Economics Discussion Paper Series EDP-1113

Re-examination of supply response to changes in food commodity prices in Asian countries

Katsushi Imai

Raghav Gaiha

Ganesh Thapa

Abdilahi Ali

May 2011

Economics
School of Social Sciences
The University of Manchester
Manchester M13 9PL

Re-examination of Supply Response to Changes in Food Commodity Prices in Asian Countries

Katsushi S. Imai*†
Economics, School of Social Sciences, University of Manchester, UK

Raghav Gaiha
Faculty of Management Studies, University of Delhi, India,
&
Department of Global Health and Population, Harvard University, Cambridge, MA, USA

Ganesh Thapa
International Fund for Agricultural Development, Rome, Italy

Abdilahi Ali
Economics, School of Social Sciences, University of Manchester, UK

May, 2011

Abstract

As an extension to Imai *et al.* (2011), this paper re-examines how commodity and input prices have affected the supply of key food commodities in 10 Asian economies. The results indicate that own prices negatively affects supply of rice, maize, wheat, fruits and vegetables. We also find that key input prices of oil and fertilizers have a negative impact on food supply. If high oil prices persist-as feared-the recent food price surge is also likely to persist. If our analysis has any validity, alarmist predictions of rise in poverty are contentious. However, as agricultural price uncertainty and volatility are likely to continue, largely as a result of the persistent uncertainty over supply against rising demand, quicker transmission of international prices to farm gate prices-especially to smallholders-open trade policies and greater investment in agricultural research and extension are imperative.

Key Words: *food commodities, prices, panel data, supply responses, smallholders, Asia*
JEL Codes**: C2, O13, Q11**

Invited contribution to the panel: Food Security in Times of Price Surge and Climate Change, World Congress, International Economic Association, Beijing, 3 July-9th July, 2011.

***Contact Address**

Katsushi S. Imai (Dr) Economics, School of Social Sciences, University of Manchester, Arthur Lewis Building, Oxford Road, Manchester M13 9PL, UK; Telephone: +44-(0)161-275-4827, Fax: +44-(0)161-275-4812 Email: Katsushi.Imai@manchester.ac.uk.

Re-examination of Supply Response to Changes in Food Commodity Prices in Asian Countries[1]

1. Introduction

A number of hypotheses have been put forward to explain the global rise in agricultural commodity prices. Some have identified demand-side factors as the culprit while others have emphasised supply-side effects- especially rising oil and other input prices.

Against this background, Imai *et al.* (2011) examined the extent to which commodity yields responded to price changes using country-panel data for 10 Asian countries covering the period 1966-2005. The present study revisits the same issue and explores how rising food commodity and input prices have influenced supply of major agricultural commodities in Asia. More specifically, we will econometrically test (i) whether an output price (or its own price) positively affects supply of a major food commodity (that is, rice, maize, wheat, fruits or vegetables); and (ii) whether an input price negatively affects their supply in Asian countries. While Imai *et al.* (2011) used oil price as a proxy for an input price, we will use alternatively a fertiliser price[2]. While these may seem elementary propositions, their implications for dampening of food price surge through a timely and adequate supply response are of considerable importance.

The structure of the rest of the paper is as follows: Section 2 reviews recent evidence on supply response to higher food prices in 2007-08; surge in food prices since mid-2010; close correlation between food and oil prices; and growth impacts of food price inflation. As the poverty impacts have been investigated in considerable detail, a distillation of the evidence is given in Section 3. This sets the stage for our econometric analysis of supply response to output and input prices. Section 4 describes salient features of the data used and the econometric specification. Section 5 contains the econometric results. Section 6 reviews evidence on the effects of the food price surge in 2007-08 on poverty. Concluding remarks are given in Section 6.

---

[1] We are grateful to Thomas Elhaut, Director, Asia and the Pacific Division, IFAD, for his encouragement and advice at all stages of this study. C. Peter. Timmer, R. Jha , Anil Deolalikar and Nidhi Kaicker offered constructive suggestions that helped in refining the analysis. Any remaining deficiencies are our responsibility.

[2] See Imai *et al.* (2011) for a broader and in-depth discussion of the econometric issues here.

2. **(a) Review of Supply Response**

Recent evidence suggests that most major cereal producers-including both consumer nations and exporter nations-responded positively to spiralling food prices in 2007-08. USDA production estimates (2009) are summarised below in Table 1.

The exporters are distinguished on the basis that they export more than 10 per cent of their production. The major consuming nations increased their production of maize by 16.8 per cent during 2007/08 and 2008/09, of rice by 12.4 per cent, and of wheat by 8.5 per cent. The response in China and India was particularly strong as they increased public agricultural spending by 25-30 per cent in 2008. The response from major exporting nations was even stronger-especially for maize and wheat production, which increased by 25-30 per cent. Rice production grew less as it is dominated by smallholders.

There were other constraining factors for rice. Firstly, rice prices rose with a lag. Secondly, in most rice producing countries, protectionist government policies limited incentives to produce more. Thirdly, Asian rice producers are much more dependent on fertilisers than smallholders from other regions. In countries where fertilisers were highly subsidised and/or their export were restricted, fertiliser price did not rise much (as in China and India) and the supply response was quite high.

Supply response is impeded by transport and other input costs. Transport costs have risen because of rising fuel prices, cutting into producers' profits. Also, given lack of data on farm gate prices, it is not straightforward to assess what fractions of retail prices are transmitted to the former.

