Domestic Wheat Price Formation and Food Inflation in India

Dipak Dasgupta and R.N. Dubey and R Sathish

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International Prices, Domestic Drivers (Stocks, Weather, Public Policy), and the Efficacy of Public Policy Interventions in Wheat Markets

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Content

Abstract

Inflation, especially in food prices, has been persistently high in India during the past twenty four months. This has been a source of concern to policy-makers. Fortunately, food price increases are now starting to ease, after the major spike that occurred in the wake of the severe drought of 2009. However, there still remains concern that we: (a) need to better understand the factors that drive such spikes in key prices; and (b) design more effective policies to prevent such future price spikes. The main approach to understanding inflation and its drivers has typically rested, on the whole, in assessing aggregate macroeconomic (aggregate supply and demand) conditions, which then typically leads to consideration of macroeconomic (and monetary) policies as the principal tool to deal with inflation surges. That may indeed be appropriate in most circumstances, but is often a blunt, sometimes costly instrument that can stifle growth, especially if price pressures arise from (temporary) supply constraints. Therefore, it may be important to complement an aggregate macroeconomic analysis of inflation with microeconomic analysis: to ascertain if inflation is being driven by specific price spikes in important food and non-food commodities, which has the potential to drive other commodity prices in a cost-push manner.

This paper, on global wheat market developments, price transmission and impacts on Indian domestic markets, as well as an assessment of public policies to manage domestic prices, is part of a larger effort to improve our in-house (Department of Economic Affairs) research---to track, monitor and forecast fast-moving key macro-economic variables with potentially large consequences for public policy. We have begun to intensify our efforts. We are investing further systematically---to understand growth and inflation dynamics in the context of rising food inflationary pressures in India and worldwide. We are capturing more high frequency data, and applying quantitative modeling tools (as evident in our current Economic Survey). This paper is also intended as an input to the deliberations of the Inter-Ministerial Group (IMG) that has been recently constituted to review the overall inflation situation, with particular reference to primary food articles.

We take up wheat in this paper, because of recent rapid price rises globally, as well as domestically, and because it constitutes a major element of the overall wholesale and consumer food price inflation indices. Some aspects of the price formation and policy intervention processes in wheat are also likely to be structurally similar for other similar classes of important food items (such as rice), permitting broader insights.

Our paper draws upon existing theoretical insights and modeling attempts in the literature; it is, nevertheless, useful to note three "biases" in our approach: (a) favoring analysis of short-term, high-frequency price formation (daily, monthly, or quarterly), versus alternative longer-term annual, structural models; (b) favoring simplified reduced form forecasting models that track high-frequency turning points well, over more elaborate models and tests of longer-duration time-series data (which may tend to be more historical and backward-looking, and less

useful for short-term forecasting); and (c) assessing current India-specific public interventions in greater detail, than in more general academic papers and models.

Foreword

The Economic Division in the Department of Economic Affairs has initiated a working paper series with the objective of improving economic analysis and promoting evidence based policy formulation. The themes to be covered in the series include both macroeconomic and sectoral issues of relevance for national policy, strategy for addressing emerging global and national development concernes and the agenda for economic policy reforms

The paper by Shri Dipak Dasgupta, Shri R.N.Dubey and Shri R.Sathish on "Domestic Wheat Price Formation and Food Inflation in India: International Prices, Domestic Drivers (Stocks, Weather, Public Policy), and the Efficacy of Public Policy Interventions in Wheat Markets" is the second working paper for 2011. This paper examines the issues relating to wheat price formation and its determinants. Rising inflation is a matter of concern now, although, there is some recent moderation in food prices. I hope that this paper will contribute to the discussion and debate on the subject and help design suitable policy in future

-Sd-

(Kaushik Basu)

Chief Economic Adviser

May 5, 2011

Disclaimer and Acknowledgements

The views expressed in this paper are those of the authors alone and do not necessarily reflect the views of the Ministry of Finance or Government of India

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Domestic Wheat Price Formation and Food Inflation in India:

International Prices, Domestic Drivers (Stocks, Weather, Public Policy), and the Efficacy of Public Policy Interventions in Wheat Markets

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Executive Summary and Conclusion

A Concern with Food Inflation. Inflation, especially in food prices, has been persistently high in India during the past twenty four months. This has been a source of concern to policy-makers. Fortunately, food price increases are now starting to ease, after the major spike that occurred in the wake of the severe drought of 2009. However, there still remains concern that we: (a) need to better understand the factors that drive such spikes in key prices; and (b) design more effective policies to prevent such future price spikes.

A Microeconomic (Commodity Specific) Approach. The main approach to understanding inflation and its drivers has typically rested, on the whole, in assessing aggregate macroeconomic (aggregate supply and demand) conditions, which then typically leads to consideration of macroeconomic (and monetary) policies as the principal tool to deal with inflation surges. That may indeed be appropriate in most circumstances, but is often a blunt, sometimes costly instrument that can stifle growth, especially if price pressures arise from (temporary) supply constraints. Therefore, it may be important to complement an aggregate macroeconomic analysis of inflation with microeconomic analysis: to ascertain if inflation is being driven by specific price spikes in important food and non-food commodities, which has the potential to drive other commodity prices in a cost-push manner.

Objectives. The objectives of this paper are to: (a) understand key factors driving near-term changes in food prices, starting with a major food commodity, wheat; (b) to start building analytical models and tools to measure the importance of drivers of near-term prices of wheat; similar approaches can then be used for other commodities (such as rice, pulses or edible oils); (c) forecast near-term wheat wholesale price movements, and impact on food price inflation (both WPI and CPI); and (d) identify public policy improvements to prevent future spikes in wheat and other food prices.

Wheat Prices and Inflation. What happens to wheat prices has major implications for food and overall inflation trends in India. Based on weights, a 10% change in wheat prices would be expected to lead to nearly 1% change in overall food inflation in the WPI, ignoring any cross-price effects on other foods; and a 2% change including such cross-price effects. For the combined rural-urban CPI, a 10% change in wheat prices would produce by itself about 1.5 percentage points change in overall CPI inflation, but potentially as much as 3 percentage points change in overall CPI inflation, taking into account cross-price effects of wheat price increases on other foods.

Drivers of Short-Term Wholesale Wheat Price Movements. The paper builds on a standard theoretical model of commodity price formation, widely used in the commodity price forecasting community, and develops this further in the India context. A reduced form model is derived to econometrically estimate, by ordinary least-squares (OLS) domestic wholesale wheat price formation. We use high-frequency data (monthly, converted to quarterly data) over the

most recent decadal time period, January 2000-January 2011. The results are also cross-checked and confirmed robustly using alternative (ARDL) cointegration tests, given the time-series data used: Specifically:

(1)We first need to check whether the "law of one price internationally" applies to wheat in India; that is, whether Indian wheat prices follow, or not, ***global wheat market prices***; there can be many reasons, such as quality, distance, transport costs, and most importantly, policy "wedges" (export bans, import restrictions) preventing private trade in wheat that can drive wheat markets in India to be more autarkic; on the other hand, border smuggling and inability to rigidly apply trade restrictions may significantly weaken the impact; and domestic prices cannot possibly stay well divergent from global conditions for long because of physical arbitrage conditions and financial arbitrage in commodity futures markets. This is an eminently testable first proposition. We expected that international price movements would have some role, and this was indeed the case, although weaker than expected. Moreover, the coefficient or size of this impact is well below 1, closer to 0.2, suggesting that wholesale domestic wheat markets and price formation in India are only moderately affected by international price movements (so far) and instead significantly intermediated by other domestic factors.

(2)If domestic market conditions and factors are therefore important, then we need to account for the impact of changes in demand and supply in domestic wheat markets. But we cannot directly or reasonably accurately observe short-term supply and demand conditions, which ultimately drive commodity prices. Instead, a "reduced form" model is derived, where we need only to know changes in stocks of the commodity---since changes in supply and demand will show up immediately in ***change in stocks***. Private stocks are mostly unobserved or not measured well for most commodities in India (indeed, we need to do this much better in future); internationally, private agents and reliable public information seek to measure changes in stocks as the main predictor of near-term price movements (in such standard commodities as oil, or other commodities, for example). Fortunately, in wheat markets in India, the Government is a major player, procuring to maintain farm prices at remunerative levels (set a floor) and disposing of such stocks through various public distribution schemes (PDS), where we do have reasonably accurate public data on public stocks of wheat---which we can then use to predict near-term wholesale prices, if they have any effect. This is, again, a testable proposition. A higher level of ***physical wheat stocks in the PDS***---measured in relation to buffer stock norms---expectedly lowers market wholesale prices. However, the effect is statistically quite weak and often insignificant. The policy implication is clear: domestically procured public stocks have a far lower market effect than is to be expected, primarily because, we presume, public stocks are rarely used effectively to stabilize wholesale market prices of wheat in India. We test this later, and there are several implications of this for more effective public policy (see below).

(3)While public stocks of wheat are directly observable, private stocks are not. Therefore, market participants will tend to rely on other additional information that may provide additional information on short-term changes in wheat supply. In particular, unexpected deviations in weather typically are used in the private forecasting community to signal likely future changes in wholesale markets. ***Drought*** during growing seasons will be expected to reduce supply and drive prices higher, and vice-versa. We test this effect, using a directly measured weather variable, a drought index that measures the deviation from normal rainfall in the weather stations in India. While the presence of drought expected raises wholesale wheat prices, the effect is not very significant statistically. What this suggests is that either the measure of weather used (measuring principally kharif weather, whereas wheat is a winter crop) is not very accurate in our study, or that other factors intervene (such as intensified irrigation since wheat is more intensively irrigated crop).

(4)The role of **physical export bans** is expected to lower domestic wheat prices relative to international wheat prices, driving a wedge between domestic and international prices. Surprisingly, we find no evidence of that. Instead, the wheat export ban variable turns out to be related positively with domestic wheat prices, meaning that the direction of causality is predominantly in the other direction: export bans are evidently applied and persistent when domestic wheat prices are high, but appears to have otherwise no independent effect in lowering domestic wheat prices relative to international prices.

(5)Commodity futures trading ban on wheat has operated on and off for some time in India, and this allows us to test, instead, for the presence or absence of any effect on domestic wheat prices from financial arbitrage with global wheat prices, and generally, the presence of financial futures markets. The effect of ***commodity futures trading*** has been highly contested: while many increasingly believe that shift of speculative flows of financial capital to commodity futures markets is one very important reason for rising global and domestic commodity price spikes episodically during the past decade, the evidence for this has been hotly contested and scanty. Indeed, a past official commission in India was unable to find any strong evidence one way or another. In this study, we find a statistically significant and very strong effect of commodity futures trading that raises domestic wholesale prices, independent of the effects of other factors described above, or controlling for them. This effect is found for both its effect on domestic wholesale prices of wheat, and on the relative domestic wholesale price to international prices.

(6)Wholesale prices of food also may tend to be "sticky", meaning that there is a short-term ***persistence of price behavior*** from the past. This quarter's wholesale prices tend to be strongly influenced by last quarter's prices. The theoretical rationale may be to reflect the fact that private traders who acquire stocks at past prices usually show time-persistence in pricing (and also because of information market failures of not knowing

what future pieces will be); they will therefore not usually lower (or raise) prices relative to past prices because it will involve a loss (gain) in such stock-holdings, unless the market availability of grain supplies in the near-term are known to be such in excess (or short supply) that they can assuredly replace stocks at lower cost (and vice-versa). Many if not most food prices tend to show such "stickiness" in prices in India and elsewhere. We find strong evidence for such time-path behavior of wheat wholesale prices in India.

Near-Term Forecast of Wheat Wholesale Prices and Food Inflation in India, 2011. Overall, our preferred model and estimated equation incorporating all these five elements (including seasonal adjustment) picks up the turning points in the past ten years high-frequency price data very well. Accordingly, it should be possible to use our results to predict with reasonable accuracy future short-term price movements. The April 2011 out-of-sample forecast using our model predicts a wholesale price of wheat in India of about Rs. 1190 per quintal, which is reasonably close to the actual latest price of about Rs. 1165/quintal in North India (Delhi) for the same month currently (using that as benchmark)---roughly 5 percent below wholesale prices last April. Our price forecast model is, thus, performing well for the latest price movements in domestic wheat markets in India, out-of-sample. And it also suggests that the record harvest and good weather is thus likely to exert a significant downward pressure on food price inflation in the next few months, not only for wheat, but also for food price inflation more generally in the WPI, and the rural-urban CPI. The main reason evidently supporting lower Indian wholesale wheat prices now (negative inflation) is the ample supplies and record crops this season---driving wheat stocks higher, and prices lower than last year.

The recent strengthening of global wheat prices since November 2010 (up from US$280 per ton, to US$340-350 per ton in April, 2011), if it persists and seasonal effects will, however, start to exert some modest upward pressures on wheat wholesale prices by about December 2011, suggesting significantly higher prices (4-5% higher than corresponding periods last year) domestically in the absence of other mitigating factors (such as rising domestic supplies and stocks). The best way to manage these anticipated price fluctuations immediately are: (a) Ensure that public stocks are replenished with better quality stocks as prices are pressured downwards; right now, farmers are selling below MSP and FCI and state agencies are in a position to pick up ample stocks of better quality wheat at these low prices, helping to support farm incomes; and (b) Then start to gear up to release more open-market sales as prices are pressured upwards later in the year---classical and efficient market-stabilisation function that is also consistent with prudent macroeconomic management (see further below).

Instruments to Manage Wheat Price Volatility More Broadly. The paper turns to assessing specific policies and options to counter possible excessive domestic price volatility, using econometric estimates of factors affecting wheat price offtake from the PDS described earlier. Five possibilities are recommended:

(1) ***Open-market stabilization efforts****, using large and growing PDS stocks and their sales (or purchases)---counter to market price movements---should play a much more powerful role than*

it does. Indeed, the evidence suggests that PDS wheat off-take has been very non-market driven so far, and one of the immediate policy tasks should be to expand the open-market sales instrument (in both directions, to procure more when prices are low, and sell more when prices are high). This is now extensively used with good results elsewhere in the world, including Bangladesh.

