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Abstract

Our analysis corroborates a strong positive yield response to higher prices in a panel of 10 Asian countries. However, there is considerable variation in the strength and speed of the yield responses among different commodities. On the other hand, the yield response in the current period is stronger for oilseeds. Oil price seems to have a negative effect on yields of most of the commodities. Marketed surplus increases more than proportionately to increases in output, as the output elasticity of marketed supply is generally larger than 1. Besides, the marketed supply response does not vary over large ranges of output over and above a subsistence level, despite one caveat that the response have weakened significantly after 2000 except for maize and fruit. Thus the potential of price policy in inducing a large supply of foodgrains is corroborated. This does not of course overlook the much emphasised role of irrigation, fertiliser and high yielding seeds in further augmenting supply. However, given market imperfections, it is also imperative that the benefits of more remunerative producer prices accrue in equal measure to smallholders. So, conditional on these measures, high foodgrain prices may help dampen the continuing surge, given a growing demand.

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

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I. Introduction

Are high prices a remedy for high prices? This possibility is often overlooked in the ongoing debates on spiralling food and oil prices. The UN summit in Rome that concluded on June 5 was no exception. The rhetoric ranged from the optimism of policy reform in developing countries geared to higher public investment in agriculture, modernisation of agricultural technology and its diffusion, and sustainable use of land and water, to the despair over unchanging lifestyles in the USA and other affluent OECD countries, and their reluctance to dismantle agricultural subsidies. In particular, subsidies for biofuel production in USA continue to divide large segments of the developing world from others, with the former exaggerating the distortions and the latter its potential benefits. Underlying these debates is the presumption that drastic policy changes in the developing or developed world would act as a magic wand in containing spiralling inflation.

A recent report, OECD-FAO Agricultural Outlook 2008-2017, released on 29 May, 2008, argues persuasively that high food and fuel prices are likely to persist during the next decade. In a broad-brush treatment of supply and demand factors, it elaborates that, despite record wheat and coarse grain crops in 2007-08 and a sustained moderate rise in production thereafter, grain markets are expected to remain tight up to 2017. Rising per capita incomes, dietary changes with significantly higher shares of meat and dairy products, and developing food markets have resulted in global demand outpacing domestic production capacity. Besides, growth in grain-based ethanol industries in USA and Europe as well as feed requirements from thriving livestock industries in developing countries are likely to exacerbate the imbalance.

Compared to the average for 1998 to 2007, (nominal) prices projected for the period 2008-2017 will on average be around 20 percent higher for beef and pork, 30 per cent for sugar, 40-60 per cent for wheat, maize and skim milk powder, more than 60 per cent higher for butter and oilseeds, and over 80 per cent higher for vegetable oils. In real terms, however, the decade-over-decade increase is lower but substantial for crops and dairy products. Besides, several factors are likely to render market prices more volatile. These factors include low stock to use ratios, changing weather patterns with more frequent droughts, growing industrial demand for agricultural commodities, and massive flow s of commercial funds in agricultural futures markets for speculative gain. In fact, billions of dollars have poured into the commodity futures market -from pension funds, endowments and a host of other institutional investors- through the new conduit of commodity index funds. Views, however, differ on whether such speculative financial flows could fuel inflation for long.

Food price inflation benefits the producers but harms net buyers of food -such as agricultural labourers. A recent and somewhat alarming estimate of the impact of soaring prices on poverty by the World Bank, for example, is that about 105 million people in developing countries are likely to be pushed into deeper poverty, 30 million in Africa alone. So the case for protecting the poor from the ravages of spiralling inflation in the short-run is unexceptionable. Although the UN Summit in Rome drew pointed attention to the imperative of much larger investments in agriculture for raising productivity, it did not emphasise the role of high prices in raising yields in the short and medium-run (2-5 years).

Our collaborative research (Imai et al. 2008 a, b) focused on the transmission of rising global prices to domestic prices, shows significant differences between China and India. The extent of adjustment in the short and medium-run is generally larger in China than in India. However, the adjustment is larger for wheat, maize and rice than for fruits and vegetables in both India and China. Also, while most of the domestic commodity prices move in tandem with global prices, the transmission is partial because of distortionary government interventions such as input subsidies, and price and quantitative restrictions on exports (e.g. on export of rice in Vietnam).

II. Review of Evidence

There is .a vast literature on foodgrain supply response to prices. Important contributions include Nerlove (1979), Krishna (1995 a, b, c), Rosegrant et al. (1998), Bardhan (2003) and Bardhan and Bardhan (2003), among others. In a more recent contribution, Kanwar (2006) presents new evidence using a panel of India's states over the period 1967 to 2000. Separate analyses are carried out for six important foodgrains comprising coarse grains *bajra* (pearl millets), *jowar* (sorghum) and maize (corn); the pulse gram; and rice and wheat. The use of panel data allows for cross-sectional or state specific variation in the variables, in contrast to all-India data which reduces such variation by aggregating some variables and averaging others. Positing a Nerlovian adaptive expectation or partial adjustment process, acreage, yield and output elasticities are computed. A relative profit variable, based on farm harvest prices, is constructed to capture the effect of prices on acreage, yields and output, as well as the effects of rainfall, irrigation and fertiliser[2]. Following some earlier work (notably Krishna, 1995), these effects are grouped into price and non-price effects. This is somewhat unclear as

[2] Kanwar (2006) is emphatic that farm harvest prices are more relevant than wholesale prices (WPI) as in the absence of storage facilities large shares of crops are marketed soon after the harvest. In that sense, farm harvest prices are closer to prices received than yearly averages of wholesale prices. While the latter tend to approximate farm harvest prices better during harvest time, during the rest of the year the wholesale prices tend to be higher. Does seasonality matter in determining inflation? In an admirably clear exposition, Srinivasan (2008) points out the conditions under which it does not (e.g. if the seasonality manifests in a proportional price effect). He also draws attention to some other difficulties in using the wholesale price index (e.g. these prices are a mix of farm- gate, factory- gate or mine-head prices, as also prices at the level of primary, secondary or other wholesale or retail markets). As a result, the correspondence between WPI and producer prices is somewhat tenuous.

limited access to water or fertiliser implies that the ‘prices’ of these inputs are high or tend to infinity.

(a) Area Response

A brief summary of Kanwar’s (2006) results is given to put our analysis in perspective. Let us first review the acreage response.

- Area or acreage allocations are heavily influenced by rainfall-more specifically, rainfall has a strong positive influence on area planted under different crops, and the associated long-run elasticities are also the highest (except in the case of area under wheat).
- Irrigation also has a strong positive effect except in the case of maize. The long-run elasticities are also substantial for most crops, but not very large with the exception of rice and wheat. These results are plausible as coarse grains and pulses are grown under mainly rainfed conditions.
- The profit variable designed to capture the price effect does not turn out to be positive and significant except in the case of gram and jowar.
- Somewhat intriguing is the absence of a significant relationship between public investment and acreage, as also between risk variables (coefficient of variation of price in a year). Arguably, these results reflect specification problems (e.g. whether public investment is instrumented, how much of the variation is random or non-random).
- The area adjustment coefficient (i.e the bridging of the gap between desired and actual area planted under a crop) ranges from 0.3 to 0.6 for some crops (e.g. bajra, gram, jowar and wheat), implying that it takes about 2-3 years for the complete area response to occur.

(b) Yield Response

Let us now turn to the findings on the yield response.

- Again rainfall is a significant determinant of yields, with the exception of wheat. The associated long-run yield elasticities are large for coarse grains.
- Irrigation also has a significant positive effect on yields, with the exception of *bajra*. The effect is large on the yields of maize, rice, and wheat.
- Two other yield enhancing variables are fertiliser and high yielding seeds. Their effects are positive and significant in all cases, as also the long-run elasticities.
- The profit variable also has the expected positive and significant effect on most crop yields except *bajra* and *jowar*. So after controlling for the effects of irrigation, high yielding varieties and fertiliser, expected profit has a positive effect.
- As in the acreage analysis, the absence of a significant relationship between public investment and yields is intriguing. Also, a similar comment applies to the weak effect of risk variables.

(c) Output Response

By adding together the area and yield elasticities different variables (e.g. expected profits, fertiliser, irrigation), total output elasticities are obtained. The main findings are summarised below.

- The largest output elasticities with the exception of wheat are those with respect to rainfall. These elasticities range from 0.4 to about 1. Despite decades of expansion of irrigation, most food crops are heavily dependent on rainfall. The only exception is wheat, and to a lesser extent, rice, as these crops have benefited mostly from expansion of irrigation.

- The output elasticities with respect to irrigation are positive and substantial for all crops, ranging from 0.1 for *bajra* to 0.6 for rice and wheat. Overall, irrigation is second in importance to rainfall.
- Next in importance are high yielding seeds and fertiliser. The latter is more important.
- The output elasticities with respect to (expected) profit are reasonably high for all crops other than gram and jowar. In general, these elasticities are lower than the corresponding irrigation and rainfall elasticities. These results, however, differ from those of Rosegrant et al. (1998) for Indonesian agriculture.

So the overall conclusion is that prices matter but input availability matters more. From this overall perspective, the present study focuses on a sample of Asian countries. Our analysis is confined to the yield elasticities of major foodgrains to their (domestic) prices, controlling for the effects of rainfall and crude oil prices (as a proxy for fertiliser prices and transportation costs). By using state-of-art econometric techniques, we aim to demonstrate how robust the yield elasticities are for specific crops.

The motivation for this study stems largely from two related concerns. One is of course to examine whether persistence of spiralling prices would to some extent correct itself through a positive supply response. A second concern is whether some recent alarmist estimates of increase in poverty could be taken at face value. Without in any way downplaying the negative welfare consequences of surging food and oil prices, a strong supply response would imply that the poverty and inequality increasing effects are likely to be somewhat exaggerated. Consider, for example, a widely reported estimate of the World Bank that about 105 million people are likely to become poor due to rising food prices (World Bank, 2008).

Between 2005 and 2007, poverty increased by 3 percentage points on average extrapolating from these results globally suggests that, as a result of the rise in food prices, total world poverty may have increased by 73 million to 105 million people, depending on the pass through of global prices to domestic prices. On the other hand, the poverty impact of rising oil prices is generally less, since a smaller share of household consumption covers fuel and energy products.[3]

Some evidence also points to accentuation of inequality. In Bangladesh, the Gini index of income inequality climbed by 5 per cent. This reflects the relatively larger gains of larger farmers. In Vietnam, while a significant number of those close to the poverty line are net sellers of rice and benefit from rising rice prices, the poorest in rural areas benefit the least and those in urban areas are the worst affected (World Bank, 2008).

The present study is based on panel data for 10 Asian countries during 1966 to 2005. The next section discusses the data sources and the methodology with focus on estimation strategies. Section IV summarises the econometric results. This is followed by a distillation of evidence on marketed surplus by size of holding in Section V. Concluding remarks are given in Section VI.

III. Data and Methodology

(a) Data

We have used FAO-STAT for much of our analysis.[4] As a proxy for agricultural production, we use yield per hectare (kg/ha) for maize, wheat, rice (paddy), fruits, vegetables, and

[3] For technical details, see Ivanic and Martin (2008).

[4] The new version of FAO-STAT data (from 1990 to 2005) is available on http://faostat.fao.org/site/570/DesktopDefault.aspx?PageID=570 and the old version (since 1966) is available in archives of the new site on http://faostat.fao.org/site/408/DesktopDefault.aspx?PageID=408 (both accessed on 27th June 2008).

oilseeds for 10 Asian countries, viz. Bangladesh, Cambodia, China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Thailand, during 1966 to 2005. The availability of data varies across countries. Commodity prices are nominal producer prices in current US$ converted by annual average exchange rate (from World Development Indicator 2008). We have constructed a ratio of oil price to producer price for each commodity where oil price refers to crude oil (petroleum) price, a simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh in US$ per barrel. This ratio proxies higher input costs such as fertilizers. We have also used the annual rainfall data from the Tyndall Climate Research Centre at University of East Anglia for 1980-2000. Descriptive statistics of the variables used are given in Appendix 1. Graphs are shown in Appendix 3.

(b) Methodology

We have employed a specification of short-run supply response to price changes premised on a partial equilibrium approach. This is applied to the cross- country panel data. Algebraically,

$$\log Y^{j}{}_{it} = \beta_0 + \beta_1 \log P^{j}{}_{it} \,|+ \beta_2 \log P^{j}{}_{it-1} + \beta_3 \log\left(\frac{P^{oil}{}_{t}}{P^{j}{}_{it}}\right) + \beta_4 \log R_{it} + \lambda^{j}{}_{i} + e^{j}{}_{it} \quad (1)$$

where log $Y^{j}{}_{it}$ is logarithm of yield per hectare for commodity *j*, country *i* in year *t*. Log $P^{j}{}_{it}$ is log of producer price, $\log\left(\frac{P^{oil}{}_{t}}{P^{j}{}_{it}}\right)$ is log of the ratio of oil price (common across commodities and countries) to producer price for each commodity *j*. $\log R_{it}$ is log of annual rainfall, specific to country *i*. $\lambda^{j}{}_{i}$ is the country specific individual effect. $e^{j}{}_{it}$ is the error term. We estimate equation (1) using the cross-country panel data for each commodity.