Table 1

Supply Response to Rising World Food Prices in 2008/09

Maize		**Rice**		**Wheat**	
Country/Region	Output (% Change)	Country/Region	Output (% Change)	Country/Region	Output (% Change)
MAJOR CONSUMERS					
South East Asia	18.5	East Asia	9.2	East Asia	17.4
East Asia	22.9	South Asia	10.4	South Asia	9.7
South Asia	12.7	Indonesia	3.5	Bangladesh	-7.1
China	23.3	China	10.0	China	17.6
		Brazil	2.2	Pakistan	5.4
		India	10.9	India	14.2
		Philippines	10.9	Uzbekistan	7.6
MAJOR EXPORTERS					
Thailand	4.3	South East Asia	5.4	Ukraine	92.6
Ukraine	56.2	Vietnam	5.1	Kazakhstan	10.0
		Pakistan	20.7		

Source: Adapted from Headey and Fan (2010).

(b) Energy and Food Price Links

Oil affects food prices through supply and demand channels[3]. Let us first consider the supply channels.

Oil and oil-related costs are a substantial component of production costs of food and non-food crops. Agriculture is second only to transportation in its oil-intensity, implying high sensitivity of marginal costs to oil prices. The effect of rising oil prices is reinforced by surge in fertiliser prices, most of which are based on energy products, such as natural gas. In fact, energy costs could account for up to 90 per cent of the fertiliser cost (e.g. nitrogen fertiliser). Moreover, the bulky nature of food-grains implies that their prices are heavily influenced by transport costs. As rise in energy prices predates that in food prices, the causality is likely to run from energy prices to food prices and not the other way around.

Demand factors further contributed to food price spiral. Of particular importance is biofuel demand (Headey and Fan, 2010, and Timmer, 2010).

[3] This draws upon Headey and Fan (2010), several recent influential writings of Timmer-especially Timmer (2010)-and IFAD (2011).

When oil prices exceed $60 a barrel, biofuels become more competitive, especially if high oil prices are expected to persist. Recent studies (cited in Headey and Fan, 2010) show that the diversion of the US maize crop from food to biofuel uses is the largest source of international biofuel demand and the largest source of demand-induced price pressure[4].

Biofuels are a major new source of demand in maize and vegetable oil markets, and so they are a potentially important factor in explaining price rises in these markets. But the knock-on effects on other food commodities are significant as well. In the United States, for example, expansion of maize area by 23 per cent in 2007 resulted in a 16 per cent decline in soya-bean area and a price rise of 75 per cent between April 2007 and April 2008. In Europe other oilseeds displaced wheat for the same reason (Headey and Fan, 2010).

Another side-effect is depletion of grain stocks. Various estimates point to substantial depletion of stocks. European wheat stocks would almost have been as large in 2007 as in 2001, as opposed to being lower by half.

Although simulations vary in methodology and coverage, they reveal useful insights. In the short-run, biofuel demand accounted for a 70 per cent increase in maize prices and a 40 per cent increase in soyabean prices (Lipsky, 2008). Rosegrant *et al.* (2008) report long-term effects on cereal prices of the acceleration of biofuel production from 2000-2007 to be 30 per cent in real terms. Maize, wheat and rice prices increased by 47, 26 and 25 per cent, respectively.

(c) Recent Surge in Food and Oil Prices[5]

Food prices have been rising substantially the world over since July 2010, as shown below[6]. After the peak in prices in 2008, good harvests helped the prices to fall back. However, adverse weather conditions in several food exporting countries affected supplies. The rise in

[4] In an emphatic comment, Timmer (2010) adds another dimension. He observes, “The emergence of biofuels as a commercially viable use of food-grains and vegetable oils not only raises the level of demand that agricultural resources and productivity must meet, but it also links the prices of energy to foodstuffs. There has long been a partial link between energy prices and food prices through production costs, but this demand side link has more troubling implications. In particular, energy prices have been more volatile for decades. A price link between energy and food implies that this volatility will extend to food prices in the future” (p. 6).

[5] This section draws upon IFAD (2011).

[6] The current situation differs in some respects from that in 2008. (i) Recent international price increases are more widespread across agricultural commodities than in 2008. (ii) Weather is a more important factor this time than in 2008, reducing production and stocks. (iii) Although trade policy responses are associated with price spikes, the former had a more important role in the earlier crisis. For details, see World Bank (2011 a).

prices is not the same for all food commodities and all regions. For instance, the price of rice has not risen by much, and those countries which do not rely heavily on food imports are not severely hit. The volatility in prices is also the result of localized weather problems, for instance, onion prices soared in India in the past few months following the unseasonal heavy rains. Evidence also points towards the role of speculators in exaggerating the rally in food prices[7]. Commodity derivatives are seen as an important portfolio hedging instrument since the returns in commodity sector are uncorrelated with the returns on other assets. This financialisation of commodities may not be a source of food inflation; however, it does play an important role in the short- term volatility in food prices (World Bank, 2011a)[8]. High oil prices, strong demand for crops from the biofuel sector, depleting stockpiles of food-grains and lower production are also responsible for the food price surge. No less important are protectionist policies adopted by many exporting nations, and expansionary monetary policies. Moreover, as markets are increasingly integrated, economic shocks in international markets get transmitted to domestic markets quickly but pass-through effects vary greatly (Timmer, 2010).