(2) A second policy instrument is, if needed, to ***regulate commodity futures*** *in wheat more effectively (and avoid an outright ban except during excessive international prices and volatility) to drive a wedge between international and domestic prices when and if it appears that there are excessive financial inflows into wheat commodity futures markets unrelated to underlying factors;*

(3) ***Export bans****, in contrast, probably remains a weak and likely ineffective or blunt instrument, at least on evidence available in this paper. However, market participants consistently believe that export bans lower domestic wheat prices, and therefore, more careful sifting of evidence is needed.*

(4) The fourth instrument is that of ***expanded targeted welfare schemes of PDS distribution to the poor****, which is one important way of protecting the poor from volatility in market prices; but doing so more effectively on the questions surrounding the efficacy of targeted distribution---e.g., strengthening food stamps or other alternatives to check leakages and pilferage from PDS.*

(5) We may also need much more attention to the ***quality of publicly procured and stored PDS wheat stocks****, because of some suggestive evidence that PDS is taking on characteristics of being an inferior "Giffen" good.*

These changes, together, should be able to play a more powerful role in moderating domestic wheat price volatility and the transmission of global wheat price shocks. In order to be able to do so, however, changes in the functioning of public agencies (such as FCI and state agencies) may be also needed---because their mandates are circumscribed to play a more effective price-stabilisation function. A review of such agency-specific instruments and effectiveness may be called for.

Conclusion. This paper provides some tools to assess and forecast wheat prices, and hence food inflation---an area of major concern in India. The paper also provides an assessment of various factors driving wheat wholesale prices over the past ten years—using high-frequency data. It predicts well in-sample and out-of-sample prices. Using the results, the paper also points to some medium-term policy options to manage sudden spikes in wheat and food prices. In the near-term, the excellent current expected domestic wheat harvest with record wheat production is lowering prices. This will help to lower food price inflation pressures and expectations, more broadly economy-wide---a welcome relief. However, eventually wheat prices are expected to start to rise, responding to persistently higher international prices and seasonal changes that will pressure prices higher. The correct responses will be to rely on more active food price open market purchases and sales. The main immediate conclusions are to: (a) keep a close watch on domestic wheat price movements, and immediately acquire low-cost and

better quality wheat as farmers are receiving low prices and help maintain the MSP; (b) as domestic food prices are sticky, lower current prices should pressure domestic wheat prices to continue to moderate; (d) but eventually, higher international prices, if they persist, will force domestic prices higher towards the end of the year, which could be potentially managed and countered by greater open market sales of stocks acquired earlier. This would also provide a setting to improve more medium-term food price and inflation management for commodities under the purview of the public distribution system, as is wheat.

Section 1

Introduction

This paper, on global wheat market developments, price transmission and impacts on Indian domestic markets, as well as an assessment of public policies to manage domestic prices, is part of a larger effort to improve our in-house (Department of Economic Affairs) research---to track, monitor and forecast fast-moving key macro-economic variables with potentially large consequences for public policy. We have begun to intensify our efforts. We are investing further systematically---to understand growth and inflation dynamics in the context of rising food inflationary pressures in India and worldwide. We are capturing more high frequency data, and applying quantitative modeling tools (as evident in our current Economic Survey). This paper is also intended as an input to the deliberations of the Inter-Ministerial Group (IMG) that has been recently constituted to review the overall inflation situation, with particular reference to primary food articles.

We take up wheat in this paper, because of recent rapid price rises globally, as well as domestically, and because it constitutes a major element of the overall wholesale and consumer food price inflation indices. Some aspects of the price formation and policy intervention processes in wheat are also likely to be structurally similar for other similar classes of important food items (such as rice), permitting broader insights.

Our paper draws upon existing theoretical insights and modeling attempts in the literature; it is, nevertheless, useful to note three "biases" in our approach: (a) favoring analysis of short-term, high-frequency price formation (daily, monthly, or quarterly), versus alternative longer-term annual, structural models; (b) favoring simplified reduced form forecasting models that track high-frequency turning points well, over more elaborate models and tests of longer-duration time-series data (which may tend to be more historical and backward-looking, and less useful for short-term forecasting); and (c) assessing current India-specific public interventions in greater detail, than in more general academic papers and models.

Section 2

Wheat Markets, and the Main Questions

The Importance of Wheat for Inflation in India. All food articles have a combined weight of about 14.3 percent in the new recently announced revised WPI index for India (versus 15.4 percent earlier). In contrast, the weights of food items in the two older CPI indices (Industrial Workers and Rural Labour) are much higher: as much as 46.2 percent and 66.77 percent respectively (where the weights of wheat are also correspondingly much greater). The weight of wheat alone in the new WPI is 1.12 percent, behind rice (1.79) and oilseeds (1.78), and well below milk (3.24), but well above other items such as pulses, potatoes, onions and fibres. The new CPI indices also have reduced weights for food, and cereals (such as wheat). Nevertheless, it is significantly greater than in the WPI: the weight of cereals in the new CPI will be 19.08 percent, 8.73 percent and 14.59 percent respectively for the rural CPI, urban CPI and the combined rural-urban CPI. Indeed, it has the single-largest weight in the share of food overall; food itself retains a high 45 percent weight overall in the combined rural-urban CPI. Wheat accounts for over one-third of the weight for cereals---or about 5 percent by itself. Individually, this would be the third-biggest weighted item after rice, and milk & milk products (7.73 percent). Wheat also enters into the processed food chain as a key input, and has significant cross-price elasticity with other cereals and foods (as substitutes and complements).

Therefore, what happens to wheat prices has significant implications for food inflation and overall inflation trends in India. Using simple arithmetic with the new weights above, for example, a 10% rise in wheat prices alone would be expected to lead to nearly 1% rise in overall food inflation in the WPI, ignoring any cross-price effects on other foods; and about 2% rise including such cross-price effects (using plausible parameters)[2]. For the combined rural-urban CPI, a 10% rise in wheat prices would produce correspondingly about 1.5% percent rise in overall inflation in the CPI index by itself; and potentially as much as 3% percentage point rise in overall CPI inflation, taking into account cross-price effects of wheat price increase on other cereals prices.

A perfect storm in global wheat markets? Wheat prices are rising rapidly in global markets, and may rise further (Food Price Watch, February 2011). In the past one year or so (January 2009-April 2010), international wheat prices rose swiftly by above 30 percent (in US dollar terms);

[2] For example, using a cross-price elasticity of wheat for rice about 0.1, implies a 10% rise in wheat price will lead to a shift to substitutes and a 1% rise in rice and other cereal demand; and given own-demand price elasticity for rice of about -2, implies a 2% consequent rise in rice and other cereal substitutes prices. See Jha and Srinivasan (2006).

since then, wheat prices have remained at elevated levels, at or about the previous peak reached in January 2008. A number of reasons are ascribed for this. The first is supply shocks among several major producers and exporters: Russia banned exports late last year because of the summer's weather and poor crops; this was also followed by expected lower crop yields in Argentina, another major exporter, because of droughts; recent floods in Australia, which are likely to affect its crop production and exports; and others. The second is the latest worry about the winter crop in northern China, the main wheat crop, where poor winter snow and rains are raising worries about the coming harvest this summer; while China is largely self-reliant in wheat (similar to India), it is a very large consumer, and if China starts to enter the global import markets, this will drive prices rapidly higher. The third is anticipatory steps in major wheat import-reliant countries, mostly in the Middle East. Already, countries in that region are starting to place large import orders to build up their national stocks in anticipation of rising prices, given the political sensitivity of higher food prices in that region and incipient incidences of food riots that are affecting popular discontent (as in Egypt and Yemen). The fourth is falling global stocks of wheat. Commodity prices react most immediately to changes in stocks---because observed changes in supply and demand show up most in changes in stocks. The fifth is the heightened interest of global investors and speculators in commodity markets, looking for investment hedges and alternatives in a world awash with liquidity; wheat is of major interest. In some respects, this set of factors may be leading to a 'perfect storm' in international wheat markets, with rapidly rising prices. On the other hand, these dire predictions may turn out to be short-lived, as good crops in other major producing countries, such as Canada and USA, and in India, are adding to global stocks and supplies, and helps restore adequate supplies and eventually moderate prices. Indeed, China has received more winter rainflall in past few weeks and that reduces the downside risks.

Whatever the actual outcomes in global wheat markets in the very near future, and given that international commodity markets are likely to remain volatile, this paper is written with also a medium-term objective: to help Indian policy-makers understand the mechanisms of transmission of global wheat prices to domestic prices, and assess the efficacy of alternative domestic policy instruments with which to influence and moderate domestic food price inflation.

Impacts on India and policies? The immediate questions for Indian policy-makers are, first, how to measure the transmission channels and impact of international prices on domestic prices, and second, how to prepare to deal with rising prices as a contingency. For India, wheat prices had risen sharply last year in the wake of India's own devastating drought in 2009, contributing to the faster food inflation; with better rabi crops and good rainfall, we are now expecting a record harvest in 2011, according to the latest second advance crop estimates. The consequent

stabilization and a small fall in wheat prices within India stand in contrast to global conditions. Rising public wheat stocks provide significant protection and cushion. In addition, India has operated a ban on wheat exports for a while. While criticized for its destabilizing impacts on global markets, the export bans are expected to continue to moderate Indian domestic prices, while government-to-government sales, especially to neighbors (as well as oil price triggered contingency wheat exports to some Gulf countries), are expected to have played a supportive role in stabilizing global wheat markets. If global prices spike up further, three sets of questions thus arise:

1) How much might Indian wheat prices be affected, and through what channels?

2) How effective are our current policy interventions to moderate these influences, including rising levels of PDS stocks and offtake? and,

3) What additional policy options might policy-makers wish to consider, if international prices start rising sharply---using or expanding the existing set of interventions (such as export bans, futures trade, open-market sales, public food distribution stocks, and enhanced releases of public food distribution (PDS) at low prices for households)?

Based on above questions, Section 3 sets out the basic features of a possible parsimonius (i.e., simplified reduced form) model of short-run price formation and transmission, in both global and domestic wheat markets. The next turns to estimating the magnitude and channels of transmission of global prices to domestic wheat markets, and other domestic factors, such as the level of PDS stocks, weather, export bans, effect of commodity futures, and PDS offtake, building and estimating a small quantitative model to quantify these impacts, presented in Section 4. Section 5 & 6 turns to the options to improve domestic price stability, assessing the impacts and efficacy of current policy interventions, especially PDS offtake, to stabilize domestic wheat markets. Section 7 details the bound test approach to cointegration in domestic wheat markets. The last section concludes.

Section 3

A Model of Short-term International Wheat Price Formation and Transmission to Domestic Prices

A simplified model of international commodity market price formation: change in stocks and volatility of weather conditions. The model of short-term global wheat price formation is relatively straightforward, if we ignore the familiar 'cobweb' problem of lagged agricultural export supply response (to previous year's prices). We can ignore this by the simplifying assumption that farmers sell forward their expected supplies, or that the distribution of supply through the year is such (different growing seasons, in northern and southern latitudes, etc.) that supply can be presumed to respond (mainly) to current prices. Traded Supply, S_t, is then determined effectively by current international prices, P_t, and weather conditions w_t in a handful of major wheat producing countries, and swings in net exports, NX_t, of otherwise autarkic (self-reliant) major producers, such as China and India. Weather conditions, also for simplicity, are taken to be a common global factor (such as effects of swings in El Nino weather patterns) that of course, affect individual countries differentially, but in total, are approximated to have linear effects (say, aggregate drought or not, weighted, say, by acreage under production). Since NX_t is relatively small and affected primarily by weather, we take total supply of traded wheat, ST_t as the addition of S_t and NX_t. Demand, D_t, is a function of current prices, P_t. Changes in world wheat stocks, XW_t, and prices, P_t, then equilibrate supply and demand. Since stocks are costly to hold, the short-term price response to changes in stocks is expected to be highly inelastic, creating the conditions for large price shocks and volatility.

$$S_t = a + b(P_t) + c(W_t) \quad \text{.....(1)}$$

$$NX_t = d + f(W_t) \quad \text{.....(2)}$$

Therefore,

$$ST_t = S_t + NX_t \quad \text{.....(3)}$$

Or,

$$ST_t = i + b(P_t) + g(W_t) \text{.....(4)}$$

$$D_t = h + i(P_t) \text{.....(5)}$$

$$ST_t - D_t = X_t \text{.....(6)}$$

Or,

$$X_t = i + b(P_t) - g(W_t) - h - i(P_t); or$$

Re-arranging terms,

$$P_t = x + y(X_t) + z(W_t) \text{.....(7)}$$

Equation (7) is a familiar and all-important reduced form equation, which effectively summarizes all the information driving short-term price movements in agricultural commodity markets such as wheat: prices react essentially to expected changes in short-term global stocks (see, for example, Economic Research Service, USDA; Sana-Helena Rantala, 2010), and swings in weather conditions (that will ultimately affect next year's change in stocks, and therefore, start to affect this year's prices, in a sense, it is also response to expected change in stocks). As a result, most commodity markets react most to news about observed changes in stocks and sudden swings in weather conditions affecting crop yields and production. Also note that exogenous shocks to supply and demand emanating from say sudden shifts in farming practices or technology, or sudden changes in consumption patterns, could also be modeled---if it were the case that the standard model 'failed' to explain swings in short-run prices. Generally, "technology" or "tastes" are well-known to slow-moving variables, even when the technology or taste change is large, because it takes time for such shifts to affect the entire market in either consumption or production, and that is why these shift variables very rarely explain short-term spikes or collapses in prices, even though the popular press play up such longer-term drivers of change as leading short-term price movements. Theoretically too, all information on supply and demand can be already expected to be capture in the existing supply and demand functions, and therefore, only completely unexpected or unknown sudden shifts in technology and tastes---which would be a stretch under most conditions in mature technology and demand markets such as food. Note too, that in short term models, the income variable is ignored, since again, there are no major expected shifts in income, except as a 'drift' time variable. Sudden collapses in short-term demand, such as a major global recession, would, however, have to be factored into our reduced form equation, if circumstances so changed. In any case, we could have introduced the standard income term into the equations, and added

that simply as a separate variable therefore into the reduced form equation (7) as a separate term, if we so wished.