Some of the explanatory variables are correlated, as shown by the correlation matrices in Appendix 2. So for each commodity *j*, we try six different specifications based on combinations of: (i) lagged commodity price, (ii) rainfall; and (iii) ratio of oil price to commodity price. Both fixed effects and random effects versions are estimated and the choice is determined by the Hausman test. As rainfall data are available only for 1980-2000, and other data vary by country and commodity, we have used the *maximum* number of years and countries for each case. As the data period is relatively long, we carry out Levin-Lin-Chu's (2002) unit root test for panel data to check the stationarity of the time-series under the alternative hypothesis that all the time series (for each country) are stationary[5].

IV. Econometric Results

Tables 1 to 6 summarise the econometric results for each commodity. As in most cases (except Case A and Case B in Table 5 for vegetables) random effects are preferred by the Hausman test, we confine our discussion to the results in the second panel of each table corresponding to the random effects version. A cautious interpretation of the results is necessary in view of serial correlation, as we cannot reject the null that there is no serial correlation (assuming no random effects) in Case A and Case B of Tables 1 and 5.

(Tables 1- 6 to be inserted)

[5] This test assumes that each individual unit in the panel shares the same AR (1) coefficient, but allows for individual effects, time effects and possibly a time trend. Lags of the dependent variable may be introduced to allow for serial correlation in the errors. The test may be viewed as a pooled Dickey-Fuller test, or an Augmented Dickey-Fuller (ADF) test when lags are included, with the null hypothesis that of nonstationarity (I(1) behaviour). After transformation, the t-star statistic is distributed standard normal under the null hypothesis of nonstationarity.

(a) Maize

Based on the results in Table, we cannot reject the null hypothesis (H_0) that one of the series is I(1) for yield per hectare (for 1966-2005) under the alternative hypothesis (H_1) that all country level time series are I(0) for yield per ha (for 1966-2005). So a cautious interpretation of the results-especially when the entire period 1966-2005 is included (i.e., Cases C-F) - is necessary. The ratio of oil to maize price has a significant negative effect on maize yield. If we consider the results in Case C or Case E where lagged maize price is included, we find that a 1% increase in maize price leads to a 0.26% (in Case E, or 0.28% in Case C) increase in yield per hectare in the next year.

(b) Wheat

A cautious interpretation of the results in Table 2 is necessary, as the null of unit roots of wheat prices and the ratio of oil to wheat price time-series cannot be rejected. Oil price (as a ratio to wheat price) has a highly significant negative effect on wheat yields. The results in Case C or E are similar in that a 1% increase in wheat price leads to a 0.31% (in Case E, or 0.30% in Case C) increase in yield per hectare in the next year.

(c) Rice

As all the time series used for the analysis in Table 3 are I (0) or stationary, the results are likely to be more robust. The oil/wheat price ratio has negative and significant effect. The results in Case C or E are again similar- a 1% increase in rice price leads to a 0.30% (in both Case C and E) increase in yield per hectare in the next year.

(d) Fruits

We cannot reject the null that all the series are non-stationary for yield of fruit, fruit price or ratio of oil price to fruit price in Table 4. No significant coefficient estimates are found for the current or lagged fruit prices and so supply response is likely to be very weak. But oil price ratio has a negative significant effect on fruit yields.

(e) Vegetable

We cannot reject the null that all the series used in Table 5 are non-stationary. Given this caveat, we find that in Cases C and E a 1% increase in price of vegetables leads to a 0.13% increase in yield per hectare. The supply responses are thus weaker than those for maize, wheat, and rice. As in other cases, oil price has a significant negative effect on fruit yields.

(f) Oilseeds

Based on the results in Table 6, and if we select the case without a trend (as shown graphically in Appendix 3), we cannot reject the null that all the series are I(1) for yield per hectare or oil price ratio. Not so surprisingly, the coefficient estimates for oil price-commodity price ratio are *positive* and significant at the 10 % level (given some substitutability between them). The coefficient of lagged price is positive but not significant. Current price, however, has a positive and significant effect on yields, with the elasticities ranging from 0.2 (Case C) to 0.27 (Case A or E). Recall that these ranges comparable to those of rice. Also, the response is quick.

(g) Change of Supply Elasticity before and after 2000

A recent increase in biofuel productions and subsidies for them in the USA particularly after the year 2000 may have significantly distorted the markets for agricultural commodities in developing countries. The price increase after 2000 observed for a number of commodity prices may also have changed the supply response in the market. The supply elasticity with respect to agricultural commodity price is thus compared for the period up to 1999 and 2000-5 in Table 7. The specification in Case F in Tables 1-6 is used where only the current log price is an explanatory variable.[6] The statistical difference of coefficient estimates of supply elasticity for the different periods is tested by Hausman test.

(Table 7 to be inserted)

Table 7 shows that the estimates of supply elasticity are significantly lower after 2000 for wheat, rice, vegetable, and oilseeds. That is, supply response has become significantly weaker for a number of different agricultural commodities, which is likely to be associated with the presence of market distortions after 2000. Exceptions are maize of which the supply elasticity became larger after 2000 and fruit with low elasticity unchanged before and after 2000.

In sum, there are two robust findings: in most cases, there is a significant yield response to higher producer or wholesale prices; and there is a significant negative effect of higher oil prices on yields, channelled through higher input prices (e.g. fertiliser) and transportation costs. Also, the supply response became significantly weaker after 2000 for a number of agricultural commodities.

[6] The similar conclusions are obtained for different specifications (e.g. with oil price) and for the comparison of the period 1990-9 and 2000-5.

V. Marketed Surplus by Size

As a prelude to our own analysis and to extend the preceding analysis by focusing on the links between output expansion and market arrivals by size of holding, a distillation of available evidence is given below. Many of the important contributions were based on Farm management studies and cost of cultivation surveys carried out by Krishna (1995 a, b, c), Bardhan (2003), Bardhan and Bardhan (2003), among others. The insights from these studies are highly relevant in the context of rising food and oil prices, and their implications for the rural poor.

Three major findings-although based on not so recent data- are of particular interest. One relates to the price response of marketed surplus of foodgrains. Bardhan and Bardhan (2003) first specify a theoretical model of farmers' foodgrain marketing decision, positing that in the production decision the relevant prices are those of foodgrains relative to competing crops and relative to agricultural inputs whereas in the consumption decision the relevant prices are those of foodgrains relative to competing consumption good including manufactured consumables. A non-price shift factors (representing technological progress) is also included. A log-linear equation is estimated in which the dependent variable is (log) of share of marketed surplus of cereals in total cereals output, and the right side variables include relative price of cereals and other (manufactured) consumables, relative price of commercial crops to cereals, and (real) agricultural income per capita as a proxy for the non-price technical progress. The regression results are as hypothesised[7]. The marketed surplus of grains is higher when the relative cereal price is higher, and it is lower when the relative price of commercial crops is higher. The intuition underlying these results is that when the relative cereal price is high, more is marketed as less is consumed; and when the relative price of

[7] Note that the sign of the non-price shift factor is indeterminate in the Bardhan-Bardhan model (2003).

commercial crops is high, marketed surplus of grains is lower because of switching of acreage.

Other findings come from Krishna's (1995 a, b) pioneering contributions to this debate. He devised an innovative methodology to compute the price elasticity of supply. First, based on the market supply-output relation, the output - elasticity of market supply is determined. The price elasticity of supply is then obtained as the product of the price elasticity of output and the output elasticity of market supply:

$$c = b\, E_{MQ} \qquad (2)$$

where c denotes price elasticity of market supply, b refers to price elasticity of output and E_{MQ} is the output elasticity of market supply. Using this procedure, Krishna (1995 b) reported that the output elasticity of market supply of wheat was high, ranging from 1.04 to 1.6. If the price elasticity of output is between 0.1-0.2, the price elasticity of market supply is likely to be 0.104-0.32.

Krishna's (1995 a, b) estimates of output elasticity of market supply based on different data sets for different parts of India are typically greater than unity, the price elasticity of market supply should normally be greater than the price elasticity of output. This implies that if output increases in response to a price increase, sales are likely to increase more than proportionately, and *vice versa*.

Of greater concern is the finding that the marketable surplus function (i.e sales as function of output of wheat or rice as a subsistence crop) is *linear* in the majority of samples analysed. The linearity of this relation has important implications. The marginal propensity to sell out of the output of a subsistence crop is constant over a wide range of output above a subsistence level. The average propensity to sell or the sale ratio (M/Q), on the other hand, rises as output increases, above the subsistence level, but at a decreasing rate. The elasticity of the aggregate surplus w.r.t. aggregate output is then obtained as marginal propensity to sell divided by the aggregate average propensity to sell. Computed from different sample, these elasticities ranged from 1.04 to 1.60. This finding raises doubts about the belief that while smallholders use up their entire output for subsistence while large farmers sell the bulk of their output in the market. The important insight here is that in many areas the small as well as large producers producing more than a subsistence level sell the same additional quantity from an additional unit of output. As Krishna (1995 a) observes "There may be important reasons for altering the farm size structure. But in areas of constant sale propensity the necessity of increasing the marketable surplus need not be one of them" (p. 28). If the constraints that smallholders confront are overcome or weakened (e.g. limited access to credit, fertiliser, and irrigation), higher producer prices of foodgrains would induce a more than proportionate increase in market sales across different size holdings.

VI. Concluding Observations

Our analysis corroborates a strong positive yield response to higher prices in a panel of 10 Asian countries. However, there is considerable variation in the strength and speed of the yield responses among different commodities. For example, a 1 % increase in own price increase results in 0.25-0.31 % of per hectare yield increase with one year lag for maize, wheat, and rice, while the response is weaker for fruits and vegetables. On the other hand, the yield response in the current period is stronger for oilseeds. Oil price seems to have a negative effect on yields of most of the commodities.

Juxtaposing these results with earlier findings, it follows that marketed surplus increases more than proportionately to increases in output, as the output elasticity of marketed supply is generally larger than 1. What is also important to note is that the marketed supply response does not vary over large ranges of output over and above a subsistence level. However, it should be noted that the response have weakened significantly after 2000 except for maize and fruit due to the market distortion for the agricultural commodity markets in developing countries possibly associated with the increase in biofuel subsidies in the USA.

From a policy perspective, our analysis corroborates the potential of price policy in inducing a large supply of foodgrains. This does not of course overlook the much emphasised role of irrigation, fertiliser and high yielding seeds in further augmenting supply-especially among smallholders. However, given market imperfections, it is also imperative that the benefits of more remunerative producer prices accrue in equal measure to smallholders. So conditional on these measures high foodgrain prices may help dampen the continuing surge, given a growing demand.

References

Bardhan, P. (2003) "Size, Productivity and Returns to Scale: An Analysis of farm-Level Data in Indian Agriculture", in P. Bardhan *Poverty, Agrarian Structure, & Political Economy in India*, New Delhi: Oxford University Press.

Bardhan, P. and K. Bardhan (2003) "Price Response of Marketed Surplus of Foodgrains: An Analysis of Indian Time-Series Data", in Bardhan *op.cit*.

Ivanic, M. and W. Martin (2008) 'Implications of Higher Global Food Prices for Poverty in Low-Income Countries', Policy Research Working Paper 4594, Washington D.C., The World Bank.

Krishna, R. (1995 a) "farm Supply Response in India-Pakistan: A case Study of the Punjab region", in V. Krishna (ed.) *Selected Writings: Raj Krishna*, New Delhi: Oxford University Press.

Krishna, R. (1995 b) "The Marketed Surplus Function for a Subsistence Crop: An Analysis with Indian Data", in V. Krishna (ed.) *op. cit.*

Krishna, R. (1995 c) "Agricultural Price Policy and Economic Development", in V. Krishna (ed.) *op. cit*

Imai, K., R. Gaiha and G. Thapa (2008 a) "Food and Oil Prices", *Economics Discussion Paper*, University of Manchester, 0801.

Imai, K., R. Gaiha and G. Thapa (2008 b) "Transmission of World Commodity Prices to Domestic Commodity Prices in India and China", *Brooks World Poverty Institute Working Pape*r 45/2008.

Kanwar, S. (2006) "relative Profitability, Supply Shifters and Dynamic Output Response, in a Developing Economy", *Journal of Policy Modelling*, vol. 28.

Levin, A., Lin, Chien-Fu, and Chu, Chia-Shang James (2002) ‘Unit root tests in panel data: asymptotic and finite-sample properties’, *Journal of Econometrics* 108 (2002) 1.24.

Nerlove, M. (1979) “The Dynamics of Supply: Retrospect and Prospect”, *American Journal of Agricultural Economics*, vol. 61, no. 5.

OECD-FAO (2008) *Agricultural Outlook 2008-2017*, Paris: OECD.