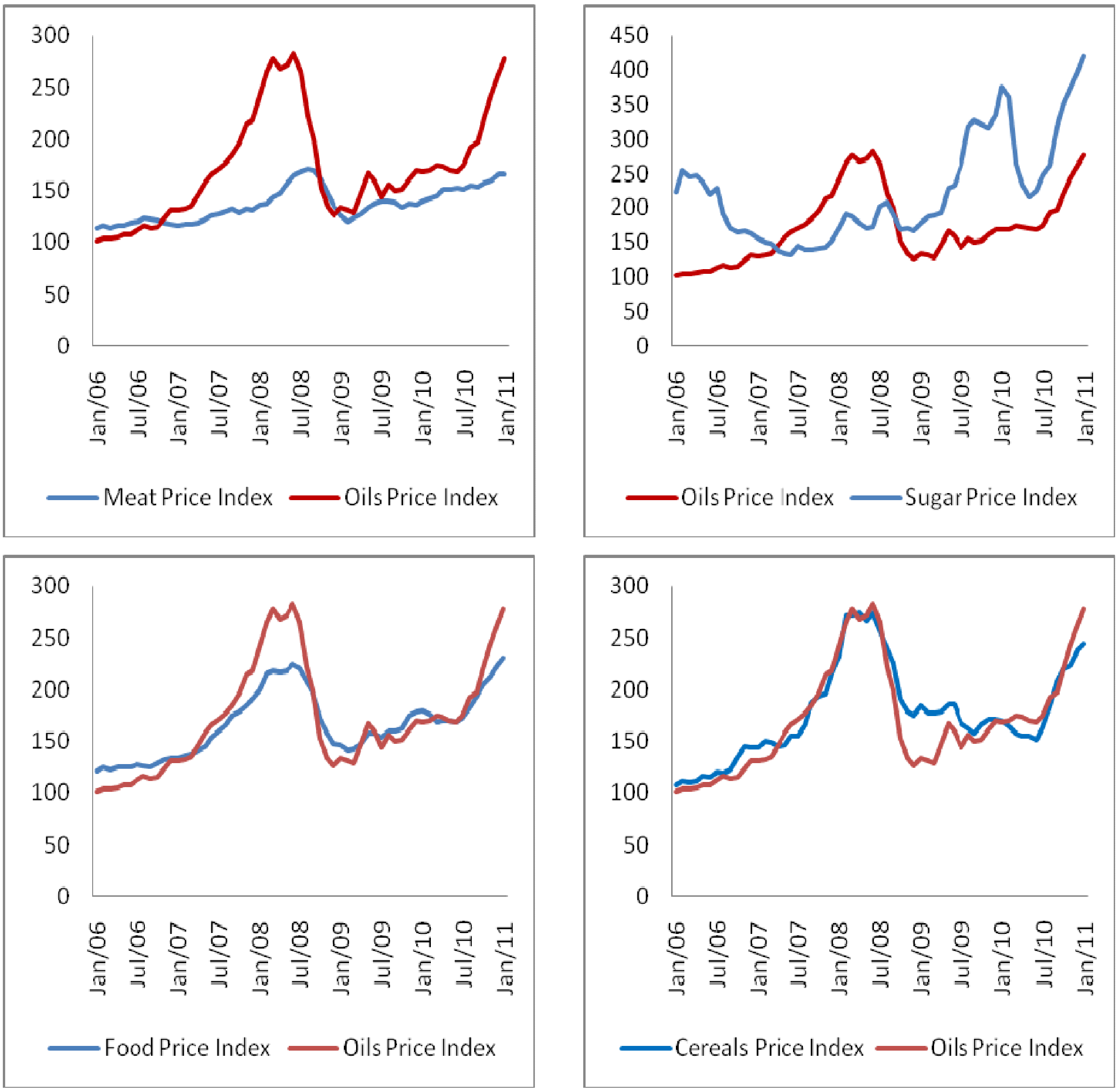
There is a high degree of correlation between food and oil prices, as may be seen from Figure 1[9]. The prices of food, cereals and dairy products are highly correlated with the oil prices. The relationships between meat and oil prices, and between sugar and oil prices, are, however, found to be weak. The increases in oil price in the last few months are a result of both shortages and rising demand, particularly from the industrial sector in China.

[7] For confirmation of role of speculators in the food crisis of 2007-08, see Timmer (2010) and Imai *et al.* (2008).

[8] As the World Bank report (2011a) points out, much of the recent increase in commodity financial transactions has occurred in the futures markets, including for maize and wheat. This is largely driven by demand from index funds holding and continuously rolling over future positions in commodity markets, without taking physical delivery. The extent to which these inflows affect spot prices, however, remains debatable.

[9] As a recent World Bank report (2011a) observes, links between crude oil and agricultural markets have become stronger since 2005, with the pass-through elasticity rising from 0.22 for the pre-2005 period to 0.28 through 2009.

Figure 1: Food-Energy Price Nexus



Source: IFAD (2011)

(d) Transmission to Domestic Prices

What is crucial for understanding the impacts of global food price surge is transmission to domestic prices. As a recent ADB (2011) study emphasises, several factors determine this transmission. For food importing countries, the key factors are the exchange rate, trade policies, and the speed of adjustment. For countries that are not so dependent on food imports, market conditions-local crop conditions, supply costs and policy measures-matter more. Available evidence suggests that international grain prices and domestic prices moved in tandem. In fact, in some cases, domestic prices rose faster.

Between June 2010 and February 2011, global rice prices increased by 16.8 per cent. But domestic rice prices, since June 2010, rose by 21.4 per cent in Bangladesh, 21.6 per cent in Indonesia, and 36.7 per cent in Vietnam. By contrast, the increases were lower (between 13.5 per cent and 10.3 per cent) in Sri Lanka, Pakistan, China and Thailand; and decreased in the Philippines (the price of well-milled rice fell by 0.9 per cent) and Cambodia (by 10.5 per cent).

Wheat prices are a different story. International prices rose by 99.6 per cent in the 8 months to February 2011 but domestic prices in Asia generally did not exceed 70 per cent. In the Kyrgyz Republic, for example, local wheat prices rose by about 67 per cent, in Bangladesh by 50 per cent, and in India, China and Pakistan by 10-20 per cent.