The domestic wheat price model analogue: **add relative autarky (trade policy wedges), and domestic policy interventions.** An analogous model would apply to domestic price formation, except, now, we would expect to see the influence of three additional sets of factors: (1) International prices, which depending on transport costs and the extent of tradeability, should influence domestic prices significantly (for example, with export-parity prices setting a floor to domestic prices, and import-parity prices a ceiling)---depending on the extent of autarky and transport costs; (2) specific international trade restrictions, such as export or import bans or tariffs, which would drive an explicit wedge between international and domestic prices (in addition to geography and transport costs); and (3) other specific domestic public policy instruments or interventions designed to influence domestic prices. Thus, the simplified reduced form for domestic price of wheat in India, PWD_t, would be expected to be affected by international wheat prices, PWI_t, domestic public stocks, STP_t, (because public stocks are dominant and have replaced private stock function), a vector of additional policy interventions, VD_t, including trade restrictions, and weather, WD_t. Thus, simplifying, the reduced form domestic price formation is expressed in equation (8) as:

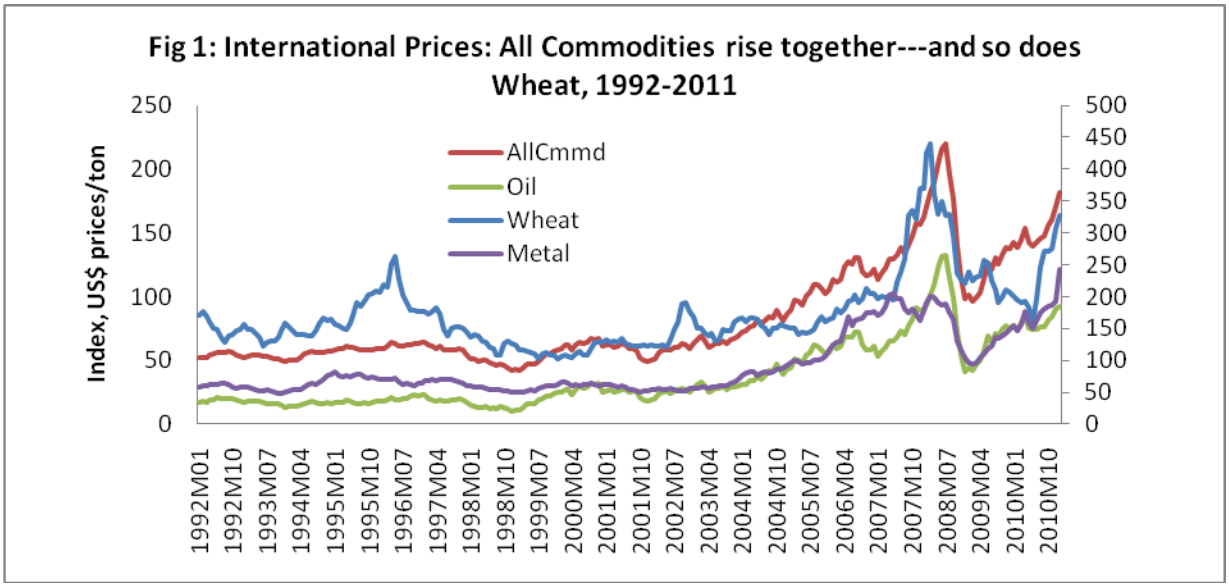
$$PWD_t = m + n(PWI_t) + o(STP_t) + p(VD_t) + q(WD_t) \quad \text{.....(8)}$$

Additional Factors: The Role of Financial Markets and Commodity Futures Trade. There are, nevertheless, two additional influential factors that might affect short-term price developments, that we need to note:

(1) Global commodity booms (and busts) in international commodity futures. The first point to note about global commodity price movements is that they exhibit very strong correlations with each other over time, even when they are quite unrelated to each other (i.e., cross-price elasticities are usually close to zero). This "co-movement", the tendency to move together, is puzzling and is unexplained and well in excess of standard macro-economic effects, such as inflation, or changes in aggregate demand, interest rates and exchange rates, whether explicit or latent (forward-looking)---as documented by Pindyck and Rotemberg (1990). Such excess co-movement "casts doubt about standard competitive commodity markets", and is "probably a result of 'herd' behavior in financial markets." (Pindyck, op.cit.). We had exactly the same phenomenon in the run-up in commodity prices before the September 2008 financial crash, when liquidity conditions were eased globally by central banks prior to the crash, and it is one again in

evidence now, after the intervening crash of 2008. Commodity prices are running up in close tandem for virtually all commodities, and groups, as traders and investors look to commodities as a possible alternative asset hedge against financial risk or speculation in a world awash with liquidity. In food commodities and metals, the indices have actually crossed the previous peaks in 2008, setting off alarms about the impacts on economies, growth and food inflation, especially in poor and import-dependent countries.

The transmission of such commodity cycles to specific markets is seen to be increasingly associated in particular through international commodity futures markets. When a speculative boom situation emerges, the argument is that investors start investing massively in futures, eventually driving up all commodity markets in a boom phase (and vice-versa during a financial downturn).



What is the evidence so far? The early paper investigating all commodities (Pindyck et. al.) globally was unable to explain the excess co-movement based on standard macroeconomic factors alone, such as exchange rates, business cycles, inflation and monetary policies. That led the authors to surmise that something else was responsible for such herd behavior, such as commodity futures markets. Another paper, looking specifically at domestic wheat markets in Pakistan, and a spike in food inflation there, examined through high-frequency monthly data, the role of monetary factors, versus domestic supply-side structural market conditions in driving the volatility of wheat prices (Mohsin Khan and Axel Schimmelpfenning, 2006). The results in that paper suggested that monetary factors drove food inflation in Pakistan, with broad money and

private sector credit growth key variables, and not structural factors. A third class of studies has focused more extensively on factors driving international commodity price volatility, especially since 2008. Roache (2009) concludes that macroeconomic factors played a dominant role in recent (1998-2005) food price volatility, especially persistent low-frequency volatility, and further, that such spot price volatility is positively correlated across different food commodities, and determined by a number of common factors, including: real US interest rates, real global activity and volatility, global inflation and exchange rates, stock markets, and the weather cycle. The paper identified the role of commodity futures markets on general food price volatility as requiring more research, since it was unable to control for endogeneity in futures trading volumes and price volatility. Continuing in the same vein of research, IFPRI papers (2009) and Jaochim von Braun et. al. (2010) provide closer evidence that the food price crisis of 2007-08, while it had some structural causes (rising demand for food, biofuels, climate change, and high oil prices), it was made much worse by the malfunctioning of world grain markets. Specifically, it identified the role of expectations, speculation, hoarding and hysteria, with speculative flows of capital into commodity futures a key factor (monthly volumes of futures contracts and open interest), but the evidence was indicative; futures index positions were associated with general agricultural commodity booms than by market specific factors such as supply or demand shocks. Alex McCalla (2009), in examining the recent doubling of what prices, and whether it would revert or not to the previous 150 years of declining cereal prices, examined three possible storylines: (1) common macroeconomic factors; (2) role of speculators in commodity markets; and (3) Supply and demand shocks. He suggests that there is a confluence of permanent (the third explanation) and transitory factors (the first two factors), and concludes that we might be in for permanently higher food prices.

(2) The Role of Domestic Commodity Futures Markets (and the Law of One Price). A potentially new transmission channel of such behavior from global commodity financial markets to domestic commodity markets in developing countries---although this is certainly less well known in the literature and unanticipated in the policy community --- is the role that commodity futures markets may play. That commodity futures trade may affect the level and volatility of spot prices of individual commodities in international markets is now becoming more discussed (and evident), after the 2008 sudden run-up in global commodity prices and since, as discussed above. But the presence and impact of domestic commodity futures markets on the level and volatility of domestic prices is less well known or discussed, and the evidence is more sparse or inconclusive. However, in theory, even if developing countries such as India are

physically less well-integrated (because of trade restrictions and other barriers), but commodity futures markets operate domestically, then such domestic financial markets have to integrate almost instantaneously with global ones (not least because they share standardized contracts)---because of arbitrage opportunities that regulation can only weakly circumvent in the presence of such near-riskless arbitrage transactions. As a result, even if the physical markets are well-separated, the existence of domestic futures markets may drive rapid convergence of individual commodity futures prices with global commodity prices in such standard commodities (oil, metals, foods), and, in turn, must force eventual convergence of spot markets (because commodity futures prices must converge with spot prices, and vice-versa, as we approach contract closing dates, with physical delivery possible). So, not only do we have periodic bouts of commodity booms and busts in global financial markets that drive specific commodity prices internationally, but we now potentially transmit them increasingly faster to otherwise previously insulated or autarkic individual country markets, such as India. An indirect evidence is that during the immediate financial year, the volume of trade in the relatively newly established (seven year-old) commodity futures markets in India rose rapidly, mirroring international trends---such trade was expected to be about Rs 112 lac crore in 2010-11 (or about % of GDP)---and has reportedly surpassed even the volumes in equity and index futures markets in India (Economic Times, 14th February, 2011, quoting Forward Markets Commission data), with a reported 50% rise in commodity trade volumes, versus 7% in equity futures.

What is the evidence so far? Given the possibility of futures trade transmitting volatility to spot markets (but not necessarily the transmission of international volatility to domestic volatility), futures markets in wheat were in fact banned in India starting February 2007, when a drought raised prices, and then subsequently repealed in May 2009, when supplies became more normal. This also occurred after the Abhijit Sen Expert Committee to Study the Impact of Futures Trading on Agricultural Commodity Prices (2008) concluded that:

- there was "(no) clear evidence of either reduced or increased volatility of spot prices due to futures trading";
- however, in the specific case of wheat, the Committee did conclude that "wheat prices did behave unusually and (high) annualized wheat WPI inflation…during the 30 months when futures trading was liquid (August 2004 to February 2007) stands in sharp contrast to inflation wither in the previous 30 months or in the year subsequent to de-listing; and

- (but) changes in fundamentals (mainly from the supply side) were thus found important in causing higher post-futures price rise (for all commodities under study, including wheat), with government policies also contributing, and the role of futures trading remains unclear." India's changes in futures markets trade in wheat thus presents an opportunity to test whether the presence or absence of such futures trade affects or not the transmission of international prices to domestic prices.

Section 4

Testing the Model of Domestic Price Formation and Transmission from International Prices

A reduced form model of domestic price formation is estimated by OLS. Given the behavior of time-series and its drift, an alternative more robust test would have been to test for stationarity of the underlying variables and then establish the existence of a long-run co-integrated equilibrium relationship between the variables. This is indeed tested, and the results are reported in detail in section 7 of this paper. The cointegration tests confirm the main results reported in the main text here, with additional insights that are reported in section 7 of this paper. We prefer to report the OLS variant of results, principally because it allows us to use it as a forecasting tool. We use underlying monthly price and other data, from which we derive quarterly data (to reduce the noisiness of monthly data, as well as the availability of public stock data on a quarterly basis) for the entire recent period, January 2000-January 2011. The reduced form estimated equation takes the following general form, as derived from the model examined in the previous section:

$$wdp = a + b(wip) + c(ps) = d(dr) + e(cf) + f(xb) + g(wdp(-1) + \varepsilon \ldots\ldots\ldots\ldots (9)$$

Where:

wdp = Domestic wholesale wheat price at quarter time t

wip =International wheat price at quarter time t (USA No.2)

ps =Public stocks of wheat at time t

dr = An indicator of weather or drought conditions, as measured by number of districts reporting below-normal rainfall, as reported by the Indian Meteorological Department

cf =a dummy variable representing commodity futures trading that takes the value 1 when there is a ban on wheat trade in domestic commodity futures markets, and zero otherwise

xb =a dummy variable on export restrictions that takes the value of 1 when an export ban is in place and zero value otherwise

$wdp(-1)$ =a lagged dependent variable, to measure the relative "stickiness" of price changes from one quarter to another, and

ε is the error term.

Results:

Five separate equations were estimated and the results are reported and summarized in Table 1. The first equation simply reports the relationship between domestic wheat prices and international wheat prices. The results are as expected with the right sign of the coefficient: international wheat prices are a strong driver of domestic quarterly wheat prices in India (see Figure 2), with a coefficient of as much as 0.6, implying a transmission of 0.6 from international prices to domestic prices (a one dollar change in international prices will cause domestic wheat prices to change by 0.6). There are, however, significant wedges between international and domestic wheat prices. Figure 3 shows the domestic and international wheat price movements over time, and while domestic prices are more stable than international prices, especially in an era of significant trade wedge (export ban) after 2006, there still remain unexpected opposite movements of domestic wheat prices, counter to international trends in recent quarters, and the fit is relatively poor.

The estimated equation 2 therefore seeks to bring in additional variables to explain domestic wheat prices (in addition to international prices): public stocks in the PDS, the effect of weather, and the effect of export bans. When we do this, four things happen: first, the international price transmission coefficient drops to as much as 0.17, meaning that international prices still matter, but quantitatively, the effect is far less important; second, public stocks, as expected, have a negative and statistically significant effect on lowering domestic wheat prices; third, drought forces domestic prices higher, an additional effect; and fourth, and unexpectedly and puzzlingly, export ban appears to raise domestic prices, counter to what should be expected. The last casts doubt on the interplay of export bans on domestic wheat prices, since it cannot be that export bans raise domestic prices; instead, the association of export bans is apparently positive, since it is simply picking-up the imposition and continuation of export bans when domestic prices are higher (reverse causation) rather than the other way around. In other words, export bans are only a very weak instrument and not much of a driver of domestic wheat prices (it is the other way around). Therefore, while the overall fit of the estimated equation is reasonable (see Fig. 4), this equation is no longer the preferred reliable estimate, and export bans are presumed to primarily operate as a result of high domestic prices, rather than the other way around, and are no longer modeled.

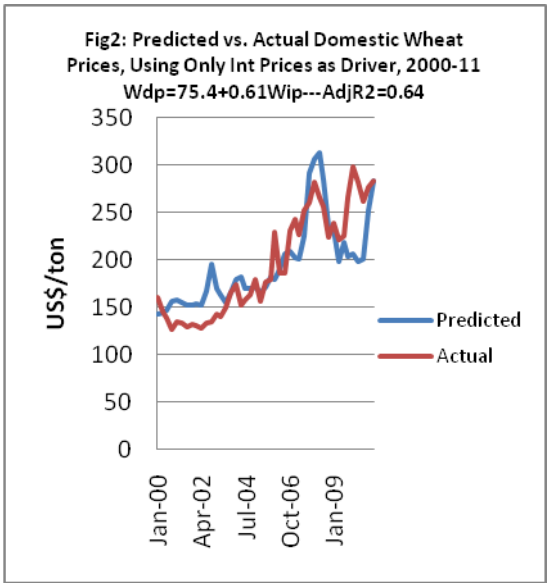
Table 1: Estimated Coefficients and Results: Dependent Variable: Determinants of Domestic Wheat Prices (wdp), January 2000-January 2011 (N=45 quarters).

