250	-0.45	-0.125	-0.27	-0.117	-0.25
t^2	0.008	3.72***	0.008	3.74***	0.008	3.52***	—	—	0.006	3.57***	0.006	2.49**
t	-0.203	-3.77***	-0.204	-3.79***	-0.190	-3.58***	-0.026	-1.02	-0.159	-3.64***	-0.190	-3.69
R^2	0.0329		0.0326		0.0321		0.0172		0.0219		0.302	
Sample Size	857		857		873		857		1088		720	
Time Period	1995-2007		1995-2007		1995-2007		1995-2007		1995-2007		1995-2005	

Note: *significant at 10%; **significant at 5%; ***significant at 1%.

Table 6. Variation Analysis for the Effect of YSI^w on the Prices

Prices	Wheat	Corn
Equation	Variance	Variance
Equations (12)	0.0443	0.2048
Equations (12) without YSI^w	0.0446	0.2054
Equations (12) without all quantity effects	0.0458	0.2083
Total variation of price	0.0474	0.2132
Explication	%	%
YSI^w in total quantity effect	18.7	15.4
YSI^w in total explained variation	3.2	1.6

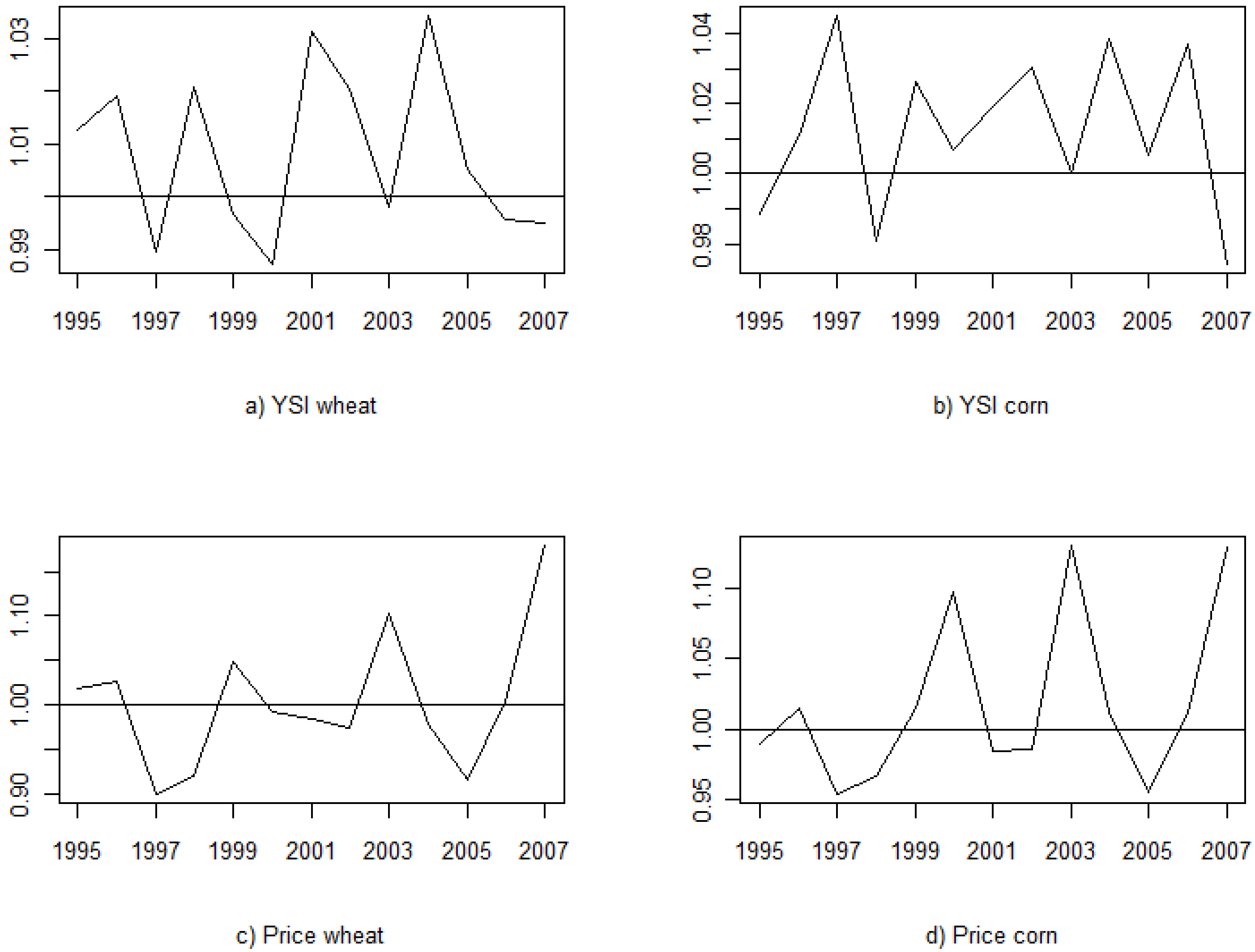

Figure 1: Average YSI^w, YSI^c and relative commodity prices

[1] FAO changed the standard of fertilizer statistics after 1990, so that we use the data after 1990, not earlier.