Since food is assigned a high weight in consumer price indices (about 59 per cent in Bangladesh, over 46 per cent in India and 40 percent in Vietnam), food price inflation is associated with general inflation. In Vietnam, for example, inflation was in double digits (about 12 per cent in January, 2011) in part due to higher food prices (about 15 per cent).

(e) Implications for Growth

Two scenarios are considered in the ADB study (2011) for selected 10 Asian countries: in the first scenario, worldwide food prices rise by 30 percent in 2011 and decline by 5 per cent in 2012; and in the second, in addition to the rise in food prices, the oil price rises by 30 per cent in 2011, and declines by 3.1 per cent in 2012[10].

In the first scenario, GDP growth in some food-importing countries will decrease by up to 0.6 percentage points in 2011. By contrast, in food exporting countries, higher global food prices are associated with growth acceleration. In Thailand, for example, the GDP growth accelerates slightly. In several countries (India, Indonesia and Malaysia), the growth impacts are likely to be stronger in 2012, as the economies take time to adjust to exogenous shocks in food prices.

[10] The simulations are done with the Oxford Economics global model. It assumes that the economies in Asia will take a tight monetary stance to prevent domestic inflation getting worse. But higher interest rates will curb investment, and higher consumer prices will restrict consumption. These two together will curb growth.

Under the second scenario, the GDP impacts are more pronounced, with growth deceleration of up to 1.5 percentage points in 2011 and 0.8 percentage points in 2012. In the Philippines, for example, the GDP growth slows down by 1.2 percentage points in 2011, and 0.9 percentage points in 2012, since it is a net importer of both food and oil.

Should these simulation results be taken at face value? We are inclined to the view that these exaggerate the slowing down of growth if yield increases occur in response to TFP growth. So, even if agricultural investment suffer under a tight monetary stance, TFP growth may be sustained through more efficient use of water, fertiliser and other resources (Fuglie, 2010, and IFAD, 2011).

3. Poverty Impacts[11]

Some useful insights into the effects of the food price surge in 2007-08, and the more recent and continuing surge are given below.

An increase in food prices adversely affects the poor since they spend a large proportion of their income on food items. In response, the poor tend to take remedial actions: switching over to less nutritious and cheaper diets, cutting down on their children's (especially girls') food intake, and reducing expenditure on non-food items such as health and education of children. In extreme situations, the poor are also forced to sell their assets such as livestock. Although food prices have been increasing since 2000, they increased at a more rapid pace between 2006 and 2007-08 when prices of major cereals surged very rapidly. Asia and the Pacific countries experienced varying spikes in these prices. These spikes have been due to a combination of both short-term (such as droughts, trade restrictions, and speculation and hoarding) and long-term factors (such as declining yield growth, inadequate investments in infrastructure, and linkages with other commodity markets such as energy markets).

Although there are alarming estimates of the impact of food price inflation on poverty – a World Bank estimate of the increase in the number of poor globally, for example, ranges from 75 million to 105 million (World Bank, 2008) – more plausible and insightful estimates are reported in a recent study by the Asian Development Bank (ADB, 2008), taking supply responses to higher food prices into account. An important finding obtained from simulations

[11] This draws upon IFAD (2011), Thapa *et al.* (2009), World Bank (2008), ADB (2008), and FAO (2008).

for China and Indonesia is that the negative effects of food price inflation (e.g. higher incidence of poverty and increase in income inequality) are dampened by the positive supply response in rural areas. The comparison is interesting as China is a net food exporter while Indonesia is a net food importer. China gains from rising global food prices. Specifically, the largest gains accrue to households dependent on agriculture. Not only does the head-count index of poverty decline but also the Gini index of income inequality, more than compensating for the unfavourable effects in urban areas. The results for Indonesia, however, differ. Although higher global food prices result in higher consumer prices, appreciation of the exchange rate and a loss of competitiveness of Indonesian exports, and a lowering of real GDP, the food crops sub-sector expands. Not surprisingly, therefore, the overall head-count of poverty rises but slightly.

Additional simulations focus on the impact of a 10 per cent increase in the price of a staple food in a small sample of countries (FAO, 2008). Households are classified across different characteristics (net market position, income quintile, sources of income). The main findings are: (i) urban consumers lose in Bangladesh, Pakistan and Vietnam; (ii) in both rural and urban areas, the poorest quintiles are the worst affected; (iii) even in some countries where rural households gain on average, such as Vietnam and Pakistan, the poorest of the poor suffer a welfare loss; (iv) disaggregating quintiles of households by landownership, the poor landless are likely to be worse-off. In Bangladesh, for example, the welfare loss of the landless is as high as 3.5 per cent in the bottom quintile; in Vietnam, the average loss of the landless is 1.8 per cent, as against 2.7 per cent of the bottom 40 per cent. Classifying households into agricultural "specialisers" – households that derived more than 75 per cent of their income from farming – an interesting finding is that their welfare improves. In Bangladesh, for example, the average welfare of agricultural specialisers – comprising 10 per cent of the rural sample – increases by 1.7 per cent (1.3 per cent in the bottom quintile, 1.8 in the top). In Vietnam too, the richer agricultural specialisers gain around 2.2-2.3 per cent[12]. Finally, welfare effects vary between male- and female-headed households. Specifically, in most urban, rural and national samples, female-headed households record greater proportional losses (or smaller proportional gains) than male-headed households. A key explanation is that female-headed households fail to benefit from agricultural income

[12] A negative correlation between rice prices and nutritional status was observed in Bangladesh and Indonesia (Torlesse *et al.*, 2003; Block *et al.* 2004).

generating activities due to their limited access to land, credit and markets (e.g. Bangladesh, Vietnam and Pakistan).