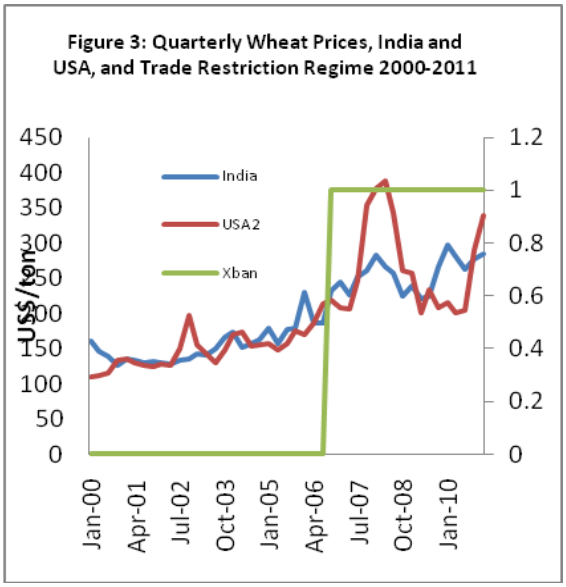
Intercept	**wip** (Int Prices)	**ps** (Public Stocks)	**Dr** (Drought)	**cf** (Com Future Ban)	**xb** (Export Ban)	**wdp-1** (Lagged Dep Var; "sticky")	**Adj.R2**
75.4*** (5.3)	**0.61***** (8.96)						**0.64 (1)**
139.7*** (8.6)	**0.17***** (2.2)	**-6.5**** (-2.4)	**0.49** (1.0)		**79.1***** (7.3)		**0.85 (2)**
72.0*** (3.54)	**0.61***** (8.56)	**-4.14** (-1.03)	**1.25*** (1.76)				**0.65(3)**
14.7 (1.10)	**0.12*** (1.71)	**-3.02** (-1.28)	**0.63** (1.46)			**0.82***** (9.17)	**0.89 (4)**
22.1 (1.62)	**0.17**** (2.37)	**-0.66** (-0.25)	**0.46** (1.08)	**-12.88*** (1.85)		**0.74***** (7.74)	**0.89 (5)**

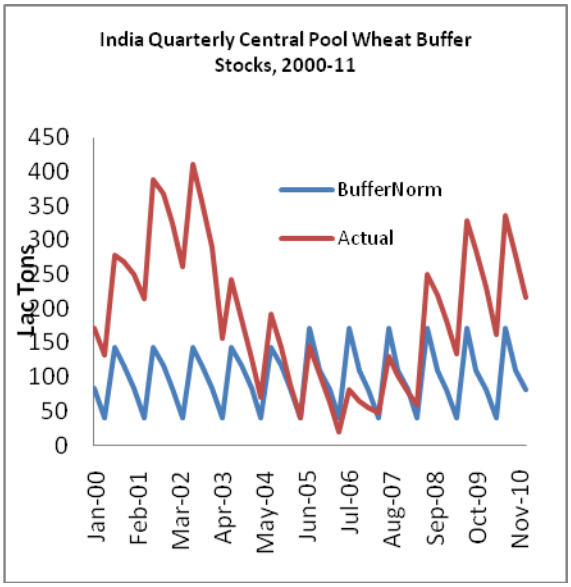
Source: Authors' estimates; t values in parentheses; *** significant at 1%; **significant at 5%; *significant at 10%.

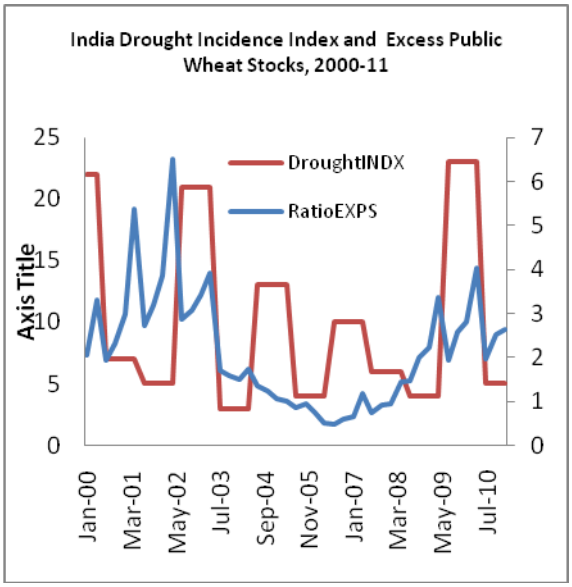
The estimated equation 3 then drops the export ban variable, and the result reverts to expected signs and significance: international prices now are once again a quantitatively very significant driver of domestic wheat prices (coefficient of 0.6), while the coefficients on public stocks (negative effect on domestic wheat prices) and drought (raises domestic wheat prices) carry the correct signs, with drought more statistically significant than public stock levels which are only a very weak effect on domestic wheat prices---meaning that public stocks are no longer carrying a domestic wheat price stabilization function, which is not unexpected given that wheat stocks in the PDS no longer carry outmarket stabilizing functions (Basu, 2011). The fit is reasonable, but is unable to pick up recent turning points well (see Fig. 5)

The estimated equation 4 then brings in a fourth variable---the one-quarter lagged dependent variable—which suggests very strongly that domestic wheat prices are very sticky. The fit improves (see Fig. 6). This means that one quarter's domestic wheat prices are often highly influenced by last quarter's prices, and indicative that domestic wheat prices, like other prices, have a very strong element of short-term persistence. This also reduces, once again, the quantitative effect of transmission of international prices to domestic prices, as a result of which, the size of the coefficient on international prices drops once again to about only 0.17---confirming more accurately that international prices remain a highly significant driver of domestic wheat prices, but other factors intrude (public stocks, drought, sticky domestic prices), but only have a quantitatively weaker effect, and that India remains to a great extent autarkic, because of distance, geography, transport costs, and trade and other restrictions.









The estimated equation 5 then introduces finally another additional variable: the effect of commodity futures bans. This equation becomes our final preferred estimating equation to forecast and predict domestic wheat prices. The effect of commodity futures is as expected in theory, and consistent with the earlier summarized theories: a commodity futures ban causes domestic wheat prices to decline, and a lifting of ban causes the opposite, with higher prices. Other factors remain much as earlier discussed. The fit improves (see Fig 7). This final estimated equation and the comparison of predicted and actual values show that the estimated equation thus predicts very well the key turning points in domestic prices. International prices are still significant, but the quantitative effect is low: the coefficient is

stable at about 0.17. Drought also raises prices, as expected, but the effect is weaker, while public stocks, while they tend to reduce prices, are no longer much significant.

Figure 4: India Wheat Price Reduced Form Model A Results---Explanatory Variables: Int Prices, Export Ban, Public Stocks and Drought

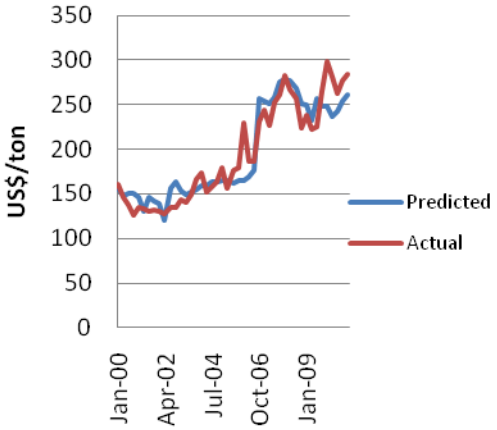


Figure 5: India Wheat Prices Reduced Form Model B---Explanatory Variables: International Prices, Public Stocks and Drought

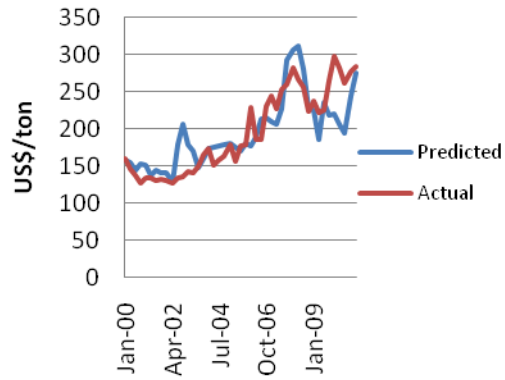


Figure 6: India Wheat Price Reduced Form Model C---Explanatory Variables: Sticky Prices (Lagged Dependent Variable), International prices, Public stocks, Drought

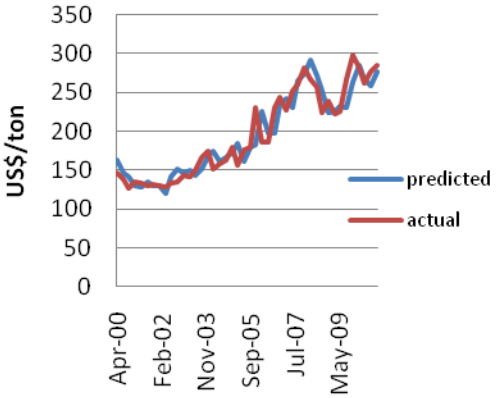
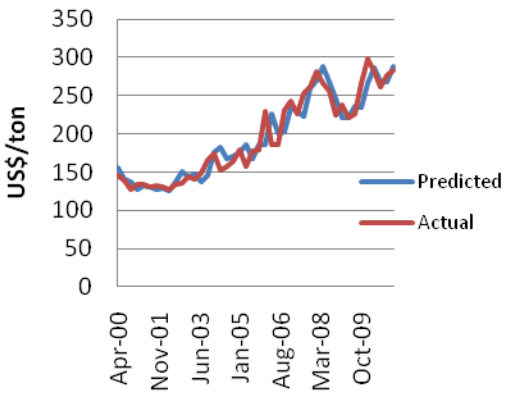


Fig 7: India Wheat Price Model D: Explanatory Variables: "Sticky" Prices (lagged Dependent Variable), International prices, Public Stocks, Drought and Commodity Futures Ban



Section 5

Testing the Efficacy of Policy Interventions to Stabilize Domestic Wheat Prices

Public Wheat Stocks. We have already seen that large public wheat stocks holding, well in excess of buffer stock norms, have had a very poor record of stabilizing domestic wheat prices. Large public stocks are held by FCI. In theory, they should enable the Government to stabilize domestic prices, and while the direction and sign is statistically correct, with larger public stocks having an effect of lowering prices, they are a very weak influence. In principle, it would be far better that very large public stocks held by FCI should operate much more counter to the market, releasing stocks when supplies are limited and drought lowers production and raises domestic prices, and buying up stocks when prices are depressed with bumper harvests or exceptionally low international prices, to moderate and stabilize domestic wheat prices. But in practice, it is evident that it does so very weakly and is not a significant influence. Kaul (2009) notes that Government buffer stocks were frequently built-up, unrelated to production; it also featured policy uncertainties, for example, when during the 2009 recent drought year, Government actually accumulated stocks and announced high open market sales prices, in contrast to a more stabilization function during the previous 2002 drought year . The way to get more traction from the massive carryover of public stocks should be to work with markets and release and buy stocks much more frequently through open-market operations----which have started but are only a very small amount and therefore cannot exercise the price stabilizing function effectively. Basu (2011) discusses the rationale and options that are available. The other role of the PDS, to directly provide access to cheap foodgrains to the poor, is discussed further below in Section 6.

Export Bans. The evidence appears to be that export bans are imposed when international wheat prices are very high, and appropriately so. However, the measured effects are counter-intuitive (raising domestic prices, rather than lowering them). Therefore, the evidence is very weak that export bans are doing much to stabilize domestic wheat prices.

Commodity Futures Regulation. The evidence is quite clear and compelling: banning wheat futures lowers domestic wheat prices, and drives a better wedge between international and domestic wheat prices, and therefore, regulatory mechanisms should be used to either regulate the domestic commodity futures better, or even to ban them outright in times of high or volatile global commodity and wheat prices.

Section 6

Assessing the Role of PDS in protecting the Poor from Price Volatility

If the availability of domestic wheat stocks in PDS were clearly not exercising a price stabilization function for the determination of domestic wholesale prices of wheat in India, as described above, then it is important to examine a more parsimonious test of the efficacy of the Public Foodgrain Distribution System (PDS): was it exercising at least the stated function and objective of adequately protecting the poor from excessive price volatility and ensuring greater physical access to wheat at a guaranteed price through the PDS rationing and welfare distribution schemes?

Taking Stock of Changing Scope and Functions of the PDS. It is important, first, to take a quick stock of the changing stated objectives of the PDS system, and its scope and reach, before we examine that narrower test of its efficacy. Swaminathan (2009) notes four phases: (1) from 1940s to 1960s, an expansion to cities, and reliance on imported food; (2) from 1960s-1978, stepped up PDS with domestic procurement and establishment of FCI; (3) from 1978-91, marked by large scale expansion; and (4) post-1991, a targeted policy and expansion of welfare schemes for the poor. Over the period as a whole, the PDS thus grew from an urban rationing system in a few cities to a national program, increasingly targeted at the poor.

The PDS emerged around 1939-1942 to deal with the shortage of foodgrain and the Bengal famine, when Government intervention in physical distribution started in cities. The PDS evolved into a national ration system, and the entire population of the country was brought under its ambit in the Seventh Five Year Plan (Department of Food & Public Distribution, 2011). It is worth noting the description of objectives and changing functions in the Government's note on PDS: "the twin objectives (are) the price support to the farmers for their product and maintenance of stocks. It is against these stocks procured under price support that every month the Government releases a prescribed quantity, in each State for distribution under the PDS. This mission is brought into reality by FCI. The Sales Division communicates the said allocation to its Regional Offices. On receipt of sub-allocation from the State Governments, the Regional Offices issue the instructions to the District Offices for releasing the stocks to the respective State Government/their nominees on prepayment basis at district level. PDS was widely criticized for its failure to serve the population below the poverty line, its urban bias, negligible coverage in the States with the highest concentration of the rural poor and lack of transport and accountable arrangements for delivery. Realising this, the GOI has introduced the Targeted Public Distribution System (TPDS) w.e.f. 1.6. 1997…to streamline the PDS by issuing special

cards to the families below the poverty line and selling essential articles....The States fix Consumer End Prices (CEP) at Fair Price Shop level not more than fifty paisa per kg. over the Central Issue Price (CIP) particularly for population below the poverty line. The States are also free to add the quantuam coverage and subsidy from their own resources." In addition to the TDPS, which accounts for the bulk of PDS offtake (by BPL and APL families under differentiated pricing) of wheat and rice, there are other welfare schemes as well: Antodaya Anna Yojana for the poorest category among the BPL; Mid-Day Meal in Primary Schools; Wheat based Nutrition Programme for children, pregnant women and nursing/lactating mothers; SC/ST/OBC Hostels; the Annapurna Scheme for destitute aged 65 years and above (free of cost for all indigent senior citizens); Sampoorn Gramin Rozgar Yojna (SGRY); Welfare Institutions and Hostels; Food for Work; Village Grain Bank; Emeregency Feeding Programme; World Food Programme projects; and others. In addition, an open-market sale scheme was started in 1993-94, to increase the availability of foodgrains in the open market to stabilize prices, and there are no upper limits to this scheme, and the scheme has been liberalized over time to permit retail and bulk (trade) consumers to lift foodgrains.