Rosegrant, M., F. Kasyrno & N. Perez (1998) “Output Response to Prices and Public Investment in Agriculture: Indonesian Food Crops”, *Journal of Development Economics*, vol. 55, no. 2.

Srinivasan, T. N. (2008) “ Price Indices and Inflation Rates”, Economic and Political Weekly, June 28.

World Bank (2008) “Double Jeopardy”, A Background paper for the G-8 Meeting in Hokkaido (Japan), 7-9 July, 2008.

Table 1 Supply Response to Price Changes for Maize

			Case A			Case B			Case C			Case D			Case E			Case F		
Maize			Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
	Fixed	log(price)$_{it}$	-0.27	(-4.35)	**	-0.18	(-3.76)	**	-0.09	(-1.21)		0.19	(4.78)	**	0.02	(0.22)		0.27	(8.16)	
	Effects	log(price)$_{it-1}$	0.13	(2.26)	*	-	-		0.29	(4.42)	**	-	-		0.27	(4.07)	**	-	-	
	Model	log($P_{oil}/P_{commodity}$)$_{it}$	-0.21	(-9.87)	**	-0.21	(-9.92)	**	-0.13	(-3.98)	**	-0.12	(-3.5)	**	-	-		-	-	
		log (rainfall)$_{it}$	-0.02	(-0.24)		-0.03	(-0.40)		-	-		-	-		-	-		-	-	
		Constant	7.92	(12.44)		8.20	(13.0)		6.27	(34.67)		6.30	(37.1)		6.01	(35.0		6.06	(38.4	
	Random	log(price)$_{it}$	-0.27	(-4.22)	**	-0.18	(-3.79)	**	-0.10	(-1.24)		0.18	(4.28)	**	0.01	(0.09)		0.25	(7.38)	**
	Effects	log(price)$_{it-1}$	0.12	(2.06)	*	-	-		0.28	(4.14)	**	-	-		0.26	(3.82)	**	-	-	
	Model	log($P_{oil}/P_{commodity}$)$_{it}$	-0.21	(-9.51)	**	-0.21	(-9.68)	**	-0.13	(-3.70)	**	-0.11	(-3.15)	**	-	-		-	-	
		log (rainfall)$_{it}$	-0.08	(-1.09)		-0.08	(-1.06)		-	-		-	-		-	-		-	-	
		Constant	8.40	(14.71)		8.56	(14.9		6.34	(31.67)		6.37	(33.8)		6.09	(31.9		6.15	(34.8)	
	Number of Observations		210			210			390			400			390			400		
	Number of Countries		10			10			10			10			10			10		
	Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
	Fixed effects model																			
	Joint Significant Tests		F(4,196)=	27.72	**	F(3,197)=	34.53	**	F(3,377)=	30.57	**	F(2,388)=	40.24	**	F(2,378)=	36.49	**	F(1,389)=	66.66	**
	R^2 (Overall)		0.039			0.0601			0.0003			0.0008			0.0008			0.0012		
	Random effects model																			
	Joint Significant Tests		Wald chi2(4)=	103.2	**	Wald chi2(3)=	99.33	**	Wald chi2(3)=	77.4	**	Wald chi2(3)=	65.9	**	Wald chi2(2)=	61.3	**	Wald chi2(1)=	54.4	**
	R^2 (Overall)		0.086			0.096			0.0002			0.0008			0.0008			0.0012		
[1]	Hausman Test for the choice		Chi^2(4)=	2.170		Chi^2(3)=	1.390		Chi^2(3)=	0.004		Chi^2(3)=	0.000		Chi^2(3)=	0.000		Chi^2(3)=	0.000	
	between fixed or random effects		Prob>Chi^2=	0.704		Prob>Chi^2=	0.708		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000	
	Model	Chosen model:	Random effects model			Random effects model			Random effects model			Random effects model			Random effects model			Random effects model		
[2]	Breusch and Pagan LM Test 2)		Chi^2(1)=	1330	**	Chi^2(1)=	1337	**	Chi^2(1)=	2220	**	Chi^2(1)=	2283	**	Chi^2(1)=	2182	**	Chi^2(1)=	2267	**
	H_0: Var(u)=0 or no random effects.		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000	
[3]	Baltagi-Li (1995) LM Test 3)		Chi^2(1)=	0.83		Chi^2(1)=	0.83		Chi^2(1)=	4.32		Chi^2(1)=	4.38		Chi^2(1)=	4.25		Chi^2(1)=	4.34	
	for Serial Correlation		Prob>Chi^2=	0.360		Prob>Chi^2=	0.360		Prob>Chi^2=	0.038	*	Prob>Chi^2=	0.036	*	Prob>Chi^2=	0.039	*	Prob>Chi^2=	0.037	*
	H_0: rho=0 or no serial correlation																			

			Without Trend		Lags(average)			With Trend		Lags(average)		
[4]	Levin-Lin-Chu's (2002) Unit Root Tests for Panel Data 4)		t value			t stat		t value			t stat	
	(for the entire period)	log(yield)$_{it}$	-4.130		2	0.034	Not I(0) for all series.	-3.153		2	3.043	Not I(0) for all series.
	(for the entire period)	log(price)$_{it}$	-10.572	**	2	-5.914	I(0)	-11.687	**	2	-5.139	I(0)
		log(oil price /commodity price)$_{it}$	-10.572	**	2	-5.914	I(0)	-11.687	**	2	-5.139	I(0)
		log (rainfall)$_{it}$	-7.921	*	2	-1.924	I(0)	-8.227	+	2	-1.306	I(0)

Notes: 1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.
2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.
3). Baltagi-Li LM test tests for the null hypothesis that there is no first-order serial correlation, assuming no random effects

4). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .
It tests that all the series are stationary under the alternative (H_1).

Table 2 Supply Response to Price Changes for Wheat

			Case A			Case B			Case C			Case D			Case E			Case F		
Wheat			Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
	Fixed	log(price)$_{it}$	-0.22	(-2.65)	**	-0.27	(-5.00)	**	-0.11	(-0.97)		0.18	(2.47)	*	0.10	(0.16)		0.13	(1.91)	+
	Effects	log(price)$_{it-1}$	-0.06	(-0.71)	*	-	-		0.30	(2.71)	**	-	-		0.31	(2.83)	**	-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.18	(-7.59)	**	-0.18	(-7.77)	**	0.05	(0.92)		0.09	(1.69)	+	-	-		-	-	
		log (rainfall)$_{it}$	-0.10	(-1.14)		-0.08	(-0.93)		-	-		-	-		-	-		-	-	
		Constant	9.35	(15.09)		9.15	(14.67)		6.53	(18.47)		6.60	(19.31)		6.60	(19.06)		6.74	(20.31)	
	Random	log(price)$_{it}$	-0.22	(-2.59)	**	-0.26	(-4.86)	**	-0.11	(-0.93)		0.19	(2.47)	**	0.10	(0.15)		0.13	(1.92)	+
	Effects	log(price)$_{it-1}$	-0.06	(-0.69)	*	-	-		0.30	(2.66)	**	-	-		0.31	(2.84)	**	-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.18	(-7.44)	**	-0.18	(-7.58)	**	0.05	(0.99)		0.09	(1.76)	**	-	-		-	-	
		log (rainfall)$_{it}$	-0.12	(-1.40)		-0.11	(-1.24)		-	-		-	-		-	-		-	-	
		Constant	9.36	(14.96)		9.20	(14.69)		6.43	(16.99)		6.50	(17.89)		6.50	(15.59)		6.65	(17.09)	
	Number of Observations		114			115			209			215			209			215		
	Number of Countries		6			6			6			6			6			6		
	Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
	Fixed effects model																			
	Joint Significant Tests		F(4,104)=	20.52	**	F(3,106)=	26.63	**	F(3,200)=	3.5	*	F(2,207)=	3.27	*	F(2,201)=	4.83	**	F(1,389)=	3.65	+
	R^2 (Overall)		0.056			0.046			0.035			0.0304			0.027			0.013		
	Random effects model																			
	Joint Significant Tests		Wald chi2(4)=	80.07	**	Wald chi2(3)=	76.99	**	Wald chi2(3)=	77.4	**	Wald chi2(3)=	6.64	*	Wald chi2(2)=	3.77	**	Wald chi2(1)=	3.67	+
	R^2 (Overall)		0.063			0.056			0.035			0.0306			0.027			0.013		
[1]	Hausman Test for the choice		$Chi^2(4)=$	0.430		$Chi^2(3)=$	0.640		$Chi^2(3)=$	0.000		$Chi^2(3)=$	0.000		$Chi^2(3)=$	0.000		$Chi^2(3)=$	0.000	
	between fixed or random effects		$Prob>Chi^2=$	0.979		$Prob>Chi^2=$	0.886		$Prob>Chi^2=$	1.000		$Prob>Chi^2=$	1.000		$Prob>Chi^2=$	1.000		$Prob>Chi^2=$	0.990	
	Model	Chosen model:	Random effects model			Random effects model			Random effects model			Random effects model			Random effects model			Random effects model		
[2]	Breusch and Pagan LM Test 2)		$Chi^2(1)=$	452	**	$Chi^2(1)=$	480	**	$Chi^2(1)=$	369	**	$Chi^2(1)=$	342	**	$Chi^2(1)=$	371	**	$Chi^2(1)=$	340	**
	H_0: Var(u)=0 or no random effects.		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000	

			Without Trend		Lags(average)			With Trend		Lags(average)		
[3]	Levin-Lin-Chu's (2002)		Without Trend		Lags(average)			With Trend		Lags(average)		
	Unit Root Tests for Panel Data 3)		t value			t stat		t value			t stat	
	(for the entire period)	log(yield)$_{it}$	-5.147	*	2	-2.181	I(0)	-5.243	+	2	-1.199	I(0)
	(for the entire period)	log(price)$_{it}$	-3.212		2	1.22	Not I(0) for all series.	-3.634		2	1.768	Not I(0) for all series.
		log(oil price /commodity price)$_{it}$	-3.212		2	1.22	Not I(0) for all series.	-3.634		2	1.768	Not I(0) for all series.
		log (rainfall)$_{it}$	-7.921	*	2	-1.924	I(0)	-8.227	+	2	-1.306	I(0)

Notes: 1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.

2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.

3). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .
It tests that all the series are stationary under the alternative (H_1).

4). Baltagi-Li LM test cannot be carried out as the panel is not perfectly balanced.

Table 3 Supply Response to Price Changes for Rice

			Case A			Case B			Case C			Case D			Case E			Case F		
Rice			Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
	Fixed	$\log(price)_{it}$	-0.25	(-5.77)	**	-0.23	(-6.58)	**	-0.09	(-1.47)		0.23	(7.79)	**	-0.02	(-0.36)		0.28	(10.2)	**
	Effects	$\log(price)_{it-1}$	0.04	(0.86)		-	-		0.31	(5.56)	**	-	-		0.30	(5.17)	**	-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.17	(-13.36)	**	-0.17	(-13.4)	**	-0.14	(-6.10)	**	-0.13	(-5.4)	**	-	-		-	-	
		log (rainfall) $_{it}$	-0.03	(-0.52)		-0.03	(-0.54)		-	-		-	-		-	-		-	-	
		Constant	8.92	(22.45)		9.01	(23.5)		6.57	(47.22)		6.52	(48.8)		6.48	(44.8)		6.42	(46.9)	
	Random	$\log(price)_{it}$	-0.25	(-5.80)	**	-0.23	(-6.60)	**	-0.09	(-1.45)		0.23	(7.78)	**	-0.02	(-0.35)		0.28	(10.2)	**
	Effects	$\log(price)_{it-1}$	0.04	(0.86)		-	-		0.30	(5.51)	**	-	-		0.30	(5.12)	**	-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.17	(-13.4)	**	-0.17	(-13.4)	**	-0.14	(-6.06)	**	-0.13	(-5.4)	**	-	-		-	-	
		log (rainfall) $_{it}$	-0.03	(-0.62)		-0.03	(-0.66)		-	-		-	-		-	-		-	-	
		Constant	8.95	(21.85)		9.04	(22.9)		6.57	(39.61)		6.53	(38.2)		6.48	(38.0)		6.43	(37.1)	
	Number of Observations		210			210			390			400			390			400		
	Number of Countries		10			10			10			10			10			10		
	Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
	Fixed effects model																			
	Joint Significant Tests		F(4,196)=	48.81	**	F(3,197)=	64.92	**	F(3,377)=	51.38	**	F(2,388)=	69.93	**	F(2,378)=	53.35	**	F(1,389)=	103.4	**
	R^2 (Overall)		0.065			0.0655			0.072			0.068			0.053			0.0553		
	Random effects model																			
	Joint Significant Tests		Wald chi2(4)=	197.9	**	Wald chi2(3)=	196.6	**	Wald chi2(3)=	152.3	**	Wald chi2(3)=	139.6	**	Wald chi2(2)=	105.3	**	Wald chi2(1)=	103.2	**
	R^2 (Overall)		0.067			0.067			0.072			0.068			0.053			0.0553		
[1]	Hausman Test for the choice		$Chi^2(4)=$	0.100		$Chi^2(3)=$	0.120		$Chi^2(3)=$	0.000		$Chi^2(3)=$	0.260		$Chi^2(3)=$	0.000		$Chi^2(3)=$	0.170	
	between fixed or random effects		$Prob>Chi^2=$	0.999		$Prob>Chi^2=$	0.989		$Prob>Chi^2=$	1.000		$Prob>Chi^2=$	0.878		$Prob>Chi^2=$	1.000		$Prob>Chi^2=$	0.681	
	Model	Chosen model:	Random effects model			Random effects model			Random effects model			Random effects model			Random effects model			Random effects model		
[2]	Breusch and Pagan LM Test [2)]		$Chi^2(1)=$	1845	**	$Chi^2(1)=$	1844	**	$Chi^2(1)=$	3869	**	$Chi^2(1)=$	3932	**	$Chi^2(1)=$	3661	**	$Chi^2(1)=$	3651	**
	H_0: Var(u)=0 or no random effects.		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000	
[3]	Baltagi-Li (1995) LM Test [3)]		$Chi^2(1)=$	4.09	*	$Chi^2(1)=$	4.08	*	$Chi^2(1)=$	11.43	**	$Chi^2(1)=$	10.83	**	$Chi^2(1)=$	11.23	**	$Chi^2(1)=$	10.60	**
	for Serial Correlation		$Prob>Chi^2=$	0.043		$Prob>Chi^2=$	0.043		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.001		$Prob>Chi^2=$	0.001		$Prob>Chi^2=$	0.001	
	H_0: rho=0 or no serial correlation																			
[4]	Levin-Lin-Chu's (2002)		Without Trend	Lags(average)					With Trend		Lags(average)									
	Unit Root Tests for Panel Data [4)]		t value			t stat			t value			t stat								