A more recent study of countries in the Greater Mekong Sub-Region offers a rich and insightful analysis of how food producers, consumers and wage labourers were affected by the food price crisis (Sombilla, 2010). While higher rice prices were welfare reducing, the favourable supply responses were weakened by higher input prices. Wage labourers lost. In Cambodia, for example, in terms of the rice wage equivalent, the average wages during the crisis were lower. In rural coastal region, the daily rice wage equivalent fell from 4.67 kg in June, 2007, to 3.84 kg in June, 2008; and in the rural plains, it fell from 5.75 kg to 4.77 kg; and in rural Cambodia as a whole, from 5.09 kg to 4.43 kg. For those surviving at bare subsistence, such reductions imply substantial welfare loss.

Two recent studies (ADB, 2011, and World Bank, 2011b) offer assessments of the impact of the recent and continuing food price surge. Both are alarmingly high. The main findings of the ADB (2011) study are given below. Changes in poverty are a pure price effect in the sense nominal incomes are held constant. There are two implicit assumptions: one is that wages adjust with a lag; and the second is delayed supply response. While both seem consistent with empirical evidence, it must be emphasised that the short-term results may be larger than longer-term effects[13].

Using the poverty cut-off of $1.25 per day (PPP 2005) and assuming that domestic food prices rise by 10 per cent, the simulations show that the number of poor in selected Asian countries rises by 64.4 million or the percentage of poor rises by 1.9 points[14]. With higher food price increases of 20 and 30 per cent, the percentage of poor rises by 3.9 points and 5.8 points, respectively[15]. As the poverty gap ratio captures both increases in the number of poor, and deterioration in their standards of living, this is the more comprehensive measure. With

[13] For details, see Gaiha (1989).
[14] Global food prices rose by more than 30 per cent in the first two months of 2011, relative to the previous year, and domestic food inflation in Asia averaged 10 per cent (ADB, 2011).
[15] The World Bank (2011b) study computes the expected domestic price changes and the associated increases in the cost of living for net consumers and profits of net producers. Using the poverty cut-off of $1.25, while in half the sample, the increase was 0.5 percentage points, in a few countries the increases were much larger (in Tajikistan the increase was 3.6 percentage points and in Pakistan it was 1.9 percentage points). By contrast, poverty fell in Vietnam, as a large fraction of poor households is net producers of rice and benefits from higher prices.

domestic food prices rising by 10 per cent, 20 per cent and 30 per cent, the poverty gap ratio rises by 1.4, 2.7 and 4.1 percentage points, respectively.

A policy concern is quick transmission of rising food prices to farm gate prices-especially for smallholders-and easy access to markets. If impediments to market access are removed, the sales of smallholders increase more than proportionately to those of wealthy farmers (Shilpi and Umali-Deininger, 2007). So, given a timely and an adequate supply response, the rise in poverty may be considerably lower than predicted without such a response[16].

4. Data and Methodology

The analysis undertaken covers the period 1966-2008 for 10 selected Asian countries (Bangladesh, Cambodia, China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Thailand). These countries have been chosen on the basis of availability of food commodity data. Unless otherwise stated, all the variables are extracted from the FAO-STAT database.

For empirical purposes, we use a specification of short-run supply response to price changes premised on a partial equilibrium approach. This is applied to the following cross-country panel model:

$$\log Y_{it}^{j} = \beta_0 + \beta_1 \log P_{it}^{j} + \beta_2 log(P_{input})_t + \beta_3 \log(Arable)_{it} + \beta_4 \log R_{it} + \eta_i + \varepsilon_{it} \qquad \textbf{(1)}$$

where $\log Y_{it}^{j}$ is the logarithm of production (in tonnes) for commodity *j* (*j* = rice, maize, wheat, fruits and vegetables), in country *i*, in period *t*. $\text{Log } P_{it}^{j}$ is commodity producer prices in current US$, obtained by using annual average exchange rate (from *WDI 2010*). $\text{Log}(P_{input})_t$ refers to two different input prices; oil prices, based on a simple average of three spot prices: Dated Brent, West Texas Intermediate, and the Dubai Fateh (from IMF's *WEO 2011*), expressed in US$ per barrel; and fertilizer prices, measured by an index which includes natural phosphate rock, phosphate, potassium and nitrogenous products (extracted from the World Bank Commodity Price database, 2011). $\text{Log } (Arable)_{it}$ measures per capita arable land (in hectares, from *WDI 2010*). Finally, $\log R_{it}$ is the logarithm of annual rainfall for each country *i* (from Mitchell *et al.*, 2003, the underlying data are from Jefferson and

[16] There is an important caveat, however. If food price volatility rises, as it has in the recent surge, it could dampen investment in augmenting supply (World Bank, 2011a).

O'Connell, 2004) while η_i is time invariant country-specific fixed effect, and ε_{it} is the error term.

In the first instance, we apply the pooled ordinary least squares estimator (OLS) with robust standard errors. However, this does not take into account unobserved country-specific effects. Hence, we use random and fixed effects models which address these issues.

5. Results

Tables 2 - 4 show how global food and input prices influence the supply of cereals (e.g. rice, maize and wheat) in our sample of countries. In all regressions, we reject the null hypothesis that there are no significant differences across the countries (tested by the Breusch-Pagan LM test) and, therefore, conclude that panel data methods are needed. To discriminate between fixed and random effects models, the Hausman test is used. The results of this test suggest that the random effects model is preferred for rice, maize and vegetables while the fixed effects model is more suitable for wheat and fruit.