Swaminathan (2009) suggests two distinguishing features of the TPDS: (a) dual central issue prices with the distinction in categories (BPL and APL), and a third price for the Antodaya scheme for the poorest; and (b) states retaining a larger additional role. She suggests that the errors under the TDPS are potentially large: missing out on eligible poor, and including the non-poor, in contrast to more universal programs with low errors of exclusion (but high errors of inclusion)----pointing to the contrast between states with universal or near-universal public distribution such as Kerala and Tamil Nadu, which had high inclusion of the poor, versus the TDPS, where the exclusion of the poor remains large. Khera (2009) too notes, in the context of a right to food act, the desirability of an universal PDS rather than a targeted scheme because of exclusion issues. In the different context of rising PDS foodstocks, Kaul (2006) suggests that the accumulation of excessive PDS stocks could be attributed to poor offtake after introduction of TDPS, and the poor quality of public foodgrains; an expansion of welfare schemes to increase the offtake was thus judged desirable. Kaul also notes that overall, most households obtained very small percentages of their food needs from fair price shops. The quantum of allocation to BPL families was also progressively raised, from 10 kg. per month per household earlier to 25 kg with effect from 2000.

The relative role of PDS versus the overall foodgrain market. There are two contrasting views about the overall role of PDS in relation to the total size of the foodgrain market in India, and therefore its role. One view visualizes a relatively modest role of PDS in the total foodgrain markets, since on average it only supplies some 15 percent of total foodgrain consumption, underscoring the importance of the open wholesale and retail markets (Persaud and Rosen,

2003). In turn, the ability of PDS to stabilize foodgrain markets is expected to be limited and modest (Gulati, Sharm and Kahkon, 1996). The second alternative view is that the role of PDS is much bigger than apparent: because farmers may retain 60 to 70 percent of their production for own consumption, feed and seeds, the FCI's operations both to procure grain and then to distribute it, may account for as much as 60-70 percent of the marketed wheat and slightly less for rice, whereas the private marketing is correspondingly much smaller. If the latter view is correct, then the PDS's role is much larger in setting market prices (through the procurement process) and in stabilizing (or not) consumer prices through PDS stocks and sales.

The Quality of PDS Stocks. Another, usually less well-understood or discussed aspect of PDS operations and stocks is that because it operates with announced minimum support prices in its procurement, it may end up acquiring poorer quality foodgrains in the market (Banerji and Meenakshi, 2006): the government may often end up purchasing lower quality and damaged grain and the quality loss is additionally severe because of commonly used methods of storage (covered plinth storage) (Ramaswami, 2003). In turn, the lower quality induces a flight away from PDS offtake towards retail markets, and a cycle of growing public foodstocks, and at the margin, rising domestic wholesale prices relative to ration prices (Ramaswami, 2003) as the quality differential spreads.

Complications in Assessing the Effectiveness of the PDS. Given the above factors, testing for the effectiveness of the role that PDS plays through its main instrument----the distribution of rationed food to poorer consumers through a vast network of states and fair price shops---is obviously very complicated and difficult to assess. A direct path would be through a much more micro-economic framework and surveys: for example, checking whether poor households are, in fact, able to access more PDS supplies when they do need it most, with rising market prices. These surveys indeed were discussed earlier, suggesting that only when the PDS was nearly universal, could we be sure that the system delivered the protection assurance, and avoided the exclusions identified---although a near-universal system would also come with very huge costs. Alternative designs such as food coupons might do this better at lower cost. But abstracting from this micro-economic evidence, can be infer some of the more market-oriented effectiveness of PDS offtake from available broader macro data? To do this, the logical path we take is to: (1) first seek to model and explain the factors that drive the aggregate physical offtake of PDS wheat through the rationing system using some broader factors; (2) then test specifically whether this offtake bears any relationship to market prices, and seek to capture other possible elements described above, such as quality differentials and the relative role of PDS vis-à-vis market forces; and (c) finally, test whether an expansion of welfare schemes directly intended to benefit the poor have had some impact. If the physical offtake of PDS wheat is, for example, driven mainly by rising price differentials between market prices and

ration prices, then we can reasonably infer that the PDS is effectively protecting the poor and the vulnerable---the main (intended) recipients of the TPDS---from rising prices. If it does not, then we are left with explaining why PDS offtake varies and what other factors matter, and if those other factors help to explain whether the PDS still does (or not) a reasonable job in protecting the poor by providing them physical access to food and food security, even if does not do so through their relationship with market mechanisms.

Modeling and Explaining the Offtake of Wheat from the PDS: Impacts of Price Incentives and Market Developments. Traditionally, the dominant theory is that offtake of wheat from the rationing system should be most directly related---positively---to the differential in domestic wholesale prices over the ration issue prices. When such price differentials rise, offtake from the rationing system should also rise---both as demand rises, and as rationed supplies respond to such price signals to protect the poor who access the rationing system. But in addition, other factors might also operate. The first is the effect of PDS stocks: because PDS stocks dictate the availability of PDS supplies, offtake quantities could be affected by the availability of sufficient stocks, the quantity rationing effect. The second is the effect of limited supplies domestically, as picked-up in the weather drought index, where limited supplies in the market should also prompt consumers to access the rationing system and raise offtake (especially for APL consumers). A third possible factor is international price differentials over domestic wholesale prices---which may lead to incentives (or otherwise) for greater offtake or leakages to respond to cross-border informal demand such as smuggling, when international price differentials increase. Thus, a composite reduced form equation is estimated first, in the form:

$$offtake = a + b(whrp) + c(ps) + d(dr) + e(\text{int } dp).....(10)$$

Where

$offtake$ =wheat offtake quantity from the PDS;

$whrp$ =domestic wholesale prices over the ration issue price

ps =PDS stocks of wheat

$\text{int } dp$ =ratio of International prices to domestic price of wheat

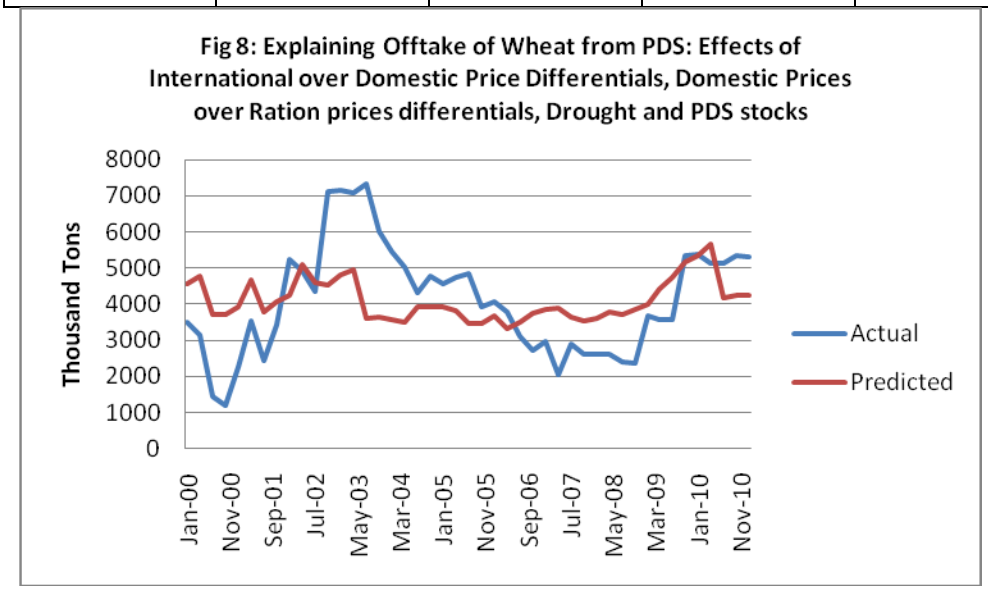
Results: The results of this first set of tests, in terms of the estimation of the coefficients of the reduced form model above are shown in Table 2 below. It suggests that the overall fit was very poor (adjusted R2 was 0.05, Fig 8), while none of the coefficients of the explanatory variables were statistically significant at acceptable levels of confidence; only the drought and public

stocks of wheat in the PDS had a weak significance and both carried the right signs. In short, the PDS offtake of wheat during the entire sample period was **not** affected by market factors. This had both negative and positive connotations. On the negative side, the variation of market prices over ration prices appeared to have no impact on the offtake of wheat from the PDS, contrary to expectations, and indicative of evidence that the PDS system was not protecting the beneficiaries from market volatility. On the positive side, the possible leakage from the PDS system due to pressures from smuggling across borders as international prices varied over domestic market prices was not significant either, suggesting that the PDS offtake remained relatively non-market determined.

Table 2: Dependent Variable: Quarterly Offtake of Wheat from the PDS, January 2000-January 2011 as Affected by Market Factors: Relative Prices, Stocks and Drought

Coefficients (t-statistics in parentheses)

Intercept	whrp Domestic Market Price Ratio to Ration Prices	intdp International to Domestic Prices	ps Stocks of PDS Wheat	dr Drought Index	Adj. R2
2895 (1.85)**	419.3 (0.80)	-441.8 (-0.36)	293.3 (1.62)*	43.7 (1.32)*	0.05
** significant at 10 percent level	*significant at 20 percent level				



Impact of Non-Market Developments: Rising Welfare Schemes and Entitlements. If price factors were not an influence on ration offtake of wheat from the PDS, were other non-market factors an influence? Here, it is clear that the PDS itself was changing in its fundamental design

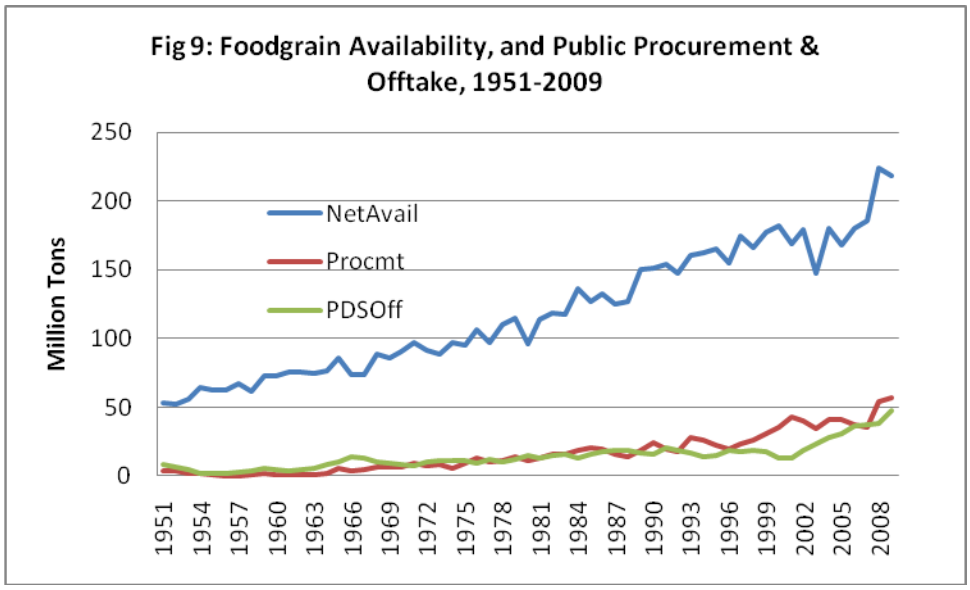
in recent years. The first was the switch to the TPDS, which started in the 1990s. But the effect of that initial targeting was evident: rationing became much more a function of eligibility of ration-cards by categories (BPL, APL), and hence, as should have been expected, offtake started to decline sharply. But given burgeoning public stocks, and in light of growing concerns about nutrition---as well as much more populist entitlement measures announced by state governments in recent years---starting around 2000, the Government has started to expand both the welfare categories eligible, and the quantum of food to be provided to ration card holders. As a result, since 2000, the overall quantum of food entitlements relative to market size has expanded dramatically, and was a sharp break from the previous decade (Fig 9).

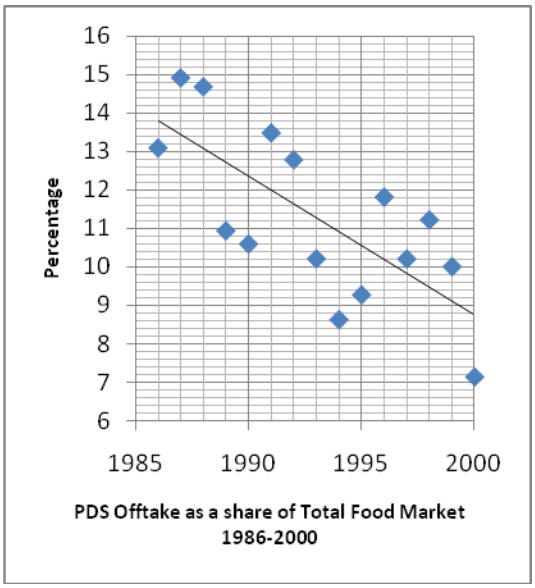
When we include this non-market structural development, the effect on wheat off-take from the PDS is now more readily understandable; the overall fit improves (Fig. 10), as does the expected signs and significance of the coefficients, as shown in Table 3. The coefficient on the level of PDS stocks is now positive and statistically significant, as expected. The effect of drought is now highly significant statistically and positive---drought now causes sharply higher offtake from the PDS, as expected. Rising welfare entitlements also has a highly significant effect---with a strongly positive and statistically significant effect attached to the coefficient on share of public distribution of all cereals in total foodgrain availability---as expected, as increases in such welfare programs and entitlements raises wheat offtake (and vice-versa).

