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

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1. Introduction

Agricultural production involves a lot of uncertainties, comprising natural risks and market risks, resulting from time lags between the planning, realization and sale of output (see Tomek and Robinson (2003) p. 61). 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 several 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 or non-deterministic factors in production on world food prices, and then empirically analyzes the prices of wheat and corn, the two most important staple foods, for almost 100 countries after the foundation of WTO.

2. A two-step Method

In the first-step the aggregate production function is separately estimated for each country. We assume the production function is in Cobb-Douglas form, and derive the yield function.

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

where y_{it}, l_{it}, c_{it} and L_{it} respectively are the yield, labor per unit of harvested land, fertilizer chemicals per unit of harvested land , and harvested land for country i at time t, respectively; and we use a quadratic form of of t to capture the deterministic technological changes. Then, we can define $HI_{it} \equiv \exp e_{it} = y_{it}/\hat{y}_{it} = Y_i t/\hat{Y}_{it}$ as the Harvest Index, which captures the non-deterministic factors. In the second step, we derive an inverse demand function for all countries,

$$\log P_{it} = \alpha_0 + \alpha_1 \log \hat{Y}_{it} + \alpha_2 \log \tilde{L}_{it} + \alpha_3 \log Pop_{it} + \alpha_4 \log GNI_{it} + \theta HI_{it} + \lambda_1 t + \lambda_2 t^2$$

Where P_{it} is the food price; Y_{it} is the predicted output from the first stage; and L_{it}, Pop_{it}, and GNI_{it} are the agricultural land size, population, and income per capita, respectively. Then, θ exactly captures the effects of non-deterministic factors on food prices. Finally, we can decompose the total variances in the last equation to see how much of the variation is explained by HI_{it} and by $\log \hat{Y}_i t$.

References

[1] W.G. Tomek, K.L. Robinson. *Agricultural Product Prices* Cornell University Press, 2003

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3. The Dataset

The panel dataset consists of agricultural time series from FAOStat and demographic and fiscal time series from the World Development Index of the World Bank. The data for the first step covers the years from 1990 to 2007 to increase the degrees of freedom. The data used in the second step dates from 1995 onwards, the WTO was founded then, because the food price in each country would be more relevant and less distorted because of less-barrier trade under WTO. The countries used in this study are producers of wheat or corn. The distribution of the countries is shown in the table:

commodity	Africa	America	Asia	Australia	Europe	total
wheat	18	14	30	1	34	97
corn	27	23	29	2	24	105

4. Results & Conclusions

The estimation results of the inverse demand functions show that the harvest index of wheat significantly influences wheat (Table 1; Model 1.1) and corn (Table 2; Model 2.1) price, which means the non-deterministic factor in wheat production can influence both prices. For instance, an unexpected small negative shock on wheat harvest, (e.g. caused by bad weather) will push up both commodity prices. In Models 1.2- 1.5 and 2.2- 2.5 we change the assumption of constant returns to scale of land and test the robustness of the results.

Additionally we can calculate the cross price elasticity in terms of the non-deterministic factors of wheat:

$$\frac{d\log p^w}{d\log p^c} = \frac{d\log p^w/dHI^w}{d\log p^c/dHI^c}\Big|_w = \frac{-0.0909}{-0.1365} = 0.67$$

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

With the variation analysis 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. 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.

Table 1

Wheat	Model 1.1		Model 1.2		Model 1.3		Model 1.4		Model 1.5	
	Non-Constant-Return-to-Scale		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
HI^w	-0.091	-2.57	-0.095	2.73			-0.091	-2.53	-0.067	-2.20
$\log(\hat{Q}^w)$	-0.065	-2.91	-0.064	-2.86			-0.071	-3.16	-0.061	-3.06
$\log(Q^w)$					-0.003	-3.06				
HI^c	0.014	0.48	0.003	0.10	-0.001	-0.05	0.006	0.21		
$\log(\hat{Q}^c)$	-0.006	-0.22	0.002	0.06	-0.014	-0.58	-0.006	-0.24		
$\log(GNI)$	-0.315	-4.12	-0.315	-4.13	-0.312	-4.07	-0.179	-2.48	-0.321	-4.56
$\log(Pop)$	-0.285	-0.48	-0.291	-0.50	-0.273	-0.47	-0.288	-0.49	0.239	0.46
$\log(AgA)$	-0.173	-0.67	-0.173	-0.67	-0.187	-0.72	-0.202	-0.77	-0.006	-0.20
t^2	0.005	4.90	0.005	4.89	0.005	4.89			0.005	5.46
t	-0.111	-4.51	-0.111	-4.50	-0.111	-4.48	-0.004	-0.38	-0.119	-5.47
R^2	0.0529		0.0533		0.0468		0.0272		0.0503	
Sample Size	892		892		892		892		1076	

Table 2

Corn	Model 2.1		Model 2.2		Model 2.3		Model 2.4		Model 2.5	
	Non-Constant-Return-to-Scale		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
HI^c	0.038	0.62	0.026	0.43			0.028	0.46	-0.002	-0.04
$\log(\hat{Q}^c)$	-0.042	-0.73	-0.025	-0.45			-0.037	-0.65	-0.015	-0.33
$\log(Q^c)$					-0.0006	-1.60				
HI^w	-0.137	-1.79	-0.131	-1.76	-0.082	-1.15	-0.139	-1.81		
$\log(\hat{Q}^w)$	0.044	0.92	0.043	0.87	0.043	0.92	0.033	0.68		
$\log(GNI)$	-0.717	-4.22	-0.716	-4.22	-0.683	-4.18	-0.489	-3.06	-0.586	-4.12
$\log(Pop)$	1.041	0.85	1.001	0.81	0.998	0.81	1.041	0.83	0.708	0.69
$\log(AgA)$	-0.202	-0.37	-0.205	-0.37	-0.084	-0.16	-0.250	-0.45	-0.125	-0.27
t^2	0.008	3.72	0.008	3.74	0.008	3.52			0.006	3.57
t	-0.203	-3.77	-0.204	-3.79	-0.190	-3.58	-0.026	-1.02	-0.159	-3.64
R^2	0.0329		0.0326		0.0321		0.0172		0.0219	
Sample Size	857		873		857		857		1088	