As may be seen from Table 2, the supply of rice is positively and significantly related to its own price. Similarly, both rainfall and the size of arable land are significant determinants of rice production. While arable land is positive and significant irrespective of the specification, rainfall is only significant in the OLS case. As expected, input prices (both oil and fertilizers) adversely affect the supply of rice in Asian countries. This is consistent with the hypothesis that supply-side factors such as input prices may have put pressure on global grain production and hence may have contributed to the high prices. Given the fact that rice is a staple good in these countries, global input prices may have consequences for, not only supply, but also consumption by poor consumers in these countries.

Table 2: Supply response to price changes for rice

	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
$Log\ (price)_{it}$	**0.596**	**0.444**	**0.440**	**0.525**	**0.411**	**0.407**
	[0.221]* **	**[0.036]*** **	**[0.037]*** **	**[0.208]** **	**[0.033]*** **	**[0.034]*** **
$Log\ (P_{oil})_t$	**-0.176**	**-0.124**	**-0.123**			
	[0.175]	**[0.023]*** **	**[0.023]*** **			
$Log\ (arable\_land)_{it}$	1.176	0.626	0.663	1.173	0.466	0.512
	[0.051]***	[0.113]***	[0.106]***	[0.050]***	[0.114]***	[0.108]***
$Log\ (rainfall)_{it}$	0.816	0.003	0.007	0.813	0.051	0.052
	[0.076]***	[0.101]	[0.101]	[0.074]***	[0.092]	[0.091]
$Log\ (P_{fertilizer})_t$				**-0.268**	**-0.297**	**-0.294**
				[0.214]	**[0.036]*** **	**[0.034]*** **
Constant	-11.486	3.988	3.376	-10.398	7.365	6.622
	[1.648]	[1.957]	[2.006]	[1.819]	[1.901]	[1.981]
Observations	350	350	350	350	350	350
R^2	0.59	0.44	0.56	0.59	0.52	0.56
B-P LM test[1]			$\chi^2(1) = 5577$			$\chi^2(1) = 5613$
(P-values)			$(P > \chi^2 = 0.000)$			$(P > \chi^2 = 0.000)$
Hausman test[1]		$\chi^2(4) = 1.71$			$\chi^2(4) = 3.17$	
(P-values)		$(P > \chi^2 = 0.788)$			$(Prob > \chi^2 = 0.530)$	

Notes: Dependent variable is rice production in log. Robust standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01. [1]The null hypothesis of the Breusch-Pagan LM test is that there is no significant difference across the countries (i.e. that the pooled OLS is appropriate). [2] The null hypothesis of the Hausman test is that there is no correlation between the unobserved effects and the explanatory variables.

Table 3 gives the results for maize. The overall picture is similar to that of rice - maize price and arable land are significantly linked to maize supply. Most importantly, global input prices have a depressing effect on maize supply – a result which is significant at the 1 percent level. In the case of maize, the coefficient estimate of rainfall is negative and significant in pooled OLS, while it is non-significant in other cases.

Table 3: Supply response to price changes for maize

	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
$Log\ (price)_{it}$	**-0.322** **[0.214]**	**0.286** **[0.039]*** **	**0.280** **[0.037]*** **	**-0.306** **[0.208]**	**0.262** **[0.042]*** **	**0.255** **[0.038]*** **
$Log\ (P_{oil})_t$	**0.042** **[0.250]**	**-0.146** **[0.037]*** **	**-0.143** **[0.038]*** **			
$Log\ (arable\_land)_{it}$	1.123 [0.048]***	0.555 [0.227]**	0.618 [0.205]***	1.123 [0.048]***	0.412 [0.227]*	0.490 [0.205]**
$Log\ (rainfall)_{it}$	-0.468 [0.218]**	-0.104 [0.153]	-0.111 [0.153]	-0.469 [0.218]**	-0.063 [0.146]	-0.072 [0.146]
$Log\ (P_{fertilizer})_t$				**-0.167** **[0.325]**	**-0.272** **[0.046]*** **	**-0.266** **[0.045]*** **
Constant	0.195 [2.518]	4.506 [3.877]	3.565 [3.572]	1.054 [2.930]	7.432 [3.893]	6.234 [3.566]
Observations	350	350	350	350	350	350
R^2	0.44	0.19	0.42	0.44	0.22	0.41
B-P LM test (P-values)			$\chi^2(1) = 5473$ $(P > \chi^2 = 0.000)$			$\chi^2(1) = 5490$ $(P > \chi^2 = 0.000)$
Hausman test (P-values)		$\chi^2(4) = 1.48$ $(P > \chi^2 = 0.830)$			$\chi^2(4) = 2.65$ $(P > \chi^2 = 0.618)$	

Notes: Dependent variable is maize production in log. Robust standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01. [1]The null hypothesis of the Breusch-Pagan LM test is that there is no significant difference across the countries (i.e. that the pooled OLS is appropriate). [2] The null hypothesis of the Hausman test is that there is no correlation between the unobserved effects and the explanatory variables.

It is also observed from Table 4 that wheat supply responds positively to higher wheat prices. However, unlike the other cereals, the effect of input price changes on wheat supply varies depending on the specification or the model chosen. If we take the case of fixed effects model, selected by the Hausman test, we can conclude that fertilizer price has a significant negative effect on wheat production.