Why a Negative Coefficient on Wholesale over Ration Prices? The coefficients attached to all factors, now therefore improve, except for one big puzzle: the apparent opposite sign and statistical significance of the coefficient on domestic price over ration price ratio. If the latter is correct, it would suggest that opposite to expectations, wheat offtake from the PDS rises when market prices increase above the ration price (and vice-versa). This cannot be correct for 'normal' goods; so the explanation must rest on something else that is going on---including the possibility of PDS wheat increasingly becoming an "inferior" good, meaning that its consumption actually falls when the relative prices of alternatives/substitutes are rising, which is examined further below, or some other non-market explanation that we are unable to pick-up----such as rising offtake by states when prices are falling, because their schemes were expanding, or some other non-market factor, such as reduced leakages of PDS more recently (see further below), driven by factors unrelated to the pricing differential of ration prices from wholesale prices?

Pilferage Drop in PDS? Earlier estimates of pilferage of food grains from the PDS are as much as at 40% - 55% of offtake. A 2005 study estimated a pilferage rate of as much as 53% for wheat and 39% for rice; more recent studies comparing NSS versus official PDS offtake data find similar amounts of leakage (Economic Survey, 2011). Some of the mechanisms are ghost ration

cards and diversion in collusion with fair price shops. In some states (Punjab and Bihar) the diversion rates were reported to be greater than 75% while others (AP, Kerala, Tamil Nadu) apparently have better performance record (leakage rates less than 25%). Given public pressures, central agencies such as FCI heva ebeen tightening their movement, while states have started to identify and cancel ghost ration cards, some are starting to implement biometric cards (Maharashtra, Orissa), and others have strengthened measures such as vehicle tracking systems (GPS, as in Orissa and Tamil Nadu), and implementing GOI guidelines on local vigilance committees at panchayat, taluk, district and state levels. It is possible that such heightened public criticism and scrutiny are leading to a reduction in pilferage rates overall, and that may well be one explanation for the observed negative coefficient.





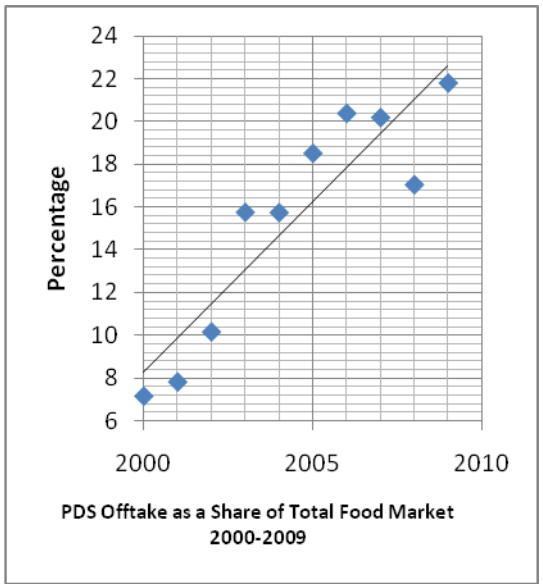
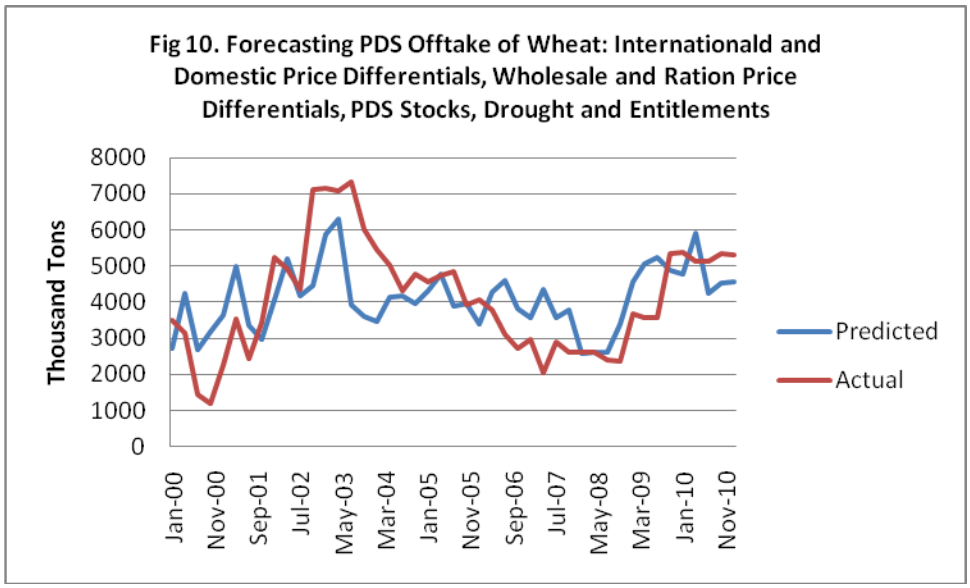


Table 3: Modeling the Offtake of Wheat from PDS: Including the Impact of Non-Market Factors.

Intercept	**Whrp** Domestic Market Price Ratio to Ration Prices	**intdp** International to Domestic Prices	**ps** Stocks of PDS Wheat	**dr** Drought Index	**share** Share of PDS in Total Foodgrain Availability	**Adj. R2**
478.7 (0.306)	**-2304.6**** (-2.47)	**603.9** (0.52)	**594.8** (1.51)*	**44.7***** (3.22)	**278.7***** (3.36)	**0.25**
*** significant at 1 percent level	** Significant at 10 percent level	*Significant at 20 percent level.				



Is PDS becoming a Giffen good? A so-called "Giffen" good is an inferior good, one for which rising prices are typically accompanied by rising consumption, and falling prices to lower consumption. This typically can be observed during periods of rising overall incomes, when consumers might decide to shift away from such inferior goods, even when their prices are falling (i.e., the income effect dominates the price effect). Given the above general finding that the variable domestic prices over ration prices appear to have no clear explanation or correlation with the quantity of PDS offtake---indeed, it is opposite to that expected---the question arises what other factors might explain this development? To explore this, we turn to the possible explanation of this differential over time (reversing the causation). Much of the reason for the rising differential is, of course, driven mechanically by the fact that market prices have risen steadily, while ration prices have been held fixed since 2002, driving the ratio steadily higher. As it turns out, the only statistically significant "factor" that we can identify is simply a time variable. Given explanations in the literature (Ramaswami, 2003) that over time, the rising procurement of PDS might cause a deterioration of the quality of stocks, then this time variable could also be simply reflecting a deteriorating quality of PDS stocks, and hence, in turn, be one possible conjectural explanation why we observe a negative relationship between wheat offtake and the differential in market prices over ration prices (Fig. 11). However, we have no direct evidence of this; this is only a conjecture. Indeed, such a rising discount over time would be difficult to explain, even with changing 'tastes' and therefore rising discount of PDS wheat versus the market availability of wheat. Nevertheless, the poorer quality of PDS wheat over time, and as average consumers become richer, may be another part of the explanation for the rising price differentials, and the negative observed relationship in turn between wheat offtake through the PDS system to this rising price differential.

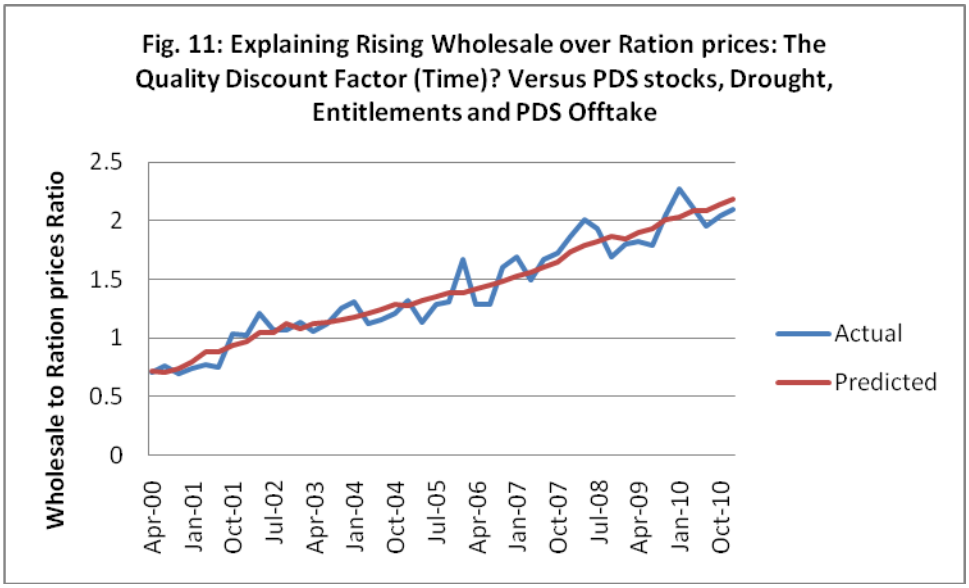


Fig. 11: Explaining Rising Wholesale over Ration prices: The Quality Discount Factor (Time)? Versus PDS stocks, Drought, Entitlements and PDS Offtake
Wholesale to Ration prices Ratio
2.5
2
1.5
1
0.5
0
Apr-00
Jan-01
Oct-01
Jul-02
Apr-03
Jan-04
Oct-04
Jul-05
Apr-06
Jan-07
Oct-07
Jul-08
Apr-09
Jan-10
Oct-10
Actual
Predicted

Section 7

A Bounds Test Approach To Cointegration in Domestic Wheat Markets

Testing for the Existence of Long-Run Equilibrium Relationships between:

---(a) ***Domestic Wheat Prices****, International Wheat Prices, Public Wheat Stocks, Weather, Commodity Futures Trade and Wheat Export Ban;*

---(b) ***Relative Domestic and International Wheat Prices****, Commodity Futures and Wheat Export Bans; and*

---(c) ***Off-take of Wheat from the Public Distribution System****, Domestic and International Wheat Prices, Public Wheat Stocks, Weather, and Share of Public Grain Distribution in Total Grain Markets.*

In addition to a standard OLS method adopted in the earlier sections of the working paper, a more robust, recently developed econometric technique in time series, the bounds test approach to cointegration developed by Pesaran and Shin (1995, 1998), within an Autoregressive Distributive Lag (ARDL) framework, has also been used in this study. This Section reports the findings of that analysis, which was judged to be important to: (a) avoid possible spurious inference of economic relationships from applying standard OLS methods to high-frequency time-series data; (b) establish the existence of cointegration and long-run equilibrating relationships between key variables that are asserted in the main text of the paper; and (c) check for the short-run dynamics of adjustment (towards long-run equilibrium) among key variables in the study. The main convergences and divergences---more strictly, the additional insights from using cointegration tests---as compared to that presented in the earlier section of the paper (using a standard OLS method) are briefly summarized first in this introduction, before we go on to detail the results.

Main Convergences. The ARDL tests confirm cointegration and the existence of robust long-run equilibrium relationships in the standard forms asserted using OLS in the earlier sections of the paper. Specifically,

(1) there exists a long-run equilibrating relationship between domestic wheat prices and international wheat prices, public stocks, weather, commodity futures and export bans, as asserted in the earlier section of the paper using OLS;

(2) there exists an equilibrium relationship between the divergence of domestic wheat prices from international wheat prices, and public stocks, weather, commodity futures and export bans; and

(3) there exists a long-run equilibrating relationship between off-take of wheat from the public distribution system and public wheat stocks, domestic and international wheat prices, weather and the share of public distribution in overall grain markets in India.

Additional Insights. The main observed divergences are in terms of the size and significance of individual variables. We start with the determinants of domestic wheat prices:

(1) Cointegration is weak or absent in the case of domestic and international wheat prices by themselves; this is consistent with what the earlier section of the paper broadly asserts, that domestic wheat prices are not explainable only by what happens to international prices (i.e., domestic wheat markets are sufficiently autarkic), and that other domestic factors and policies have to be included to make the relationship robust, but divergent in that by themselves, there is no strong cointegration;

(2) Conversely, the size of the coefficient attached to the international wheat price variable is higher (0.25 versus 0.17) when using the ARDL test than under the standard OLS estimate;

(3) public wheat stocks as a determinant of domestic wheat price turns out to be statistically significant, with higher stocks associated with lower prices (negative sign of the coefficient), which is more re-assuring than the findings using OLS, which were more mixed;

(4) drought, or the weather variable, throws no additional insights, as was also the case with OLS;

(5) the sign of the coefficient on the commodity futures ban remains negative, and turns very robustly significant, when we change the dependent variable to a ratio of domestic to international prices; the absolute value of the coefficient, at -0.26, is also very important, in suggesting that the ratio of domestic to international wheat prices may drop by as much as 26% when the commodity futures ban is in existence versus otherwise---a first time in the literature that we actually have a statistically robust evidence of whether a commodity futures trading restriction makes a difference to domestic wheat prices as opposed to international price movements; and,

(6) the coefficient of the export ban variable remains, counter-intuitively, positive. This can only be explained in terms of what the main text has already suggested---that wheat export bans only apply when domestic wheat prices soar (rather than affecting domestic prices directly, in the opposite way).

(7) When we turn to the determinants of off-take of wheat from the PDS, the coefficient of the public stock variable is robustly significant and positive, as in the case of the standard OLS results reported, although the size of the coefficient is greater; the drought variable is not even now weakly significant (in contrast to main text where drought is highly significant); the price effects are now more significant and stronger, with international wheat price ratio over domestic wheat prices now significant (i.e., more supportive of evidence for "leakage" and smuggling of domestic wheat across borders from PDS offtake, when international prices rise above domestic wheat prices), and the confirmation again of the opposite than expected (negative) sign of the wheat ration price over wholesale price persists---

meaning that when wheat ration prices rise relative to wholesale prices, PDS off-take is higher, which is unexplainable except in terms of non-standard explanations offered in the main text (i.e., inferior Giffen good); and finally, the share variable (share of public grain distribution in total grain market) is somewhat less statistically significant.