(for the entire period)	log(yield) $_{it}$	-5.997	+	2	-1.314	I(0)	-5.424		2	-0.662	Not I(0) for all series.
(for the entire period)	log(price) $_{it}$	-6.888	*	2	-2.014	I(0)	-8.366	+	2	-1.253	I(0)
	log(oil price /commodity price) $_{it}$	-6.888	*	2	-2.014	I(0)	-8.366	+	2	-1.253	I(0)
	log (rainfall) $_{it}$	-7.921*		2	-1.924	I(0)	-8.227	*	2	-1.306	I(0)

Notes: 1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.
2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.
3). Baltagi-Li LM test for the null hypothesis that there is no first-order serial correlation, assuming no random effects
4). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .
It tests that all the series are stationary under the alternative (H_1).

Table 4 Supply Response to Price Changes for Fruit

			Case A			Case B			Case C			Case D			Case E			Case F		
Fruit			Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
	Fixed	log(price) $_{it}$	0.04	(0.76)		0.05	(1.15)		-0.03	(-0.45)		-0.03	(-0.76)		0.02	(0.34)		0.03	(1.11)	
	Effects	log(price) $_{it-1}$	0.01	(0.23)		-	-		0.00	(0.03)		-	-		0.01	(0.11)		-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.04	(-1.58)		-0.04	(-1.61)		-0.09	(-2.53)	*	-0.09	(-2.7)	**	-	-		-	-	
		log (rainfall) $_{it}$	-0.17	(-1.77)		-0.17	(-1.77)		-	-		-	-		-	-		-	-	
		Constant	9.67	(13.53)		9.69	(13.64)		8.86	(49.05)		8.84	(52.3)		8.69	(51.5)		8.67	(54.9)	
	Random	log(price) $_{it}$	0.04	(0.77)		0.05	(1.14)		-0.03	(-0.45)		-0.03	(-0.73)		0.02	(0.36)		0.04	(1.20)	
	Effects	log(price) $_{it-1}$	0.01	(0.20)		-	-		0.00	(0.04)		-	-		0.01	(0.12)		-	-	
	Model	$\log(P_{oil}/P_{commodity})_{it}$	-0.04	(-1.62)		-0.04	(-1.64)		-0.09	(-2.56)	*	-0.09	(-2.73)	**	-	-		-	-	
		log (rainfall) $_{it}$	-0.11	(-1.24)		-0.10	(-1.18)		-	-		-	-		-	-		-	-	
		Constant	9.25	(13.87)		9.22	(14.05)		8.87	(40.32)		8.85	(42.7)		8.69	(41.9)		8.67	(44.6)	
	Number of Observations		195			195			331			339			331			339		
	Number of Countries		10			10			10			10			10			10		
	Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
	Fixed effects model																				
	Joint Significant Tests		F(4,181)=	3.24	*	F(3,182)=	4.32	**	F(3,318)=	2.43	+	F(2,327)=	3.27	*	F(2,319)=	0.44		F(1,328)=	1.24	
	R^2 (Overall)		0.098			0.098			0.058			0.064			0.053			0.055		
	Random effects model																				
	Joint Significant Tests		Wald chi2(4)=	11.32	*	Wald chi2(3)=	11.14	**	Wald chi2(3)=	7.6	+	Wald chi2(3)=	8.91	*	Wald chi2(2)=	1.03		Wald chi2(1)=	1.43	
	R^2 (Overall)		0.068			0.064			0.059			0.065			0.053			0.055		
[1]	Hausman Test for the choice		$Chi^2(4)=$	2.640		$Chi^2(3)=$	3.110		$Chi^2(3)=$	0.160		$Chi^2(3)=$	0.200		$Chi^2(3)=$	0.260		$Chi^2(3)=$	0.360	
	between fixed or random effects		$Prob>Chi^2=$	0.620		$Prob>Chi^2=$	0.375		$Prob>Chi^2=$	0.983		$Prob>Chi^2=$	0.903		$Prob>Chi^2=$	0.880		$Prob>Chi^2=$	0.546	
	Model	Chosen model:	Random effects model			Random effects model			Random effects model			Random effects model			Random effects model			Random effects model		
[2]	Breusch and Pagan LM Test 2)		$Chi^2(1)=$	1034	**	$Chi^2(1)=$	1037	**	$Chi^2(1)=$	1744	**	$Chi^2(1)=$	1812	**	$Chi^2(1)=$	1754	**	$Chi^2(1)=$	1825	**
	H_0: Var(u)=0 or no random effects.		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000		$Prob>Chi^2=$	0.000	
[3]	Levin-Lin-Chu's (2002)		Without Trend		Lags(average)							With Trend		Lags(average)						

Unit Root Tests for Panel Data [3]		t value			t stat		t value			t stat	
(for the entire period)	log(yield) $_{it}$	-2.022		2	0.4352	Not I(0) for all countries.	-5.730		2	-0.85	Not I(0) for all countries.
(for the entire period)	log(price) $_{it}$	-4.685		2	-0.351	Not I(0) for all countries.	-5.723		2	-1.05	Not I(0) for all countries.
	log(oil price /commodity price) $_{it}$	-4.685		2	-0.351	Not I(0) for all countries.	-5.723		2	-1.05	Not I(0) for all countries.
	log (rainfall) $_{it}$	-7.921	*	2	-1.924	I(0)	-8.227	+	2	-1.31	I(0)

Notes: 1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.
2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.
3). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .
It tests that all the series are stationary under the alternative (H_1) .
4). Baltagi-Li LM test cannot be carried out as the panel is not perfectly balanced.

Table 5 Supply Response to Price Changes for Vegetable

		Case A			Case B			Case C			Case D			Case E			Case F		
Vegetable		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
Fixed	log(price) $_{it}$	-0.21	(-5.08)	**	-0.23	(-7.17)	**	-0.06	(-1.54)		0.08	(4.09)	**	-0.01	(-0.30)		0.13	(8.59)	**
Effects	log(price) $_{it-1}$	-0.03	(-0.87)		-	-		0.13	(3.78)	**	-	-		0.13	(3.71)	**	-	-	
Model	log(P_{oil}/$P_{commodity}$) $_{it}$	-0.14	(-8.96)	**	-0.14	(-8.92)	**	-0.06	(-3.59)	**	-0.06	(-3.21)	**	-	-		-	-	
	log (rainfall) $_{it}$	0.01	(0.09)		0.01	(0.16)		-	-		-	-		-	-		-	-	
	Constant	10.05	(21.72)		9.98	(21.99)		8.60	(102.50)		8.54	(104.34)		8.45	(113.62)		8.41	(117.36)	
Random	log(price) $_{it}$	-0.21	(-4.85)	**	-0.24	(-7.09)	**	-0.06	(-1.55)		0.08	(4.02)	**	-0.01	(-0.32)		0.12	(8.45)	**
Effects	log(price) $_{it-1}$	-0.04	(-1.10)		-	-		0.13	(3.76)	**	-	-		0.13	(3.69)	**	-	-	
Model	log(P_{oil}/$P_{commodity}$) $_{it}$	-0.14	(-8.66)	**	-0.14	(-8.56)	**	-0.06	(-3.55)	**	-0.06	(-3.16)	**	-	-		-	-	
	log (rainfall) $_{it}$	-0.12	(-2.27)	*	-0.12	(-2.32)	*	-	-		-	-		-	-		-	-	
	Constant	10.99	(26.76)		10.94	(27.26)		8.60	(63.57)		8.55	(66.48)		8.46	(65.28)		8.42	(68.88)	
Number of Observations		210			210			390			400			390			400		
Number of Countries		10			10			10			10			10			10		
Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
Fixed effects model																			
Joint Significant Tests		F(4,196)=	21.3	**	F(3,197)=	28.19	**	F(3,377)=	28.82	**	F(2,388)=	42.92	**	F(2,378)=	35.66	**	F(1,389)=	73.75	**
R^2 (Overall)		0.136			0.107			0.0063			0.0051			0.007			0.005		
Random effects model																			
Joint Significant Tests		Wald chi2(4)=	88.42	**	Wald chi2(3)=	87.39	**	Wald chi2(3)=	84.36	**	Wald chi2(3)=	83.16	**	Wald chi2(2)=	69.57	**	Wald chi2(1)=	71.46	**
R^2 (Overall)		0.612			0.6114			0.0062			0.0051			0.007			0.005		
Hausman Test for the choice		$Chi^2(4)$=	16.790	**	$Chi^2(3)$=	18.210	**	$Chi^2(3)$=	0.000		$Chi^2(3)$=	0.000		$Chi^2(3)$=	0.000		$Chi^2(3)$=	0.000	
between fixed or random effects		Prob>Chi^2=	0.002		Prob>Chi^2=	0.000		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000		Prob>Chi^2=	1.000	
Model	Chosen model:	Fixed effects model			Fixed effects model			Random effects model			Random effects model			Random effects model			Random effects model		
Breusch and Pagan LM Test [2]		$Chi^2(1)$=	856	**	$Chi^2(1)$=	1844	**	$Chi^2(1)$=	4022	**	$Chi^2(1)$=	4129	**	$Chi^2(1)$=	4022	**	$Chi^2(1)$=	4146	**
H_0: Var(u)=0 or no random effects.		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000	
Baltagi-Li (1995) LM Test [3]		$Chi^2(1)$=	2.47		$Chi^2(1)$=	2.52	*	$Chi^2(1)$=	9.26	**	$Chi^2(1)$=	9.55	**	$Chi^2(1)$=	9.26	**	$Chi^2(1)$=	9.52	**

for Serial Correlation	Prob>Chi^2=	0.116	Prob>Chi^2=	0.112	Prob>Chi^2=	0.002	Prob>Chi^2=	0.002	Prob>Chi^2=	0.002	Prob>Chi^2=	0.002
H_0: rho=0 or no serial correlation												

Levin-Lin-Chu's (2002)		Without Trend		Lags(average)			With Trend		Lags(average)		
Unit Root Tests for Panel Data [4]		t value			t stat		t value			t stat	
(for the entire period)	log(yield) $_{it}$	-4.105		2	-0.0435	Not I(0) for all countries.	-6.819		2	0.224	Not I(0) for all countries.
(for the entire period)	log(price) $_{it}$	-5.465		2	-0.476	Not I(0) for all countries.	-7.064		2	-0	Not I(0) for all countries.
	log(oil price /commodity price) $_{it}$	-5.465		2	-0.476	Not I(0) for all countries.	-7.064		2	-0	Not I(0) for all countries.
	log (rainfall) $_{it}$	-7.921	*	2	-1.924	I(0)	-8.227	+	2	-1.31	I(0).

1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.
2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.
3). Baltagi-Li LM test tesys for the null hypothesis that there is no first-order serial correlation, assuming no random effects
4). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .
It tests that all the series are stationary under the alternative.