Table 4: Supply response to price changes for wheat

	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
$Log\ (price)_{it}$	**0.925**	**1.143**	**0.925**	**1.288**	**1.307**	**1.288**
	[0.380]**	**[0.285]*****	**[0.380]****	**[0.318]*****	**[0.233]*****	**[0.318]*****
$Log\ (P_{oil})_t$	**0.560**	**-0.076**	**0.560**			
	[0.261]**	**[0.086]**	**[0.261]****			
$Log\ (arable\_land)_{it}$	1.115	4.231	1.115	1.115	3.641	1.115
	[0.046]***	[0.562]***	[0.046]***	[0.044]***	[0.567]***	[0.044]***
$Log\ (rainfall)_{it}$	-1.717	-0.357	-1.717	-1.748	-0.214	-1.748
	[0.159]***	[0.387]	[0.159]***	[0.162]***	[0.379]	[0.162]***
$Log\ (P_{fertilizer})_t$				**-0.100**	**-0.801**	**-0.100**
				[0.312]	**[0.186]*****	**[0.312]**
Constant	1.844	-59.493	1.844	2.685	-47.774	2.685
	[1.916]	[10.188]	[1.916]	[2.117]	[10.086]	[2.117]
Observations	185	185	185	185	185	185
R^2	0.56	0.29	0.56	0.55	0.43	0.55
B-P LM test (P-values)			$\chi^2(1) = 269$ $(P > \chi^2 = 0.000)$			$\chi^2(1) = 274$ $(P > \chi^2 = 0.000)$
Hausman test (P-values)		$\chi^2(4) = 53.58$ $(P > \chi^2 = 0.000)$			$\chi^2(4) = 93.43$ $(P > \chi^2 = 0.000)$	

Notes: Dependent variable is wheat production in log. Robust standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01. [1]The null hypothesis of the Breusch-Pagan LM test is that there is no significant difference across the countries (i.e. that the pooled OLS is appropriate). [2] The null hypothesis of the Hausman test is that there is no correlation between the unobserved effects and the explanatory variables.

Tables 5 – 6 show that fruits and vegetables are also responsive to own price changes. Similarly, in line with cereals, it is found that a high input price - irrespective of whether it is proxied by oil price or fertiliser price - had a dampening effect on fruit and vegetable supplies. Rainfall is not significant.

Table 5: Supply response to price changes for fruit

	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
$Log\ (price)_{it}$	**0.902**	**0.611**	**0.682**	**0.817**	**0.515**	**0.596**
	[0.098]* **	**[0.070]*** **	**[0.075]*** **	**[0.092]*** **	**[0.067]*** **	**[0.076]*** **
$Log\ (P_{oil})_t$	**-0.425**	**-0.335**	**-0.362**			
	[0.122]* **	**[0.063]*** **	**[0.064]*** **			
$Log\ (arable\_land)_{it}$	0.370	1.758	0.871	0.365	1.558	0.533
	[0.046]***	[0.350]***	[0.217]***	[0.045]***	[0.339]***	[0.138]***
$Log\ (rainfall)_{it}$	-0.092	-0.178	-0.110	-0.084	-0.106	-0.036
	[0.071]	[0.217]	[0.222]	[0.071]	[0.205]	[0.188]
$Log\ (P_{fertilizer})_t$				**-0.646**	**-0.487**	**-0.572**
				[0.172]* **	**[0.086]*** **	**[0.093]*** **
Constant	3.726	-16.979	-3.359	5.775	-12.648	3.469
	[1.241]	[6.046]	[4.029]	[1.424]	[5.808]	[2.758]
Observations	343	343	343	343	343	343
R^2	0.35	0.33	0.28	0.35	0.33	0.23
B-P LM test (P-values)			$\chi^2(1) = 2590$ $(P > \chi^2 = 0.000)$			$\chi^2(1) = 2615$ $(P > \chi^2 = 0.000)$
Hausman test (P-values)		$\chi^2(4) = 17.11$ $(P > \chi^2 = 0.002)$			$\chi^2(4) = 15.81$ $(P > \chi^2 = 0.003)$	

Notes: Dependent variable is fruit production in log. Robust standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01. [1]The null hypothesis of the Breusch-Pagan LM test is that there is no significant difference across the countries (i.e. that the pooled OLS is appropriate). [2] The null hypothesis of the Hausman test is that there is no correlation between the unobserved effects and the explanatory variables.

Table 6: Supply response to price changes for vegetables

	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
$Log\ (price)_{it}$	**-0.287**	**0.191**	**0.179**	**-0.294**	**0.137**	**0.126**
	[0.125]**	**[0.039]*****	**[0.039]*****	**[0.115]****	**[0.039]*****	**[0.037]*****
$Log\ (P_{oil})_t$	**0.036**	**-0.154**	**-0.149**			
	[0.186]	**[0.052]*****	**[0.053]*****			
$Log\ (arable\_land)_{it}$	1.294	0.853	0.986	1.292	0.748	0.910
	[0.046]***	[0.325]***	[0.263]***	[0.045]***	[0.327]**	[0.266]***
$Log\ (rainfall)_{it}$	0.033	-0.210	-0.212	0.035	-0.157	-0.164
	[0.103]	[0.223]	[0.215]	[0.104]	[0.219]	[0.212]
$Log\ (P_{fertilizer})_t$				**-0.315**	**-0.289**	**-0.278**
				[0.230]	**[0.081]*****	**[0.077]*****
Constant	-6.518	0.777	-1.325	-4.852	3.187	0.610
	[1.325]	[5.796]	[4.853]	[1.733]	[5.793]	[4.803]
Observations	350	350	350	350	350	350
R^2	0.63	0.12	0.61	0.63	0.13	0.62
B-P LM test (P-values)			$\chi^2(1) = 4686$ $(P > \chi^2 = 0.000)$			$\chi^2(1) = 4722$ $(P > \chi^2 = 0.000)$
Hausman test (P-values)		$\chi^2(4) = 1.31$ $(P > \chi^2 = 0752)$			$\chi^2(4) = 1.91$ $(P > \chi^2 = 0.752)$	

Notes: Dependent variable is vegetable production in log. Robust standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01. [1]The null hypothesis of the Breusch-Pagan LM test is that there is no significant difference across the countries (i.e. that the pooled OLS is appropriate). [2] The null hypothesis of the Hausman test is that there is no correlation between the unobserved effects and the explanatory variables.