Overall Conclusions. The ARDL cointegration tests confirm the results presented earlier, and are mostly in the same direction. These also confirm, robustly, the existence of a long-run equilibrating relationship among the different variables driving domestic wheat prices. The ARDL and ECM results, confirm, overwhelmingly, a one-quarter lag in most cases, suggesting the validity of using a 1 quarter lagged dependent variable in OLS. Finally, the policy inferences and results of the main text are once again confirmed: (a) that domestic wheat prices are only modestly driven by international wheat price movements and that domestic factors intrude; (b) that domestic prices tend to be sticky (with persistence of a one quarter lag); (c) that PDS stocks, while they do affect domestic wheat prices in the right expected direction, are less than fully effective; (d) that export bans are only a very weak influence; (e) that commodity futures restrictions do play a more significant role in lowering domestic wheat prices; and (f) that PDS offtake is less explained by relative price movements than by the availability of physical public stocks, drought, and a proxy measuring expansion of entitlement programs in recent years, so that there remains much greater scope to use PDS to start affecting and stabilizing open-market prices, but which would require very different "rules of the game" for PDS. The rest of this section details the findings of the ARDL tests of cointegration.

ARDL Model Specifications and Results.

Model specification

$$wdp = c + \sum_{i=1}^{p} \beta_i Z \ + \varepsilon_t \quad \text{.....(1)}$$

where

wdp = domestic wheat price in US$ terms

Z = array of independent variables

c = the drift component and

ε_t is white noise

Stationarity Test

In this study quarterly time-series data covering the period from 2000Q1 to 2010Q1 has been used. It is, therefore, necessary to examine time-series properties of the variables. There is a need to check whether the variables are stationary or not. By doing so, it is easier to avoid spurious results. Second, to establish the long-run equilibrium relation among the variables of interest, it is necessary to cointegrate them. Cointegration among the variables, in turn, requires checking the order of integration among variables. The variables cannot be integrated in the presence of unit root. Therefore, we need to

check the same by conducting a stationarity test. It is needless to say that in a time-series data variables may be stationary either at their level, i.e. I (0) or at their first difference, i.e. I (1) or at their second difference, i.e. I (2). The order of integration of the variable in a time series may be at I(0) or I(1) or I(2).

The conventional Augmented Dicky Fuller (ADF) test is applied to detect presence of unit root. The ADF test for unit root hypothesis is applied to the variables in their level, followed by their first difference form (Table 4). The results show that the variables have different orders of integration. It is evident from Table 4 that variables are a mixture of $I(0)$ or $I(1)$.

Table 4 tests for unit root

Variables	Trend	Intercept	Level		First difference		classification
			t statistics	critical value 5% or 1%	t statistics	critical value 5% or 1%	I(0), I(1)
wdp	yes	yes	-3.823	-3.515 (5%)			I(0)
wip	yes	yes	-3.053	-3.518 (5%)	-4.604	-2.619 (1%)	I(1)
ps	no	no	-1.020	-1.949 (5%)	-2.286	-1.949 (5%)	I(1)
dr	no	no	-0.202	-1.950 (5%)	-7.033	-2.624 (1%)	I(1)
offtake	no	yes	-1.778	-2.292 (5%)	-3.189	-2.935 (5%)	I(1)
whrp	yes	yes	-5.519	-4.180 (1%)			I(0)
intdp	no	yes	-3.220	-2.929 (5%)			I(0)
share	yes	yes	-2.084	3.515 (5%)	-6.915	3.592 (1%)	I(1)

There are several methods available for conducting a cointegration test. The traditional time-series cointegration techniques are the Engel and Granger test (1987), maximum likelihood method, Johnson and Juselius test (1990) and Gregory and Hansen test (1996). All these techniques of cointegration require that the variables should be either I (0) or I(1) and they are more suitable for large sample size. However, the Autoregressive Distributed Lag(ARDL) model for cointegration, a robust econometric technique is used in the present chapter. The ARDL model was popularized by Pesaran and Pesaran (1997), Pesaran and Shin (1995), Pesaran and Shin (1998) and Pesaran et al. (2001). The ARDL model is suitable for small sample size and unlike other techniques, is applicable with variables having different orders of integration namely, I (0) or I(1) or mutually cointegrated.

The main advantage of the ARDL model given the power and testing of the long-run relationship is that it can be applied irrespective of the order of integration (and to small samples) while other cointegration techniques require all the variables to be at equal degree of integration (and large samples). It is evident from Tables A1 that variables in the different individual states are a mixture

of $I(0)$ or $I(1)$. Therefore based on the unit root test we reject the null hypothesis of presence of unit root in the variables and proceed to ARDL with variables having integration order of $I(0)$ or $I(1)$. Though the ARDL bound test does not require any pre-testing of variables, the stationarity test is conducted for all variables to determine their order of integration and to ensure that none of the variables have integration of order 2 or beyond. In the presence of $I(2)$ variables the computed F statistics provided by Pesaran, Shin and Smith (1999) are not valid because the bound test is based on the assumption that the variables are $I(0)$ or $I(1)$. Thus the stationarity test at the very beginning has helped us avoid spurious results and to ensure that $I(2)$ variables are not taken.

Bounds Tests Approach to Cointegration

Keeping in view the above, this study has used the bounds tests approach to cointegration analysis. It may be stated that this method can make a distinction between regressond and regressors. The advantage of the bounds tests or ARDL procedure is that estimation is possible even when the explanatory variables are endogenous (Pesaran, Shin and Smith 2001). The ARDL has been adopted for the following reasons:

(i) The bounds tests procedure is simple. As opposed to other multivariate cointegration techniques such as the Johansen and Juselius, it allows the cointegration relationship to be estimated by Ordinary Least Square (OLS) once the lag order of the model is identified.

(ii) The bounds testing procedure does not require the pre-testing of the variables included in the model for unit roots unlike other techniques such as the Johansen approach. It is applicable irrespective of whether the regressors in the model are purely I(0), purely I(1) or mutually cointegrated.

(iii) The test is relatively more efficient for small or finite sample data sizes as is the case in this study. The procedure will, however, crash in the presence of 1(2) series.

(iv) In this approach the model takes sufficient number of lags to capture the data-generating process in a general-to-specific modelling framework (Laureaceson and Chai 2003). With the ARDL model it is possible for different variables to have different optimal numbers of lags; while in Johansen type models, this is not possible.

(v) Moreover a dynamic Error-Correction Model (ECM) can be derived from the ARDL through a simple linear transformation. The ECM integrates the short-run dynamics with long-run equilibrium without losing long-run information.

Bounds Tests for Cointegration

To apply bounds procedure, the following ARDL model is estimated in order to test the cointegration relationship among domestic wheat prices and other sets of variables. Equation 1, (using model 2) , can be written as a conditional error correction model:

$$\Delta wdp = a_0 + a_1 xb + \sum_{i=1}^{n} \beta_i \Delta wdp_{t-i} + \sum_{k=1}^{n} \phi_k \Delta wip_{t-k} + \sum_{j=1}^{n} \varpi_j \Delta ps_{t-j} + \sum_{l=1}^{n} \eta_l \Delta dr_{t-l} + \\ + \delta_1 wdp_{t-1} + \delta_2 \ln wip_{t-1} + \delta_3 \ ps_{t-1} + \delta_4 dr_{t-1} + + \varepsilon_t \quad (2)$$

where,

wdp = wheat domestic price in US $

a_0 = a drift component

XB = export ban dummy

wip is international wheat price

ps = public stock

$\beta_i, \phi_k, \varpi_j, \eta_l,$ = short run dynamic coefficients;

δs = long run multiplier; and

ε_t = white noise error.

i = number of lags

The first step in the bounds test approach is to test for the cointegration relationship between domestic wheat prices and its explanatory variables by estimating equation (2) by OLS technique. Second, the presence of cointegration can be traced by restricting all estimated coefficients of lagged-level variables equal to zero which is based on Wald of F- statistic. The asymptotic distribution of the F-statistic is non-standard under null hypothesis which means that there is no cointegration relationship between the estimated variables, irrespective of whether the underlying explanatory variables are 1(0) or I(1). More formally, F- tests is performed for a joint significance of the coefficients of lagged levels of variables where the null hypothesis is

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$$

as against the alternative,

$$H_A : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$$

Pesaran et al. (2001) have tabulated two sets of appropriate critical values of F. These two asymptotic critical value bounds provide a test for cointegration when the independent variables *I(d)* with $0 \leq d \leq 1$: the lower bound assumes that all the regressors are I(0) and the upper bound assumes that they are I (1). This provides a band covering all possible classifications of the variables into I(1) and I(0) or even fractionally integrated. If the computed F-statistic lies above the upper level of the band, the null is rejected, indicating cointegration. If the computed F -statistic lies below the lower-level band, the null cannot be rejected, supporting the absence of cointegration. If the statistic falls within the band, the inference would be inconclusive. After confirmation of the existence of long-run relationships among the variables in the model, the long and short-run models can be derived by using information criteria such as the the Schwartz Bayesian Criteria (SBC) or Akaike Information Criteria (AIC).

In the second stage, if there is evidence of a long-run relationship in the model then conditional ARDL (p, q_1 ,q_2, q_3) method is applied to estimate the long -run coefficient. In order to estimate the long-run coefficient the following long-run model is used.

$$wdp = a_0 + a_1 xb + \sum \delta_1 wdp_{t-1} + \sum_{i=1}^{q_1} \delta_2 wip_{t-1} + \sum_{i=1}^{q_2} \delta_3 ps_{t-1} + \sum_{i=1}^{q_3} \delta_4 dr_{t-1} \ldots (3)$$

This involves selecting the order of the ARDL (p, q_1 ,q_2, q_3) model among the set of variables using the Akaike Information Criterion (AIC). Since it is quarterly data, a lag length of maximum 4 is taken.

If there is evidence of a long run relation then in the third step, the following equation is utilized to estimate the short -run dynamic coefficient by estimating error correction model associated with long-run estimates.

$$\Delta wdp = a_0 + a_1 xb + \sum_{i=1}^{n} \beta_i \Delta wdp_{t-i} + \sum_{k=1}^{n} \phi_k \Delta wip_{t-k} + \sum_{j=1}^{n} \varpi_j \Delta ps_{t-j} + \\ + \sum_{l=1}^{n} \eta_l \Delta dr_{t-l} + vecm_{t-1} + \varepsilon_t \quad (4)$$

Where VECM is the error-correction term in the model indicating the pace of adjustment restore back to the long-run equilibrium following a short-run shock. All the coefficients of the short-run equation are relating to short run dynamic of the model that will converge to equilibrium and represent the speed of adjustment.

General –to- Specific Model: F- Test

While estimating the long-run relationship, the most important issue is the choice of order of the distributed lag function on Yt and the forcing variables Xt for unrestricted ECM. The model with the

highest goodness of fit is the preferred one with high F- value. One of the main advantages of the ARDL model is that it takes sufficient numbers of lags to capture the data-generating process in a general-to-specific modelling framework (Laurenceson and Chai 2003). A general-to-specific approach is used by eliminating variables that are not significant and by taking sufficient number of lag lengths in order to investigate long-run cointegrating relationship among the variables of interest.

In the first step of the ARDL analysis, the presence of long-run relationship in equation (1) is tested by using equation (2), wherein general-to-specific modeling approach is used guided by the short data span and AIC respectively and eliminating variables that are not significant. Following the procedure of Pesaran and Pesaran (1997), an OLS regression for equation 2 is first estimated and then test for the joint significant among the parameters of the lagged-level variables.

Different combination of variables underlining the long-run relationship among domestic wheat price and its determining factors have been tried out and are given below in equation 5; those relating to the ratio of domestic over international prices are specified in Equation (6); and the explanations for determinants of off-take of wheat from the PDS are specified in Equation (7).

Equation 5: Domestic Wheat prices

$$M1: wdp = \alpha_0 + \beta_1 wip + \varepsilon_t$$

$$M2: wdp = \alpha_0 + \alpha_1 xb + \beta_1 wip_{BR} + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

$$M3\&4: wdp = \alpha_0 + \beta_1 wip + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

$$M5: wdp = \alpha_0 + \alpha_1 xb + \alpha_2 cf + \beta_1 wip + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

$$M6: wdp = \alpha_0 + \alpha_1 xb + \alpha_2 cf + \alpha_3 td + \beta_1 wip + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

Equation 6: Ratio of Domestic to International Wheat Prices

$$M7: wdp / wip = \alpha_0 + \alpha_2 cf + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

$$M8: wdp / wip = \alpha_0 + \alpha_1 xb + \alpha_2 cf + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

Equation 5: Explaining Offtake of Wheat from the PDS

$$M9: offtake = \alpha_0 + \gamma_1 whrp + \gamma_2 \text{int}\, dp + \beta_2 ps + \beta_3 dr + \varepsilon_t$$

$$M10: offtake = \alpha_0 + \gamma_1 whrp + \gamma_2 \text{int}\, dp + \beta_2 ps + \beta_3 dr + \beta_4 share + \varepsilon_t$$

where,

td = is the time dummy 1 for Q4 of 2009 and Q1 of 2010, otherwise zero and other variables are described in the main text of the working paper. Dependent variable is domestic wheat price in Model 1 to model 6, for model 7&8, the dependent variable is ratio of domestic to international price of wheat and for model 9 &10, and the dependent variable is offtake of wheat.

The F- statistic tests the joint null hypothesis that the coefficients of the lagged variables are zero (the hypothesis is, no long-run relationship exists between variables) as against the alternative hypothesis of a long-run relationship.

Results of calculated F -statistic are given in Table 5. The domestic wheat price is taken as a dependent variable followed by its forcing variables as independent variables. Thus by running simple OLS regression F-test is applied for joint significance among the variables.