Table 6 Supply Response to Price Changes for Oilseeds

		Case A			Case B			Case C			Case D			Case E			Case F		
Oilseeds		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value		Coef.	t value	
Fixed	log(price) $_{it}$	0.29	(1.44)		0.47	(3.42)	**	0.20	(1.67)	+	0.27	(3.84)	**	0.13	(1.12)		0.22	(3.34)	**
Effects	log(price) $_{it-1}$	0.26	(1.34)		-	-		0.10	(0.93)		-	-		0.12	(1.11)		-	-	
Model	$\log(P_{oil}/P_{commodity})_{it}$	0.14	(1.90)	+	0.14	(1.84)	+	0.09	(1.79)	+	0.10	(1.88)		-	-		-	-	
	log (rainfall) $_{it}$	0.31	(1.03)		0.34	(1.15)		-	-		-	-		-	-		-	-	
	Constant	1.68	(0.7)		1.87	(0.81)		5.10	(13.5)		5.26	(14.9)		5.21	(13.9)		5.38	(15.5)	
Random	log(price) $_{it}$	0.27	(1.33)		0.45	(3.26)	**	0.20	(1.65)	+	0.27	(3.78)	**	0.12	(1.09)		0.21	(3.24)	**
Effects	log(price) $_{it-1}$	0.25	(1.26)		-	-		0.10	(0.91)		-	-		0.12	(1.08)		-	-	
Model	$\log(P_{oil}/P_{commodity})_{it}$	0.14	(1.88)	+	0.14	(1.83)	+	0.10	(1.81)	+	0.10	(1.90)		-	-		-	-	
	log (rainfall) $_{it}$	0.28	(1.04)		0.31	(1.15)		-	-		-	-		-	-		-	-	
	Constant	2.22	(1.0)		2.36	(1.07)		5.38	(8.1)		5.52	(8.8)		5.49	(8.4)		5.65	(9.5)	
Number of Observations		123			125			220			227			220			227		
Number of Countries		7			7			7			7			7			7		
Period covered		1980-2000			1980-2000			1966-2005			1966-2005			1966-2005			1966-2005		
Fixed effects model																			
Joint Significant Tests		$F(4,112)$=	3.62	**	$F(3,115)$=	4.11	**	$F(3,210)$=	5.28	**	$F(2,327)$=	7.4	**	$F(2,211)$=	6.26	**	$F(1,219)$=	11.16	**
R^2 (Overall)		0.0294			0.0198			0.065			0.059			0.09			0.0898		
Random effects model																			
Joint Significant Tests		Wald chi2(4)=	13.05	*	Wald chi2(3)=	11.41	**	Wald chi2(3)=	15.4	**	Wald chi2(3)=	14.36	**	Wald chi2(2)=	11.94	**	Wald chi2(1)=	10.49	**
R^2 (Overall)		0.0291			0.0202			0.034			0.057			0.09			0.0898		
[1] Hausman Test for the choice		$Chi^2(4)$=	0.040		$Chi^2(3)$=	1.490		$Chi^2(3)$=	0.940		$Chi^2(3)$=	0.160		$Chi^2(3)$=	1.330		$Chi^2(3)$=	12.130	**
between fixed or random effects		Prob>Chi^2=	0.999		Prob>Chi^2=	0.474		Prob>Chi^2=	0.816		Prob>Chi^2=	0.983		Prob>Chi^2=	0.513		Prob>Chi^2=	0.001	

	Model	Chosen model:	Random effects model			Random effects model			Random effects model			Random effects model			Random effects model			Fixed effects model		
[2]	Breusch and Pagan LM Test [2)]		$Chi^2(1)$=	840	**	$Chi^2(1)$=	2923	**	$Chi^2(1)$=	2748	**	$Chi^2(1)$=	1744	**	$Chi^2(1)$=	2741	**	$Chi^2(1)$=	2915	**
	H_0: Var(u)=0 or no random effects.		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000		Prob>Chi^2=	0.000	

[3]	Levin-Lin-Chu's (2002)		Without Trend		Lags(average)			With Trend		Lags(average)		
	Unit Root Tests for Panel Data [3)]		t value			t stat		t value			t stat	
	(for the entire period)	log(yield) $_{it}$	-3.809		2	-0.9936	Not I(0) for all countries.	-9.811	*	2	1.016	I(0)
	(for the entire period)	log(price) $_{it}$	-4.436	*	2	-1.659	I(0)	-6.040	**	2	-1.85	I(0)
		log(oil price /commodity price) $_{it}$	-4.436		2	-1.659	Not I(0) for all countries.	-6.040		2	-1.85	Not I(0) for all countries.
		log (rainfall) $_{it}$	-7.921	*	2	-1.924	I(0)	-8.227	+	2	-1.31	I(0)

Notes: 1). '**' '*' and '+' indicate that the parameter estimate is statistically significant at 1% level, 5 % level and 10 % level respectively.

2). Breusch and Pagan LM Test is for testing the null hypothesis that there is no random effects, assuming no serial correlation.

3). Levin-Lin-Chu's test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects effects (and a time trend) .

It tests that all the series are stationary under the alternative (H_1) .

4). Baltagi-Li LM test cannot be carried out as the panel is not perfectly balanced.

Table 7 The Change of Supply Elasticity after the year 2000

		Maize	Wheat	Rice	Fruit	Vegetable	Oilseeds
-1999	Supply Elasticity						
	w.r.t. Price	**0.204**	**0.309**	**0.275**	**0.015**	**0.113**	**0.246**
	(z value)	(8.55)**	(3.79)**	(11.18)**	(0.47).	(7.93)**	(3.55)**
	No. of Observations	340	179	340	279	340	185
2000-2005	Supply Elasticity						
	w.r.t. Price	**0.301**	**0.065**	**0.17**	**0.06**	**-0.033**	**-0.107**
	(z value)	(1.60)	(2.93)**	(3.74)**	(0.52)	(-1.09)	(-1.16)
	No. of Observations	60	36	60	60	60	42
Hausman Test (without constant)							
	$Chi^2(1)$	0.27	9.68**	7.51**	0.16	29.04**	32.93**
	$Prob>Chi^2(1)$	0.6	0.0019	0.0061	0.6868	0	0

Notes 1). '**' indicates that the parameter estimate is statistically significant at 1% level.

2). The specification is based on Case F in previous tables where only log price is used as an explanatory variable. Random effects models are chosen except for Oilseeds.

Appendix 1 Descriptive Statistics of Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
$\log(rain)_{it}$	210	7.210805	0.6700929	5.221437	8.114205
Maize					
$\log(yield/hectare)_{it}$	400	7.347328	0.4958457	6.482878	8.581321
$\log(price)_{it}$	400	4.704347	0.500295	1.857057	6.107436
$\log(price)_{it-1}$	390	4.697975	0.5043859	1.857057	6.107436
$\log(P_{oil}/P_{commodity})_{it}$	400	-1.222656	0.5783912	-2.663411	1.134165
Wheat					
$\log(yield/hectare)_{it}$	220	7.362093	0.4703869	6.186373	8.360631
$\log(price)_{it}$	215	4.932568	0.3633624	3.068053	5.908906
$\log(price)_{it-1}$	209	4.938608	0.3444888	3.068053	5.908906
$\log(P_{oil}/P_{commodity})_{it}$	215	-1.462799	0.5056231	-2.421359	0.8967159
Rice					
$\log(yield/hectare)_{it}$	400	7.810317	0.3834416	6.544041	8.756685
$\log(price)_{it}$	400	4.882204	0.3914299	2.590044	5.736959
$\log(price)_{it-1}$	390	4.87642	0.3940326	2.590044	5.736959
$\log(P_{oil}/P_{commodity})_{it}$	400	-1.400513	0.4646137	-2.589135	0.4011778
Fruit					
$\log(yield/hectare)_{it}$	343	8.843507	0.4271826	7.770329	10.12679
$\log(price)_{it}$	394	5.054545	0.6010737	3.304703	6.482756
$\log(price)_{it-1}$	384	5.045899	0.5986075	3.304703	6.367773
$\log(P_{oil}/P_{commodity})_{it}$	394	-1.567579	0.6595065	-3.202523	0.187094
Vegetable					
$\log(yield/hectare)_{it}$	400	9.02037	0.3683442	8.189689	9.979991
$\log(price)_{it}$	400	4.861557	0.6759802	2.600218	6.083246
$\log(price)_{it-1}$	390	4.853208	0.6771664	2.600218	6.083246
$\log(P_{oil}/P_{commodity})_{it}$	400	-1.379866	0.7101953	-3.184703	0.6738527
Oilseeds					
$\log(yield/hectare)_{it}$	282	6.689854	1.247013	5.118114	10.60831
$\log(price)_{it}$	267	5.458915	0.6204912	3.596216	7.089735
$\log(price)_{it-1}$	259	5.456603	0.6199371	3.596216	7.089735
$\log(P_{oil}/P_{commodity})_{it}$	267	-1.990667	0.6965932	-3.957725	- 0.2970511

Appendix 2 Correlation Matrices of Variables

Maize	$\log(\text{yield/hectare})_{it}$	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
$\log(\text{yield/hectare})_{it}$	1				
$\log(\text{price})_{it}$	-0.3136	1			
$\log(\text{price})_{it-1}$	-0.2704	0.8029	1		
$\log(P_{oil}/P_{commodity})_{it}$	-0.0155	-0.5974	-0.5032	1	
$\log(\text{rain})_{it}$	-0.3022	0.384	0.3822	-0.1927	1

Wheat	$\log(\text{yield/hectare})_{it}$	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
$\log(\text{yield/hectare})_{it}$	1				
$\log(\text{price})_{it}$	-0.1342	1			
$\log(\text{price})_{it-1}$	-0.0957	0.7996	1		
$\log(P_{oil}/P_{commodity})_{it}$	0.0029	-0.1768	-0.0788	1	
$\log(\text{rain})_{it}$	-0.292	0.3019	0.2698	-0.1608	1

Rice	$\log(\text{yield/hectare})_{it}$	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
$\log(\text{yield/hectare})_{it}$	1				
$\log(\text{price})_{it}$	-0.0213	1			
$\log(\text{price})_{it-1}$	0.0011	0.6766	1		
$\log(P_{oil}/P_{commodity})_{it}$	-0.213	-0.2604	-0.181	1	
$\log(\text{rain})_{it}$	-0.1794	-0.0097	-0.0143	0.0116	1

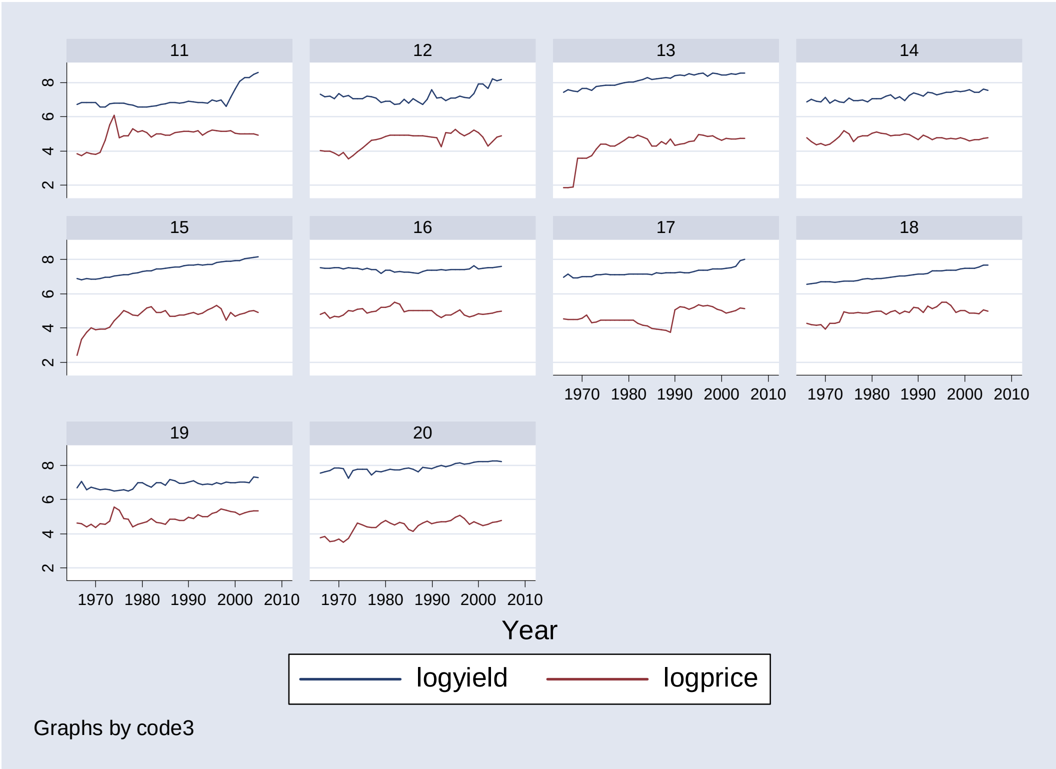
Fruit	$\log(\text{yield/hectare})_{it}$	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
$\log(\text{yield/hectare})_{it}$	1				
$\log(\text{price})_{it}$	0.0849	1			
$\log(\text{price})_{it-1}$	0.0699	0.9016	1		
$\log(P_{oil}/P_{commodity})_{it}$	-0.1297	-0.7479	-0.6923	1	
$\log(\text{rain})_{it}$	0.3657	0.1958	0.2	-0.1674	1