6. Concluding remarks

Primary commodity prices have been increasing especially since the early 2000s and at an accelerated pace during 2007-08, with implications for food security in the developing world. Against this backdrop, much of recent research has focused on understanding the causes and consequences of food price increases. The objective of the preceding analysis was to examine how food commodity and input prices have affected the supply of the former in 10 Asian economies. This analysis assumes greater significance in the context of the recent surge in oil and food prices, and its persistence. If, for example, oil prices continue to rise-as feared on present evidence-the food price surge may also persist.

Our analysis suggests that own prices positively influence supply of rice, maize, wheat, fruits and vegetables. We also find that key input prices such as oil and fertilizers have a negative impact on their supply.

The effects of the food price surge of 2007-08 in Asia are revealing. Rejecting alarmist predictions, our review points to highly varied effects conditional on whether a country is a net exporter or importer of food, and whether a household is an agricultural "specialiser'- derives the bulk of its income from farming. Labourers, however, lose. Timely and adequate supply response makes a difference.

More recent estimates of the effects on poverty of the recent and continuing food price surge are alarming too, primarily because of their neglect of supply response.

A policy challenge is to ensure that higher food prices are transmitted to food producers- especially smallholders- and impediments to market access are removed through larger public investment in rural infrastructure. Besides, as agricultural price uncertainty and volatility are likely to continue, largely as a result of the persistent uncertainty over supply against rising demand, open trade policies and greater investment in agricultural research and extension are imperative too.

References

Asian Development Bank (2008) *Asian Development Outlook Update 2008*, Manila.

Asian Development Bank (2011) "Global Food Price Inflation and Developing Asia", March 2011.

Block, S., L. Keiss, P. Webb, S. Kosen, R. Moench-Pfanner, M. W. Bloem, and C. P. Timmer (2004) Macro Shocks and Micro Outcomes: Child Nutrition during Indonesia's Crisis", *Economics and Human Biology*, 2 (1).

FAO (2008) *Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required*, High Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, Rome 3-5 June.

Fuglie, K. O. (2010) "Total Factor Productivity in the Global Agricultural Economy: Evidence from FAO Data", Chapter IV in *Shifting Patterns of Agricultural Production and Productivity Worldwide*, Ames: Iowa, The Midwest Agribusiness Trade Research and Information Centre.

Gaiha, R. (1989) "Rural Poverty, Agricultural Growth and Prices – A Reformulation". *Cambridge Journal of Economics*, June 1989.

Headey, D. and S. Fan (2010) Reflections on the Global Food Crisis, Washington DC: IFPRI.

IFAD (2011) *Agriculture-Pathways to Prosperity in Asia and the Pacific*, Asia and the Pacific Division, Rome, mimeo.

Imai, K. S., R. Gaiha and G. Thapa (2008) "Foodgrain Stocks, Prices and Speculation", Brooks World Poverty Institute Working Paper 6408, University of Manchester.

Imai, K. S., Gaiha, R., and Thapa, G. (2011) 'Supply Response to Changes in Agricultural Commodity Prices in Asian Countries', *Journal of Asian Economics*, 22(1), 61-75.

Jefferson, P.N., O'Connell, S.A. (2004), 'Rainfall shocks and Economic Performance in Four African Countries', Worldwide Database on rainfall and drought severity, http://www.acad.swarthmore.edu/rain-econ/Framesets/HomePage.htm.

Mitchell, T. D., Carter, T. R., Jones, P. D., Hulme, M., & New, M. (2003). 'A Comprehensive Set of High-Resolution Grids of Monthly Climate for Europe and the

Globe: The Observed Record (1901–2000) and 16 Scenarios (2001–2100)'. Tyndall Centre for Climate Change Research Working Paper 55. Norwich, UK.

Shilpi, F. and D. Umali-Deininger (2007) 'Where to Sell? Market Facilities and Agricultural Marketing', Washington DC: Policy Research Working Paper 4455, World Bank.

Sombilla, M. A., D. B. Antiporta, A. M. Balisacan and R. W. Dikitanan (2010) "Policy Implications to Food Price Crisis and their Implications: The Case of Greater Mekong Sub-Region Countries", A Report submitted to Asia and the Pacific Division, IFAD, Rome, mimeo.

Thapa, G., R. Gaiha, K. Imai and Varsha S. Kulkarni (2009) 'Soaring Food Prices: A Threat or Opportunity in Asia?', Brooks World Poverty Institute Working Paper Series, 6909.

Timmer, C. P. (2010) 'Reflections on Food Crises Past", *Food Policy*, vol. 35.

Torlesse, H., L. Kiess and M. W. Bloem "Association of Household Rice Expenditure with Child Nutritional Status Indicates a Role for Macroeconomic Food Policy in Combating Malnutrition", *Journal of Nutrition*, 133 (5).

World Bank (2008) *World Development Report 2008*, Washington DC.

World Bank (2011a) *Responding to Global Food Price Volatility and Its Impact on Food Security*, A report prepared for Development Committee meeting on 16th April, 2011.

World Bank (2011b) "Food Price Watch", Washington DC: February, 2011.