Table 5 Bounds Tests for Cointegration

		95%		99%		Estimated	Inference
	lag length	I(0)	I(1)	I(0)	I(1)	F- statistic	
Model 1	1	5.17	6.15	6.65	7.80	0.34	No cointegration
	2	5.17	6.15	6.65	7.80	0.30	No cointegration
	3	5.17	6.15	6.65	7.80	0.67	No cointegration
	4	5.17	6.15	6.65	7.80	0.37	No cointegration
Model 2	**1**	**3.66**	**4.76**	**4.57**	**5.90**	**6.70**	**cointegration**
	2	3.66	4.76	4.57	5.90	3.23	No cointegration
	3	3.66	4.76	4.57	5.90	2.96	No cointegration
	4	3.66	4.76	4.57	5.90	3.75	No cointegration
Model 3 & 4	1	3.66	4.76	4.57	5.90	1.02	No cointegration
	2	3.66	4.76	4.57	5.90	0.79	No cointegration
	3	3.66	4.76	4.57	5.90	1.61	No cointegration
	4	3.66	4.76	4.57	5.90	1.20	No cointegration
Model 5	1	3.66	4.76	4.57	5.90	9.29	**cointegration**
	2	3.66	4.76	4.57	5.90	6.84	**cointegration**
	3	3.66	4.76	4.57	5.90	5.15	**cointegration***
	4	3.66	4.76	4.57	5.90	3.20	No cointegration

Model 6	1	3.66	4.76	4.57	5.90	8.80	**cointegration**
	2	3.66	4.76	4.57	5.90	6.25	**cointegration**
	3	3.66	4.76	4.57	5.90	4.38	No cointegration
	4	3.66	4.76	4.57	5.90	4.96	No cointegration
Model 7	1	4.23	5.29	5.38	6.54	10.38	**cointegration**
	2	4.23	5.29	5.38	6.54	6.70	**cointegration**
	3	4.23	5.29	5.38	6.54	3.98	No cointegration
	4	4.23	5.29	5.38	6.54	4.73	No cointegration
Model 8	1	4.23	5.29	5.38	6.54	9.55	**cointegration**
	2	4.23	5.29	5.38	6.54	6.53	**cointegration***
	3	4.23	5.29	5.38	6.54	5.21	No cointegration
	4	4.23	5.29	5.38	6.54	3.12	No cointegration
Model 9	1	3.28	4.39	4.09	5.40	4.23	No cointegration
	2	3.28	4.39	4.09	5.40	6.87	**cointegration**
	3	3.28	4.39	4.09	5.40	5.05	No cointegration
	4	3.28	4.39	4.09	5.40	2.80	No cointegration
Model 10	1	3.00	4.13	3.73	5.02	3.63	No cointegration
	2	3.00	4.13	3.73	5.02	5.00	**cointegration***
	3	3.00	4.13	3.73	5.02	3.30	No cointegration
	4	3.00	4.13	3.73	5.02	4.15	No cointegration

*at 5% level of significance

It is evident from the table that the estimated F-statistic is higher than the critical upper bound value both at 1per cent level as well as at 5 per cent level for Model 2 with one lag, Model 5 upto three lags and model 6 with two lags. Therefore, the null hypothesis of no cointegration is rejected implying long-run cointegrating relation among domestic wheat price and other variables. For model 7&8 and model 9&10 cointegration exists with 2 lags. For brevity, the result of model 2 is not given here. The results of long run estimate of model 6 shows that there is structural break in the model (not shown here), therefore, we have introduced a time dummy (1 for 2009q4 and 2010Q1, otherwise zero) and the results is given in Table 6 where all the variable are having expected sign except export ban. This has motivated us to investigate further and we have taken the ratio of domestic price to international price of wheat as the dependent variable in model 7&8, the results are given in Table A4 and A5.

Long-run Estimates

After establishing long-run cointegration relationship, among domestic wheat price and other variables for model 2 with one lag and model 5 with two lags, we have used respective equation having cointegration relation of ARDL model is used to bring out long run coefficients. Table 6 gives the long run coefficients estimates of domestic wheat price for the period 2000Q1 to 2010Q1 for model 2 with one lag and model 5 with two lag.

Table 6: Estimated long run coefficients using the ARDL approach

Models	Dep. Vari	constant	wip	ps	dr	cf	xb	td	whrp	intdp	share
Model 6	wdp										
		145.96	0.25	-6.1	-0.73	-15.59	56.53	68.75			
		(10.43)***	(3.64)***	(-2.0)**	(-1.52)	(-1.99)	(5.71)***	(3.95)***			
Model 7	dpip										
		0.997		0.05	0.005	-0.261					
		(12.45)***		(1.780)*	(0.97)	(-3.03)***					
Model 8	dpip										
		0.91		0.10	0.01	-0.36	0.14				
		(10.33)***		(2.53)*	(0.89)	(-3.69)***	(1.69)*				
Model 9	offtake										
		952.73		1112.90	17.84				69.05	867.30	
		(0.43)		(3.28)***	(0.29)				(0.07)	(0.39)	
Model 10	offtake										
		-10817.5		2593.8	3.5				-5444.8	4838.8	740.3
		(-2.06)**		(3.15)*	(0.05)				(-2.31)**	(1.76)*	(2.81)**

Note: t values in parentheses; *** significant at 1%; ** significant at 5% and * significant at 10%

The error correction term indicates the speed of adjustment among the variables before converging to equilibrium in the dynamic model (see Table 7). The coefficients of ECM shows how quickly variables return back to equilibrium and it should have a statistically significant coefficient with a negative sign. A highly significant error correction term is further proof of the existence of a stable long-term equilibrium.

Table 7: Error Correction Mechanism

	Coefficient	T-Ratio	Prob.
Model 6	-0.801	-5.865	0.00
Model 7	-0.597	-4.441	0.00
Model 8	-0.658	-4.119	0.00
Model 9	-0.321	-4.848	0.00
Model 10	-0.288	-3.340	0.00

The existence of a significant error correction term is evidence of causality in at least one direction. Short-run coefficient estimate of Model 6 (where dependent variable is domestic price wheat) reveals the dynamic adjustment of the variables that is, 80 percent of the disequilibrium is corrected within one quarter. For model 8 and 10, 66 percent and 29 percent of the disequilibrium is corrected within two quarters.

The ARDL equation also passes the diagnostic tests against serial correlation, functional form misspecification, non-normal errors and heteroscedasticity (Table 8) except model 6 and model 8 which fails to satisfy the normality and serial correlation respectively.

Table 8: The Diagnostic Statistics of ARDL estimates

	Serial Correlation	Functional Form	Normality	Heteroskedasticity
Model 6	4.90 (0.297)	0.147 (0.701)	59.94 (0.00)	0.02 (0.88)
Model 7	4.20(0.380)	0.135 (0.713)	0.81(0.667)	0.059 (0.807)
Model 8	13.44 (0.009)	1.429 (0.232)	4.33 (0.115)	0.21 (0.650)
Model 9	4.62 (0.328)	0.170 (0.680)	1.80 (0.406)	0.98 (0.332)
Model 10	7.62 (0.106)	0.536 (0.464)	0.30 (0.860)	3.29 (0.070)

Note: p values in parentheses

The present study empirically investigates a long-run equilibrium relationship among domestic wheat price, relative price of wheat and offtake and its determinants to supplement the OLS method used in the study; the bound test approach to cointegration confirms the results of OLS.

Section 8

Conclusions

This paper was prepared with a view to deriving a reduced form model to estimate and forecast likely domestic wholesale wheat prices, given a variety of factors at play. To do this, we collected a wide variety of likely high-frequency data (monthly data, converted to quarterly data) over the most recent time period, January 2000-January 2011. In particular, we expected that international price movements would have a key role, and this was indeed the case. But we also expected that other domestic factors would be important, such as the level of physical wheat stocks in the PDS, which indeed lowers market prices, and the effect of drought, which should raise domestic prices, as it indeed appears to. But beyond this, domestic commodity futures markets appear to also impact spot prices (with a statistically negative effect of commodity futures ban on wheat trade the main evidence). Domestic wheat prices also appear to be strongly persistent and sticky: this quarter's prices are strongly influenced by last quarter's prices. Overall, our preferred model and estimated equation incorporating all these five elements pick up the turning points very well, and should be able to be used with reasonable accuracy as a tool to predict future price movements.

The paper then turned to specific policies and options to counter excessive price volatility in domestic wheat prices. Four possibilities are suggested. (1) It was evident that the operation of open-market sales of PDS, using large PDS stocks and their sales counter to the market price movements, should play a much more powerful role than it does. Indeed, PDS wheat offtake has been very non-market driven so far, and one of the first policy tasks should be to expand open-market sales counter to the market much more than so far evident. (2) The second policy instrument clearly is to regulate commodity futures in wheat much more strongly (and even to ban it during excessive international prices) to drive a better wedge between international and domestic prices than does outright export bans, which remains a weak and likely ineffective or blunt instrument. (3) The third instrument is that expanding welfare schemes of PDS distribution to the poor is clearly one way of protecting the poor from volatility in market prices; and this appears to have been happening. (4) Finally, at the same time, to be much more effective as a market stabilizing instrument, the evidence is suggestive that we may need to pay much more attention to the quality of publicly procured and stored PDS wheat stocks, and other non-market drivers. These four instruments, together, should be able to play a much more powerful role in moderating domestic wheat price volatility.

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Annexure Table 1: India and International (USA Hard Winter Red No.2) Monthly Wheat Prices (US$/ton)

Date	India	WheatUSNo2	Date	India	WheatUSNo2	Date	India	WheatUSNo2
Jan-00	160.73	110.75	Oct-03	165.98	147.25	Jul-07	252.41	246
Feb-00	160.8	112.75	Nov-03	166.79	165.5	Aug-07	249.88	273
Mar-00	160.87	114.75	Dec-03	170.26	173.67	Sep-07	252.85	342.5
Apr-00	160.94	116.75	Jan-04	174.05	170.25	Oct-07	260.69	353.5
May-00	161.01	118.75	Feb-04	174.23	164.75	Nov-07	261.16	334.6
Jun-00	161.08	120.75	Mar-04	163.71	168.25	Dec-07	261.16	380.67
Jul-00	138.31	116	Apr-04	152.06	173.4	Jan-08	281.94	376.75
Aug-00	130.06	113	May-04	148.62	166.75	Feb-08	281.9	438.6
Sep-00	127.48	122.4	Jun-04	148.54	159.75	Mar-08	276.26	481.5
Oct-00	126.57	133.5	Jul-04	157.47	154.25	Apr-08	266.12	388.75
Nov-00	133.6	129	Aug-04	164.92	145.75	May-08	255.16	350.2
Dec-00	133.69	130.8	Sep-04	162.73	153.5	Jun-08	253.39	357.5
Jan-01	134.56	135.25	Oct-04	163.55	155.2	Jul-08	256.77	342.75
Feb-01	135.8	130.75	Nov-04	169.88	162.75	Aug-08	256.17	340.8
Mar-01	138.03	132.8	Dec-04	176.22	160	Sep-08	241.44	312.25
Apr-01	133.79	130.25	Jan-05	179.43	157	Oct-08	224	260.4
May-01	127.24	136.75	Feb-05	177.43	153.75	Nov-08	226.99	247.25
Jun-01	121.78	130.8	Mar-05	173.95	158	Dec-08	234.38	235.25
Jul-01	129.93	126.75	Apr-05	156.61	148.6	Jan-09	238.4	256.4
Aug-01	128.37	126	May-05	166.7	150.5	Feb-09	240.56	240.75
Sep-01	130.38	127.25	Jun-05	175.54	148	Mar-09	229.55	245.5
Oct-01	131.61	125	Jul-05	176.85	147.6	Apr-09	221.79	241.5
Nov-01	131.25	128.8	Aug-05	174.23	155.25	May-09	222.54	260.8
Dec-01	129.64	125.5	Sep-05	175.36	166.2	Jun-09	225.83	269.5
Jan-02	130.33	128.25	Oct-05	179.61	174.5	Jul-09	225.42	233.2
Feb-02	129.39	126.5	Nov-05	189.15	167.25	Aug-09	230.27	217.75
Mar-02	130.44	125.4	Dec-05	198.73	167.4	Sep-09	240.72	200.75
Apr-02	127.76	126.5	Jan-06	229.73	169.5	Oct-09	265.91	208.8
May-02	128.9	122.8	Feb-06	212.72	180.5	Nov-09	296.8	227.5
Jun-02	131.48	133.25	Mar-06	209.76	180.8	Dec-09	296.64	221.75
Jul-02	134.13	150.25	Apr-06	185.76	187	Jan-10	297.85	214.8
Aug-02	132.23	163	May-06	187.18	199.25	Feb-10	303.68	207
Sep-02	133.67	189.5	Jun-06	186.71	203.8	Mar-10	302.63	205.5
Oct-02	135.21	196.5	Jul-06	186.18	213	Apr-10	281.75	200.2
Nov-02	139.78	182.8	Aug-06	210.57	199.25	May-10	250.21	195.75
Dec-02	146.6	167.5	Sep-06	216.83	207.4	Jun-10	259.44	182.75
Jan-03	143.33	155.4	Oct-06	230.92	218.25	Jul-10	261.99	204.6
Feb-03	146.63	154.75	Nov-06	254.18	218	Aug-10	264.72	267.75
Mar-03	146.12	145.75	Dec-06	244.18	216.6	Sep-10	265.39	303.75
Apr-03	140.86	143.25	Jan-07	243.63	208.5	Oct-10	277.23	290
May-03	142.58	146.2	Feb-07	235.51	206.75	Nov-10	275.84	291.5
Jun-03	149.56	135	Mar-07	236.2	209.2	Dec-10	284.94	319.8
Jul-03	149.47	130.75	Apr-07	226.57	206.25	Jan-11	284.00	339.0
Aug-03	148.6	152.2	May-07	224.37	203			
Sep-03	150.76	150.75	Jun-07	233.01	225.2			

Source: FAO

Annexure Table 2: Public Stocks and Buffer Norms for Wheat (Quarterly, '000 tonnes)

Date	BufferNorm	Actual
Jan-00	84	171.7
Apr-00	40	131.87
Jul-00	143	277.57
Oct-00	116	268.5
Jan-01	84	250.41
Apr-01	40	215.04
Jul-01	143	389.2
Oct-01	116	368.26
Jan-02	84	324.15
Apr-02	40	260.39
Jul-02	143	410.74
Oct-02	116	356.37
Jan-03	84	288.3
Apr-03	40	156.45
Jul-03	143	241.94
Oct-03	116	184.27
Jan-04	84	126.87
Apr-04	40	69.31
Jul-04	143	191.52
Oct-04	116	142.23
Jan-05	84	89.31
Apr-05	40	40.66
Jul-05	171	144.54
Oct-05	110	102.9
Jan-06	82	61.88
Apr-06	40	20.09
Jul-06	171	82.07
Oct-06	110	64.12
Jan-07	82	54.28
Apr-07	40	47.03
Jul-07	171	129.26
Oct-07	110	101.21
Jan-08	82	77.12
Apr-08	40	58.03
Jul-08	171	249.12
Oct-08	110	220.25
Jan-09	82	182.12
Apr-09	40	134.29
Jul-09	171	329.22
Oct-09	110	284.57
Jan-10	82	230.92
Apr-10	40	161.25
Jul-10	171	335.84
Oct-10	110	278
Jan-11	82	215.4

Source: FCI and other documents, Ministry of Consumer Affairs and Food Distribution, GOI.