Vegetable	log(yield/hectare)	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
log(yield/hectare)	1				
$\log(\text{price})_{it}$	-0.4215	1			
$\log(\text{price})_{it-1}$	-0.408	0.893	1		
$\log(P_{oil}/P_{commodity})_{it}$	0.1631	-0.731	-0.6747	1	
$\log(\text{rain})_{it}$	-0.782	0.2612	0.259	-0.1682	1

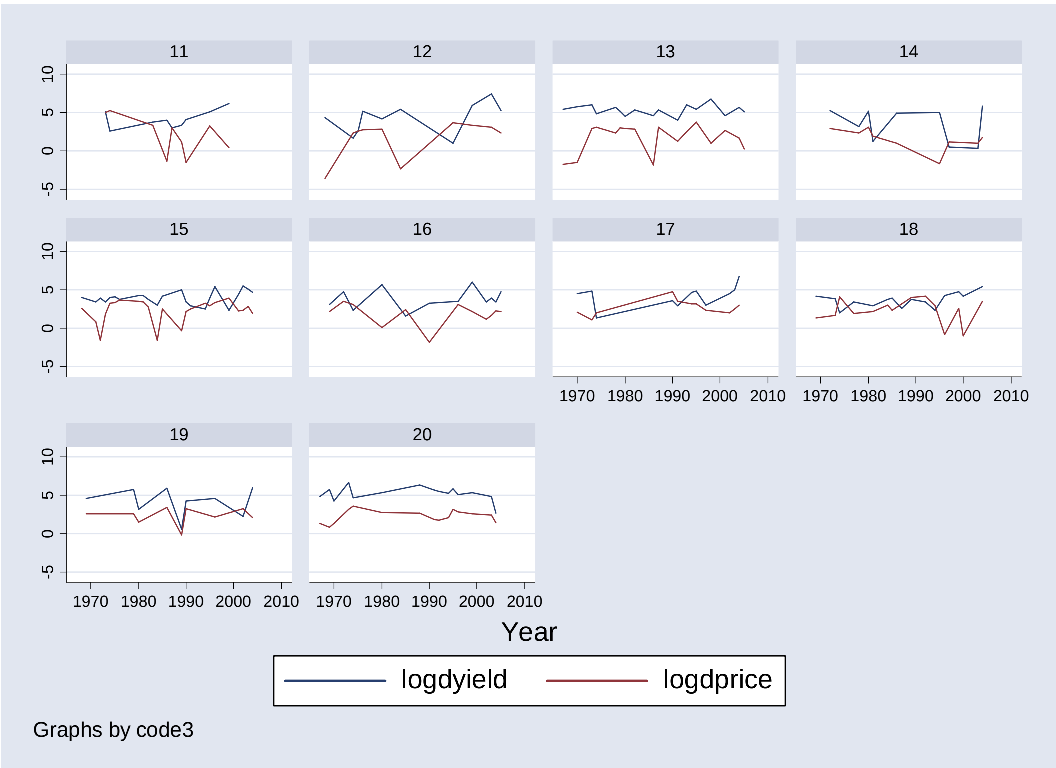
Oilseeds	log(yield/hectare)	$\log(\text{price})_{it}$	$\log(\text{price})_{it-1}$	$\log(P_{oil}/P_{commodity})_{it}$	$\log(\text{rain})_{it}$
log(yield/hectare)	1				
$\log(\text{price})_{it}$	-0.3595	1			
$\log(\text{price})_{it-1}$	-0.3343	0.9459	1		
$\log(P_{oil}/P_{commodity})_{it}$	0.2632	-0.7483	-0.7155	1	
$\log(\text{rain})_{it}$	0.0868	0.0481	0.074	-0.0936	1

Appendix 3 Graphs of log(yield/hectare) and log(price) (levels and first differences)

Maize: log(yield/hectare) and log(price) (Levels)

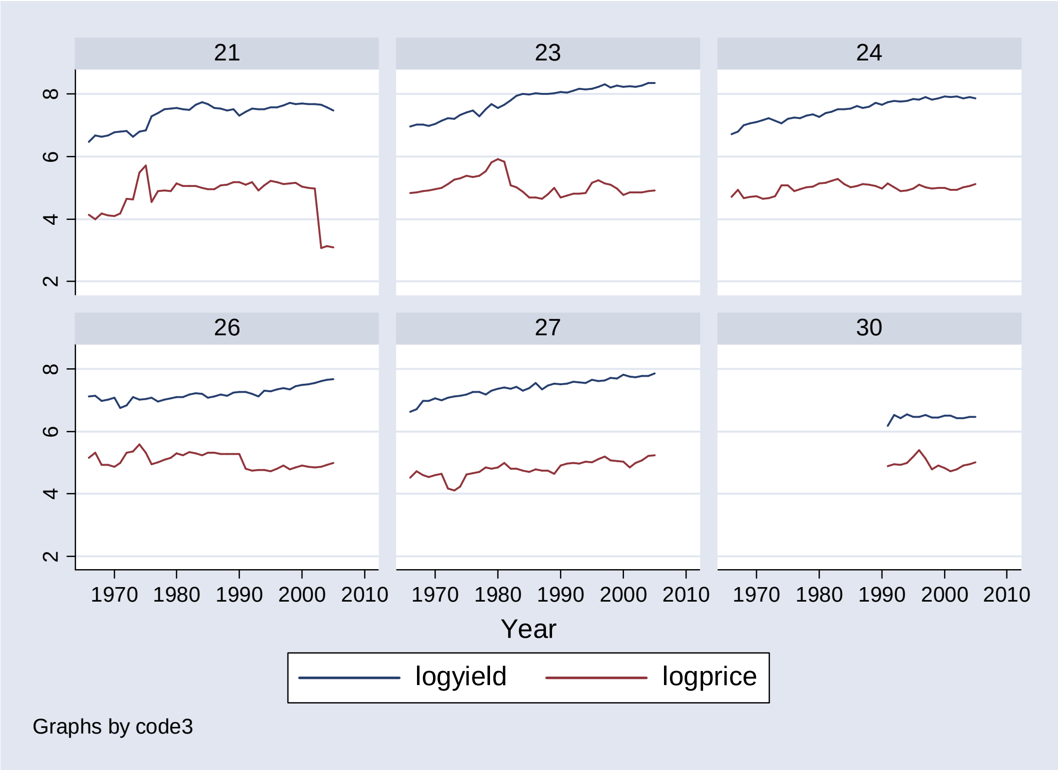


Maize: D log(yield/hectare) and D log(price) (first differences)

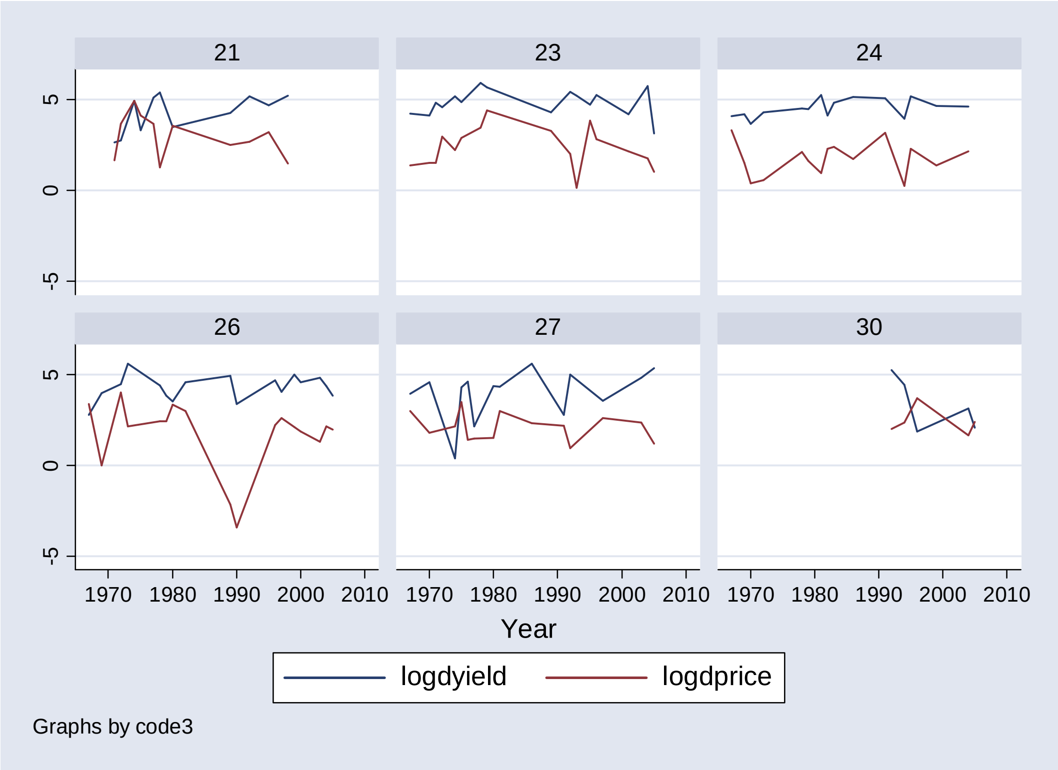


11	12	13	14	15	16	17	18	19	20
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand

Wheat: log(yield/hectare) and log(price) (Levels)

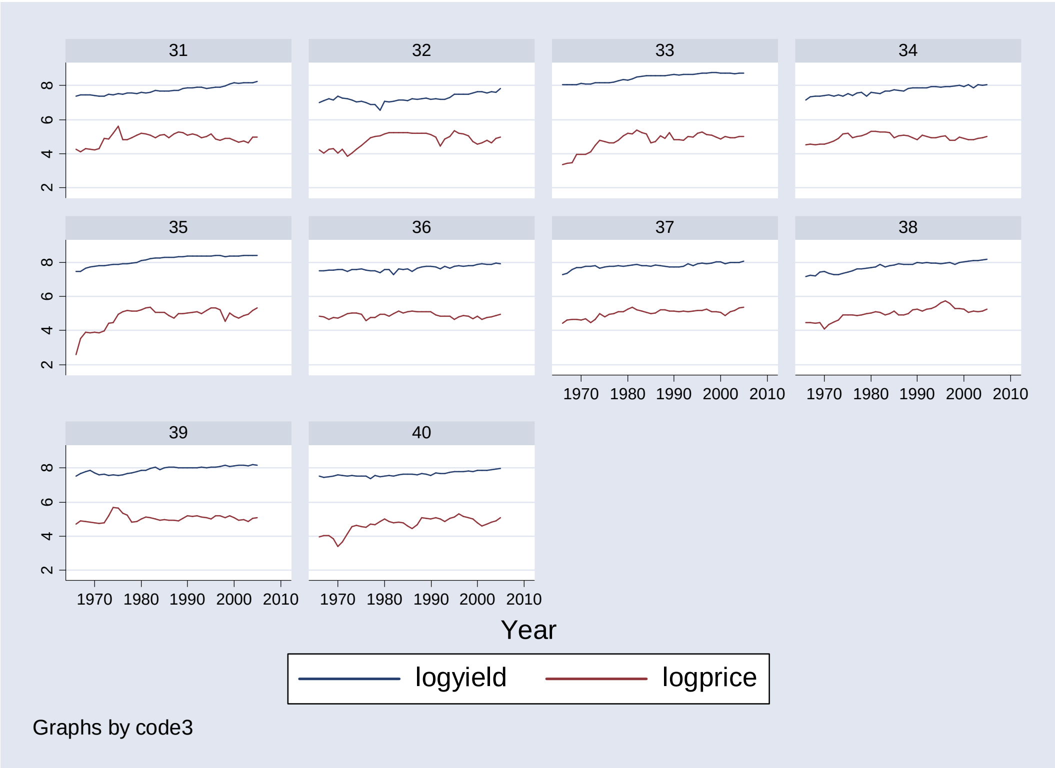


Wheat: D log(yield/hectare) and D log(price)   (first differences)

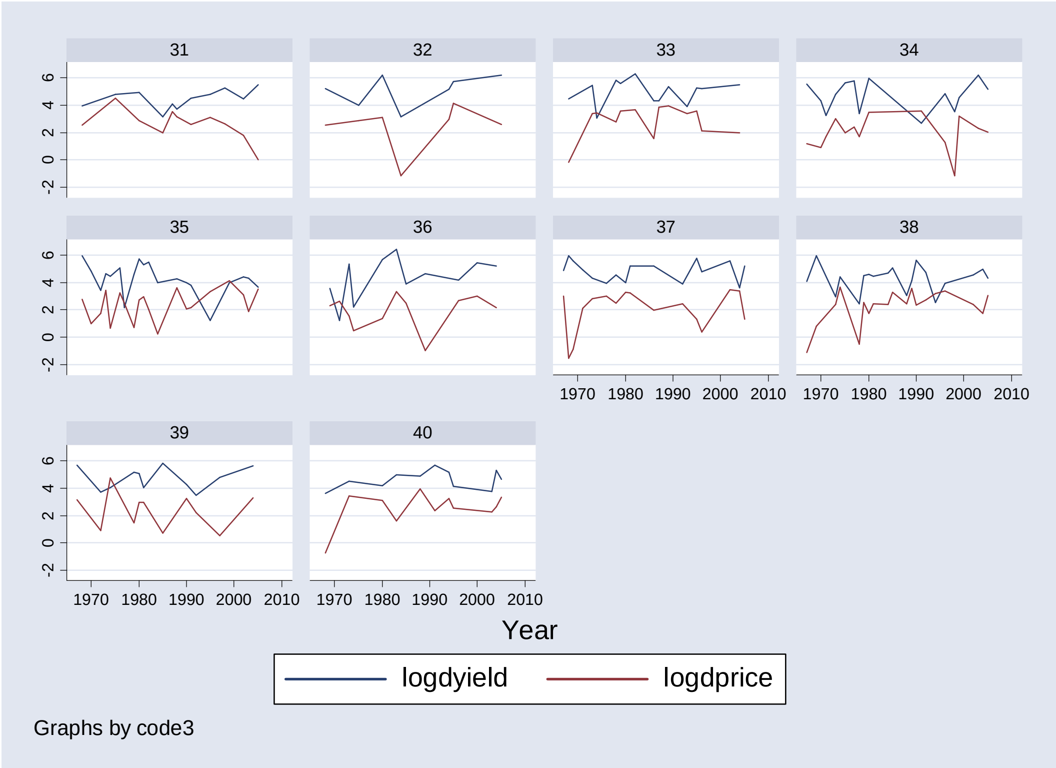


21	23	24	26	27	30
Bangladesh	China	India	Nepal	Pakistan	Thailand

Rice: log(yield/hectare) and log(price) (Levels)

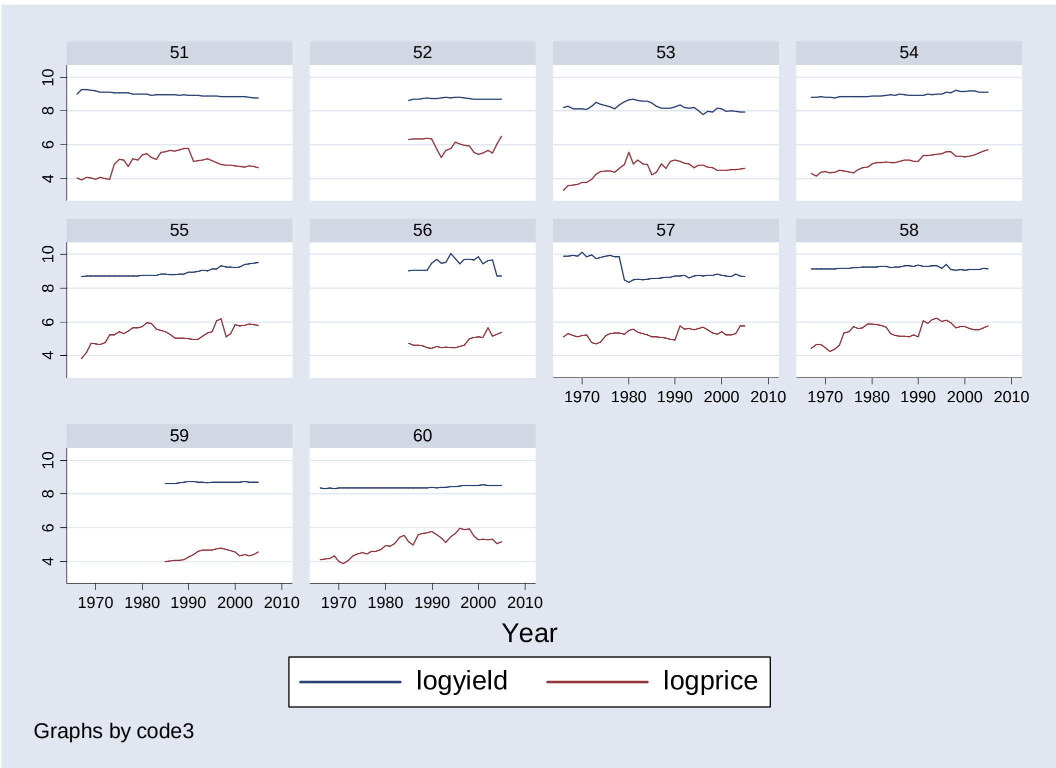


Rice: D log(yield/hectare) and D log(price)   (first differences)

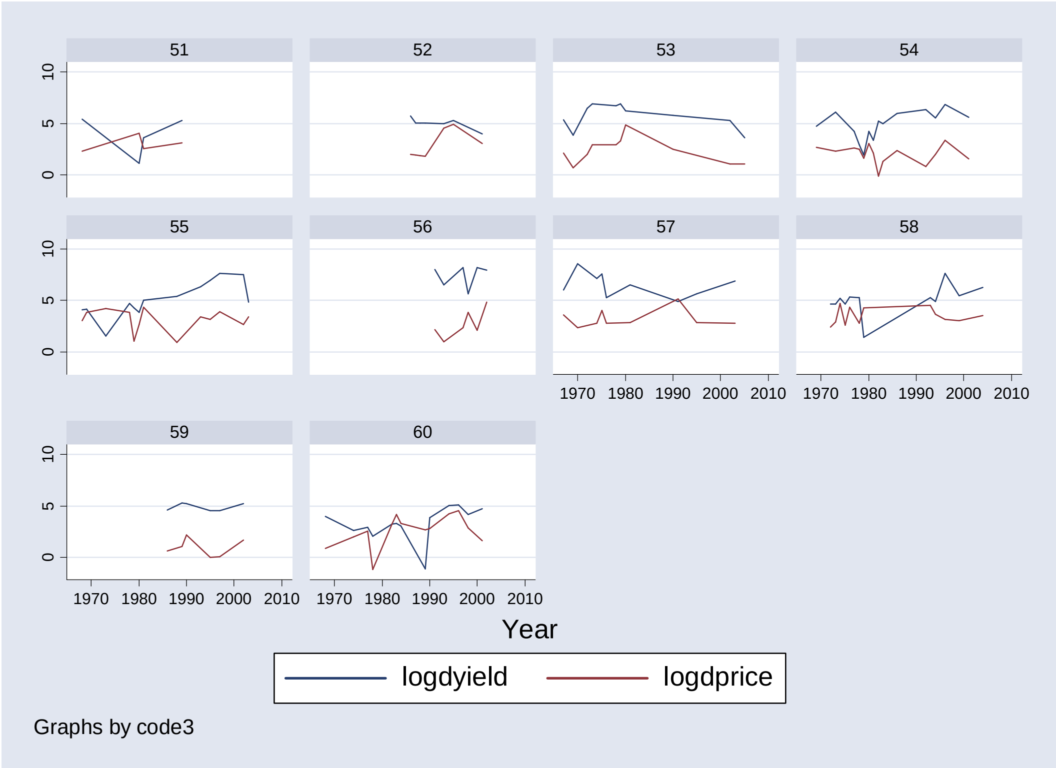


31	32	33	34	35	36	37	38	39	40
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand

Fruit: log(yield/hectare) and log(price) (Levels)

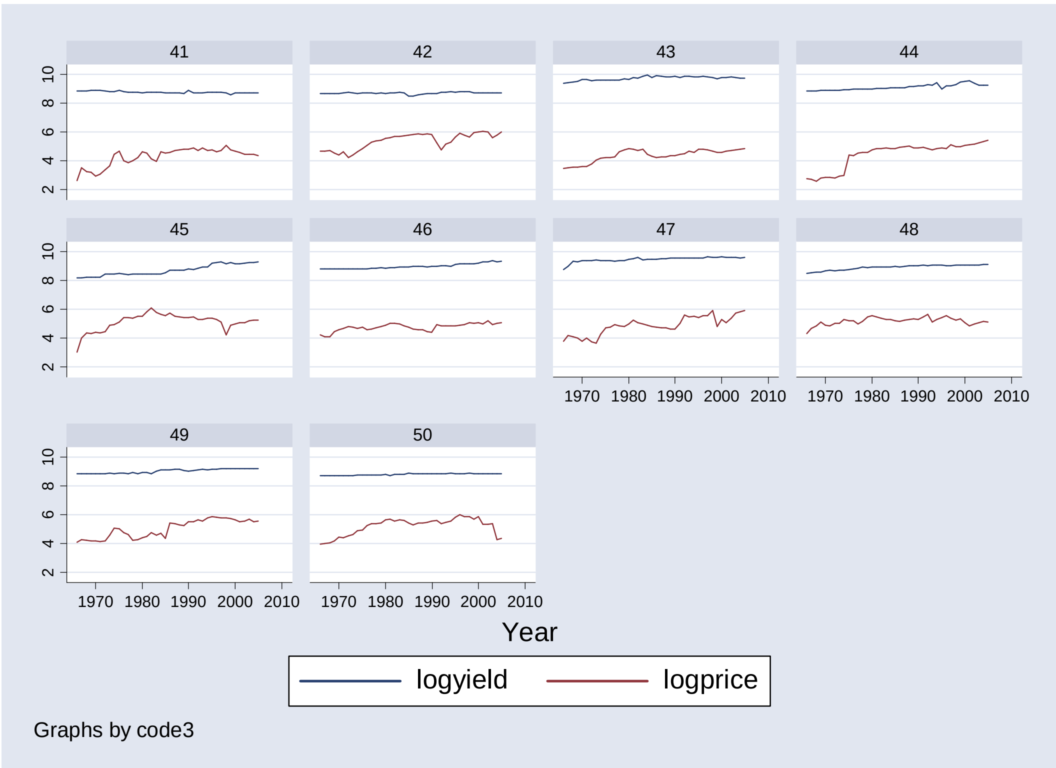


Fruit: D log(yield/hectare) and D log(price) (first differences)

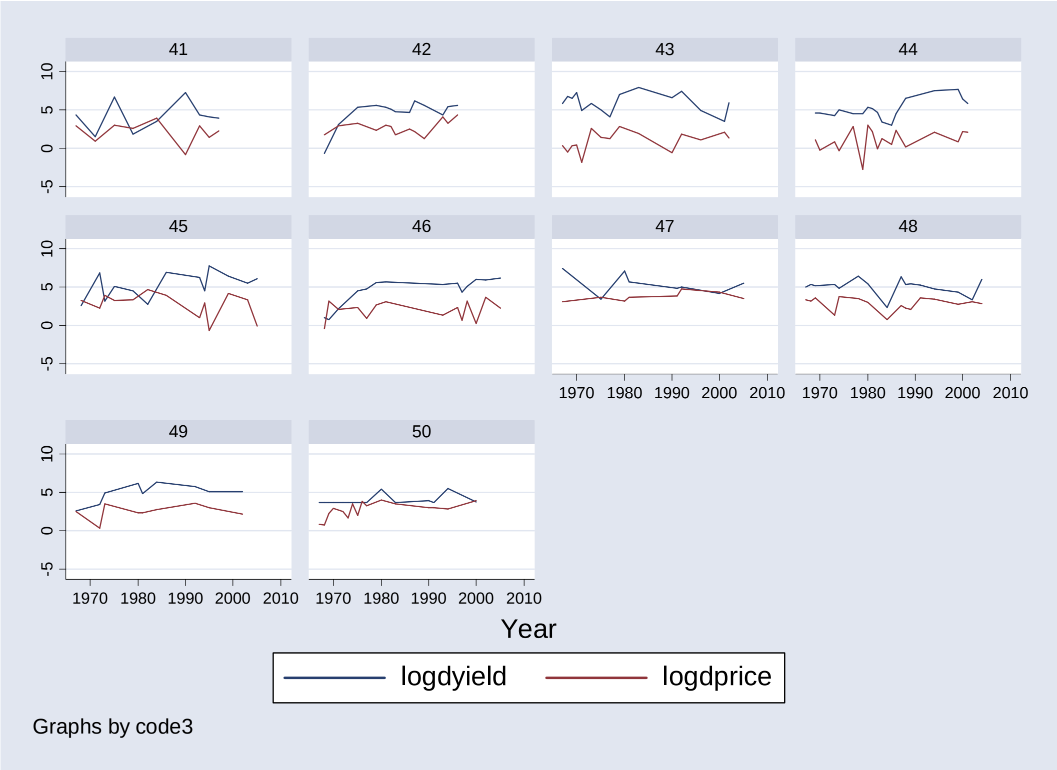


51	52	53	54	55	56	57	58	59	60
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand

Vegetable: log(yield/hectare) and log(price) (Levels)

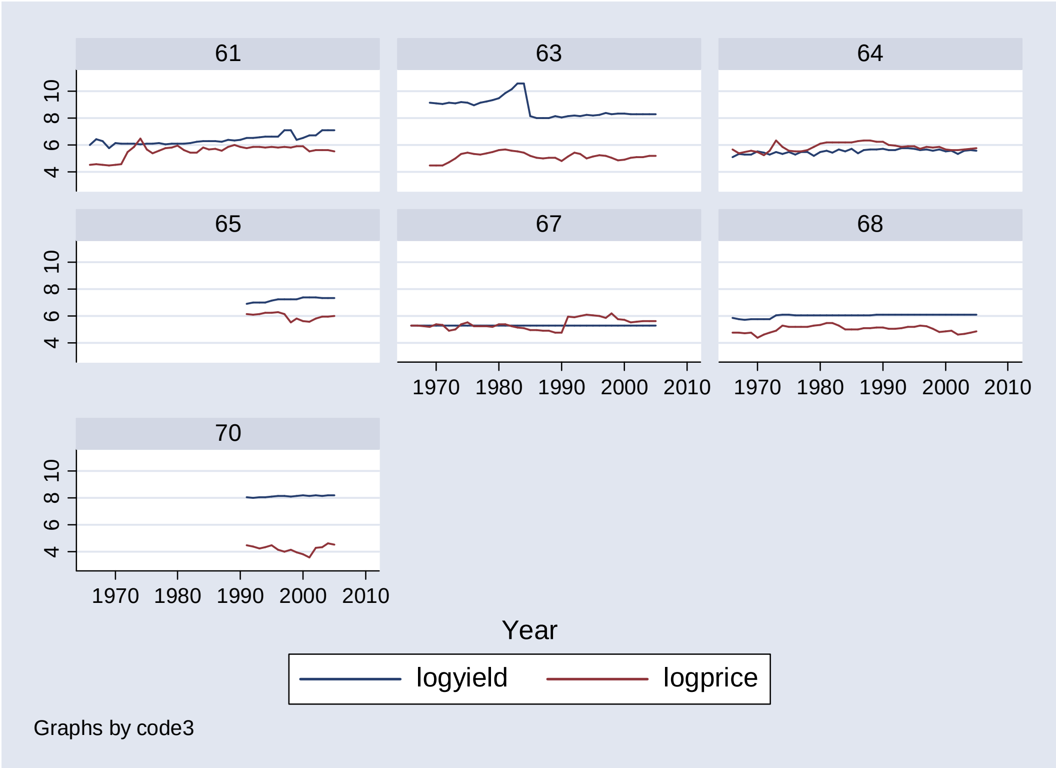


Vegetable: D log(yield/hectare) and D log(price)   (first differences)

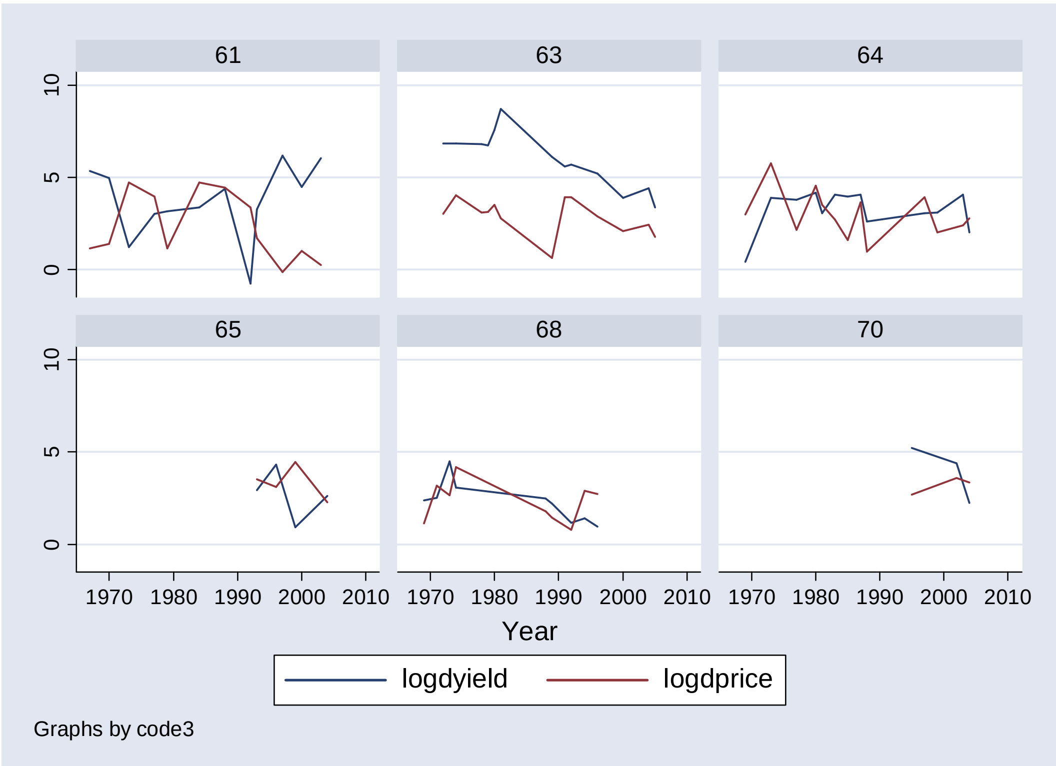


41	42	43	44	45	46	47	48	49	50
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand

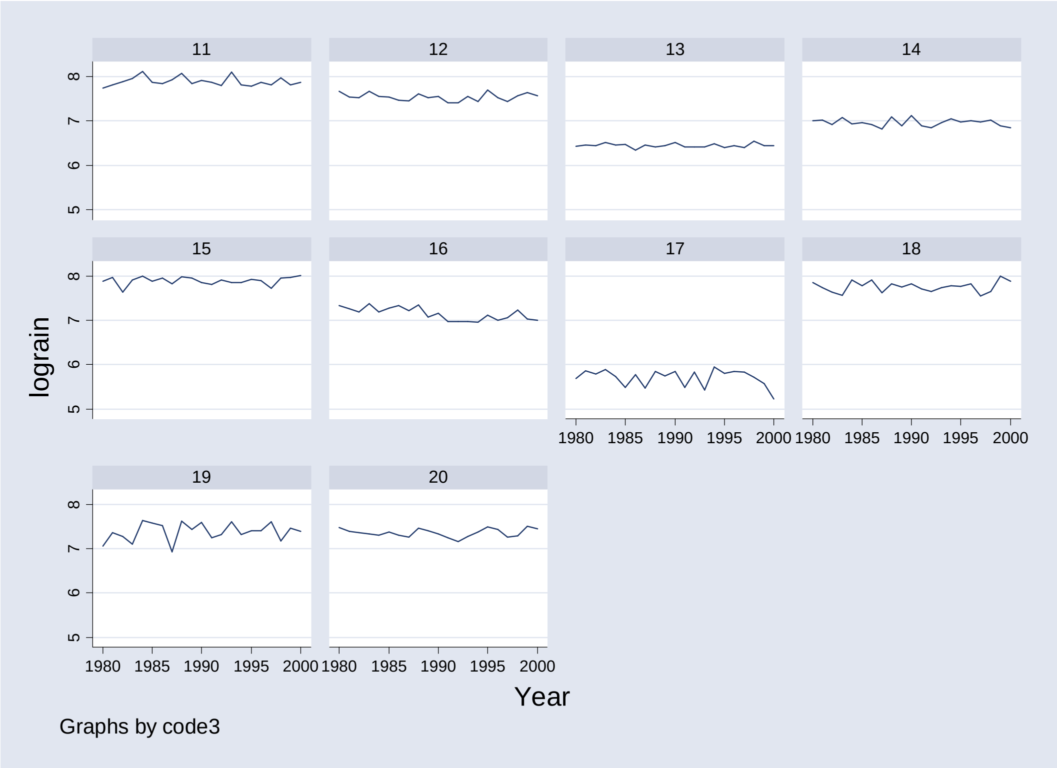
Oilseeds: log(yield/hectare) and log(price) (Levels)



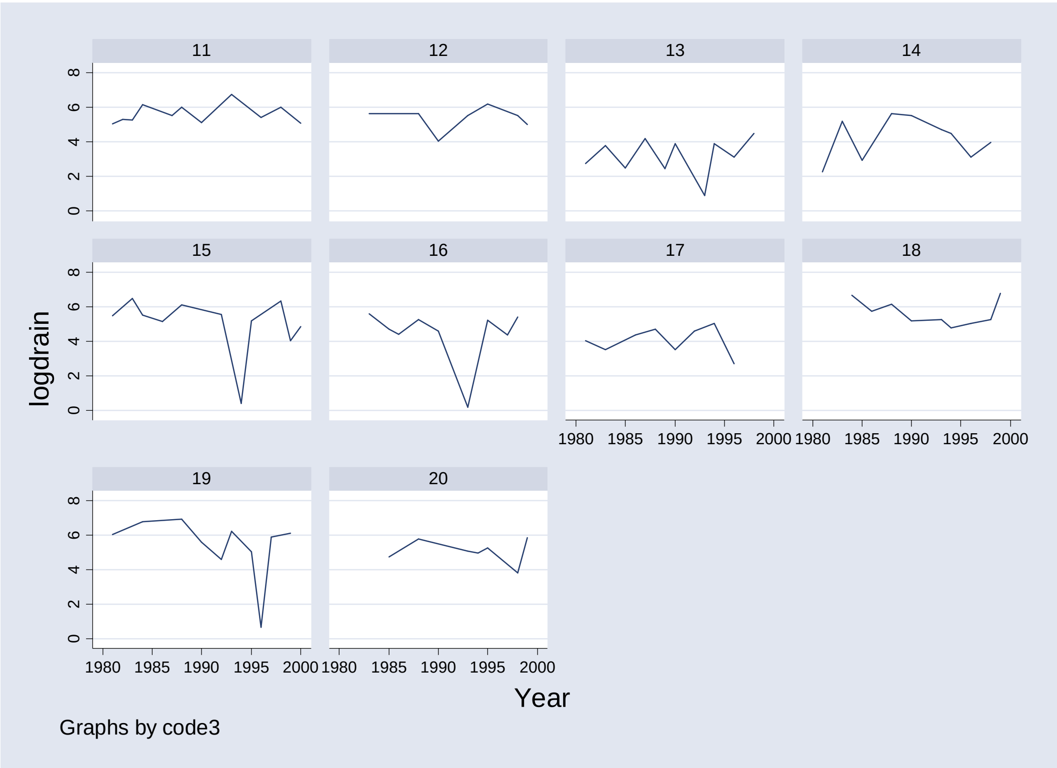
Oilseeds: D log(yield/hectare) and D log(price) (first differences)



Log (Annual Rainfall) (level)



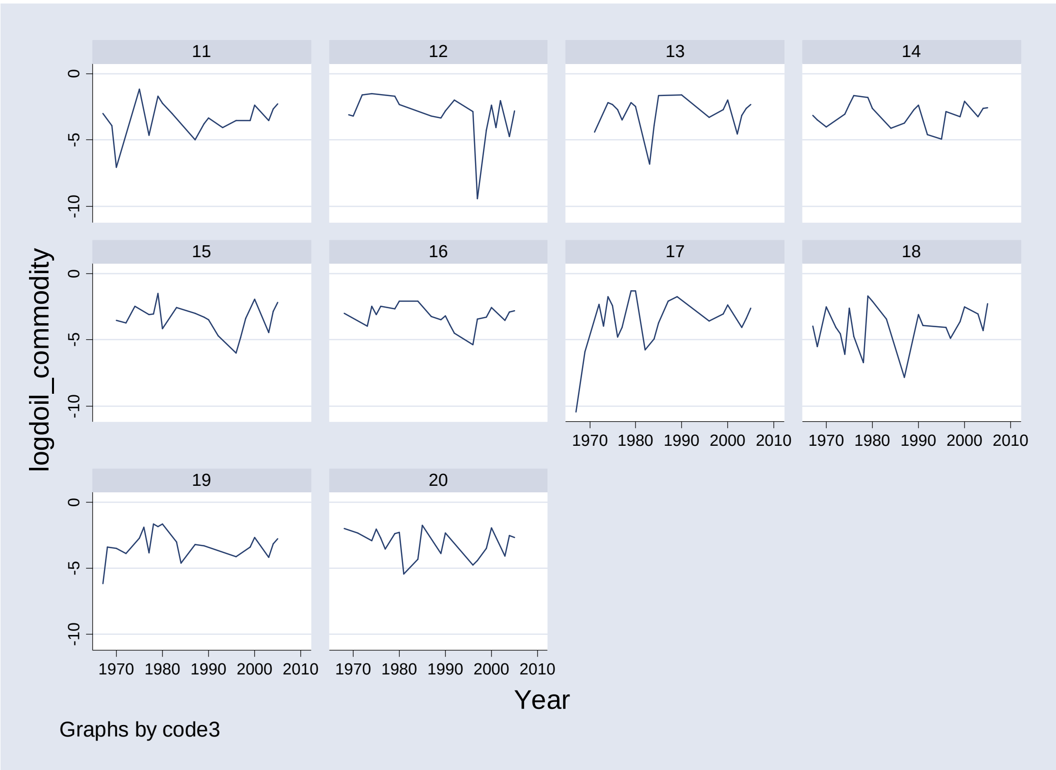
D Log (Annual Rainfall) (first difference)



11	12	13	14	15	16	17	18	19	20
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand

log(Oil price/maize price) (Levels)

Dlog(Oil price/maize price) (first differences)



11	12	13	14	15	16	17	18	19	20
Bangladesh	Cambodia	China	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand