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A Decision Support Tool for Government Engagements in Market for Essentials – the case of Food grains in Bangladesh

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Sajjad Zohir*

I. Introduction

Researchers and authors of studies on foodgrain market and on government policies and interventions apparently position themselves as neutral observers[1]. Economists, in particular, tend to distance themselves from policy prescriptions at operational levels since *ceteris paribus* conditions rarely prevail and probability of prediction error is likely to be fatally high! A large bulk of the literature on food market is empirical, some of which estimate parameters useful for general policy making and several others look into institutional and administrative aspects of managing food market. There is also a segment in the literature dealing with analytical models that incorporate key characteristics of the market (such as, storage and speculative behavior of private agents) to infer on price dynamics (e.g., Dorosh 2001, Derek *et al* 2006, Sivakumar *et al* 2006, Cafiero *et al* 2009, etc.). The last set of literature delves into assessing the need of government interventions in foodgrain market, but falls short of deriving the desired actions at practical levels.

At a general level, conclusions are reached to suggest that "Policy should foster the use of market-based instruments and targeted safety nets to manage the risks of adverse food market outcomes" (Derek *et al* 2006). The tools to guide "use of market-based instruments", however, failed to go beyond the accounting-type exercises, which could only set the boundaries for *ad hoc* political choices. Yet, prudent acts of interventions demand *ex ante* decisions, which may only be arrived at if objectives are explicitly formalized within the setting of accounting constraints. Thus, an essential first step to construct a decision support tool (DST) is to develop an analytical framework that guides information compilation based on which decisions are to be made; and this has been attempted in the current exercise. It also recasts the analytics to allow compilation of consistent macro (food) accounting data in a dynamic setting. However, the paper refrains from suggesting a unique criterion to arrive at decisions. In stead, within the proposed perspective, it outlines the kind of questions that may pose dilemmas during *ex ante* decision-making.

The paper develops a general framework to guide government actions on markets of essentials where the government has obligation to its citizens to ensure price stability and, at times, to make those essentials accessible to people at less than the market price (or, at zero price). In all such cases, inter-temporal arbitraging, or, spatial arbitraging with significant time lags (between purchase and sale) call for storage demand. Therefore, *ex ante* decisions based on expectations are unavoidable. In addition, all such instances involve producers (at home and abroad), processors (at home and abroad), consumers at

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[1] The literature on market management (handling of both stocks and flows beyond pricing policies) is largely biased towards foodgrains. In the Bangladesh context, fertilizer market surfaced more in the context of subsidy, an element of pricing policy. However, procurement, stocks, offtakes and one's ability to influence prices are all interlinked.

home, and the government as a provider (as arbitrageur in the guise of trader and/or processor)[2]. Some of the commodities for which the generic approach applies are cereals, edible oil and sugar. The suggested structure of compiling data would also apply to markets for certain agriculture inputs, such as, chemical fertilizer (and fuel), which are perceived essentials for production of staple food. It needs no mention that price (and/or supply) volatility in the markets of these commodities and the perceived implications of such price dynamics on political stability call for better understanding of market forces and for consistent and timely response from the government. The present paper confines to developing the first building block towards informed decision making and refrains from formalizing formation of expectations on future prices, currently considered given.

II. General Perspective

Few basic assumptions underlie the exercises undertaken in this paper. First, government's role as a regulator and facilitator in governing the market is not looked into in this paper.[3] In stead, the **government is considered an actor/provider in the market** like any other provider; but having additional instruments in hand as a regulator. Second, the government recognizes that the private sector actors in the market normally deliver services incurring lower costs, yet market outcomes are often socially harmful if left completely at the whims of private sector; and it calls for **strategic engagement by the government as a 'provider'**. Ideally, a government, claiming to uphold a 'social objective function', would make its decisions upon taking into account of all market variables, including the responses of private actors in response to those variables and government policies. That is,

$$(1) \qquad D_g = \int(X_m, D_v), \text{ and } D_v = V(X_m, D_g)$$

In other words, decision of government ought to be a function of market variables (X_m) and of decisions made by private providers (D_v). It is also important to recognize that decisions by private providers are expected to take cognizance of market variables and of decisions made by the government (D_g). Thus, final outcomes observed in the market are likely to be the end-product of the above decision processes. On the latter presumption, Figure 1 describes the basic blocks involved in **a support tool to facilitate informed decision-making**.

Even though far from reality, we will **assume that the government is in a position to collect and process information to arrive at realistic conjectures on behavior of private sector actors, and makes its decisions in pursuit of a greater social good**. It is not expected that the government will be in a position to marginalize all political economy considerations and that it will have all the relevant information to decide in accordance to the above framework. Yet, having a framework in place helps ensuring a learning process with continuity of institutional knowledge.

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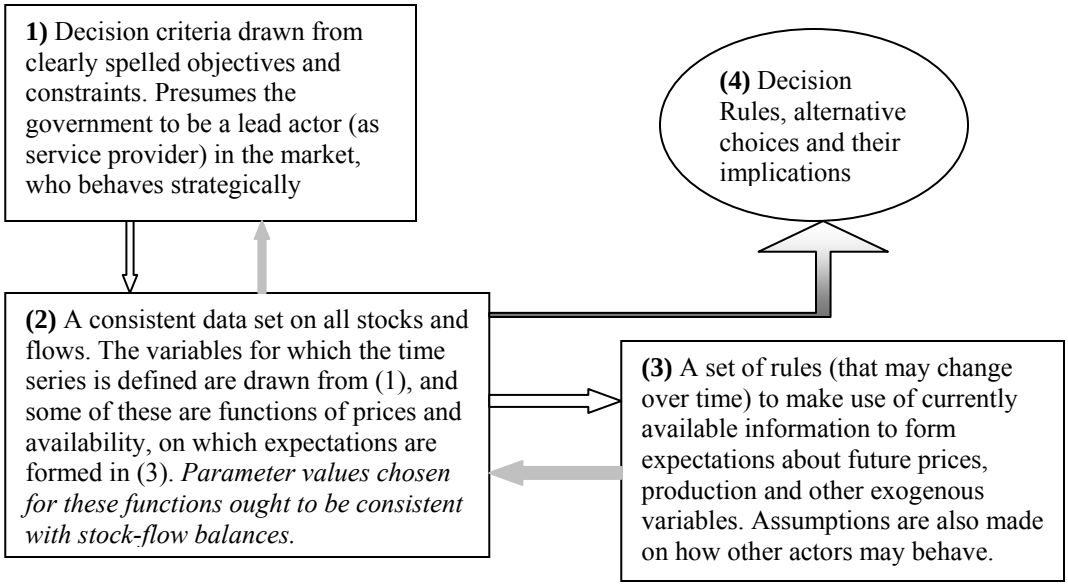
[2] The act of storage may be subsumed under the broader role of an arbitrageur.

[3] Quite unfortunately, governance has so many connotations that it is often difficult to convey a unique message. The difficulty aggravates when regulation and control are interchangeably used by many amongst policymakers. Here, we abstract from the government's role in governance of market.

Figure 1: Primary Boxes in a Decision Support Tool



With a view to operationalize the decision framework, the current exercise takes up the case of foodgrain (particularly rice and wheat)[4] and considers the decision-making at the Food Planning and Monitoring Committee (FPMC), an inter-Ministerial subset of the Cabinet. Decisions at the FPMC on various aspects of food market interventions (see Annex 1) are normally preceded by information gathering and processing by its secretariat, a role played by the Food Policy Monitoring Unit (FPMU) of the Ministry of Food. The decision support tool subsequently developed in an excel environment is meant to serve the needs of the FPMU in supporting decisions made at the FPMC. References to various variables and analytical categories referred to in the analytical framework may draw upon the experiences of FPMU – though these apply to other commodities and corresponding government agencies as well.[5]

III. Decision Framework

III.1 Road map – introducing the departure

The decision support tool developed has an underlying model – more precisely, it has the segment of a model that defines the choice set for the decision-makers. The paper does not propose a new unique model; instead, basic relations already identified in the

[4] It would be useful to deal with rice and wheat separately since information compilation and PFDS policy decisions make such distinctions. The current exercise abstracts from it for ease in illustrating the structure of a decision support tool and argues for its relevance. Once it is found structurally acceptable, the relevant agency within the government may engage its resources to do so with minimal external support. Following the first presentation, there was an understanding reached that two periods within a year would be considered and separate treatment of rice and wheat would be left for a later period.

[5] An earlier paper (Zohir 2012a) described "objectives", "instruments" and "variables" considered in the decision process within Ministry of Food.

literature are critically examined and included within a coherent framework. The process of identifying the variables that define the choice set, had to account for variables that may potentially define the decision function. An illustration of the latter is presented towards the end of the paper.

Several features that characterize the current exercise are mentioned below:

- The exercise is meant to predict outcomes of alternative actions over a very short term; and production is considered exogenous. In reality, decision-makers in the Ministry of Food operate in such environment and decisions are made assuming fixed-point expectations on production[6]. One may however add on new equations (with assumed parameter values) to make output endogenous and generate a longer series of outcome variables if the purpose is differently set. This and many other intricacies may be added in future once the basic frame of the decision support tool is proposed in this paper.
- The exercise does not try to solve equilibrium market prices. In stead, it takes a given price-quantity relation, and given domestic production, finds implications of government's action on market prices in the immediate future. While one could extend that to include supply (of cereal) function responding to price variations, a numerical model is likely to have large error term representing the influences of left-out variables. Thus, demand for data would increase manifolds.
- A major methodological departure in the current exercise is in the estimation of elasticity parameters that are, by design, consistent with the compiled aggregate level time series data. Usually, micro-econometric estimates of these parameters from survey data are used in simulation models, and more often than not, these estimates are found inappropriate in explaining variations over time.[7] All basic rules of hypothesis testing, used to justify (or, nullify) micro-econometric estimates (from survey data), do not apply in case of our estimates and therefore rigor in choice needs to be introduced through alternative means.
- A second distinguishing feature surfaces in connection with validation. In cases of models where some of the observed variables are outcomes of interactions among multiple agents abstracted in the model, numerical results of the model may be cross-checked with observed data for the purpose of validating the model. Such validation exercise aims at simultaneous assessment of both the model and the parameter values. In the alternative route adapted in this exercise, past actions (reflected in observed data) are embedded in outcomes of the subsequent periods (which are also included in the past). With increasing number of functional estimates, consistency across those functions and intuitive appeal of the recreated history are considered more relevant criteria for validation of specification and estimates.[8]

[6] We abstract from the process of continuous updating of such expectation, considered outside the scope of the present study.

[7] Price changes and growth in crop production have often come under scrutiny and elasticity parameters are rarely mentioned in resolving conflicts due to implicit recognition of redundancy of their known values.

[8] As will be shown, several functional estimates, having meaningful parameters, will be derived from compiled data. The initial set however attempts to fill the gaps in data, which may be expanded to endogenize few other variables, such as, production, private stock, and private import. All these would

- As will be noted later, private domestic procurement, off-take and stock; and household consumption (from own production and market purchases) are major unknowns addressed.

The analytical framework underlying the decision tool involves time-contingent variables though the general framework does not tie to any specific notion of time. Once developed and translated into an excel-based decision frame, one needs to specify the time period over which decisions are made. For the purpose of illustration and acknowledging the seasonality in crop production, the quantitative exercise (to follow)[9] deals with national level data compiled for half-yearly periods. However, the framework may be modified to accommodate shorter periods and (on some aspects) spatial units at sub-national levels.[10]

The following two sub-sections describe the basic set of constraints that ensure consistency across all stocks and flows and propose ways to fill the gaps in our database on some of the important variables to close the stock-flow loops. Subsection III.4 lays out the arbitraging principles – both spatial and temporal. Though these are derived from behavioral principle (of profit maximization), the current exercise considers those as constraints on two counts. First, fulfillment of the constraint or the degree of its violation can be considered as an indicator to assess the cost of pursuing social objectives as well as for reality check. More importantly, private arbitrageurs may be presumed to follow the arbitraging principles in government's strategic decision-making. Subsection III.5 indulges in discussing possible objective function that may be pursued by the government, which, along with specification of cost functions in III.6, would allow one to engage in preliminary comparative static analysis in the concluding part (III.7). Not all of these are translated to the template that is meant to act as the decision support tool, but the discussion in last part of the paper allures to the wider canvass the Decision Support Tool may be extended to address.

III.2 Constraints: the basic block

The literature on foodgrain market dynamics and on government food policies aptly capture the basic accounting constraint that maintains ***Stock-Flow Consistency*** for any given unit one chooses for time periods[11]. This is captured in equation (2), which summarily states that changes in the stocks in a given territory (Bangladesh) will be equal to the net inflow during a period. In a way, it is the overall food (grain) balance equation at the national level.

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fine-tune the conditional choice sets for the government to make strategic decisions; and technicality would involve ensuring consistency – not validation of results.

[9] The excel-based template is developed along the analytics developed in this paper.

[10] The purpose of the present exercise is to develop the basic framework. Once accepted, the excel-based framework may be modified by relevant agencies to address monthly/quarterly data allowing decisions to be made once in every month/quarter.

[11] Consultation with data availability and upon considering the crop cycles in Bangladesh and elsewhere, two periods are considered: 1 May till 30 October and 1 November till 30 April. The periodization roughly corresponds to the Bangla calendar year. Please read the text in the second box in Figure 1. Similar (but not exact) two periods were considered in Dorosh (2001), May-November and December-April.

(2) $S^{g}_{-1} + S^{v}_{-1} + M^{g} + M^{v} + M^{F} + R^{g} + R^{v} - D^{v} - D^{g} - O^{g} - X = S^{g} + S^{v} + L$

where,
S = foodgrain stock (end period), with superscripts g and v referring to government and private respectively, and subscript (-1) refer to lag of one (previous) period;
M^{g} and M^{v} = imports/external procurements by government and private sector;
M^{F} = Food aid which has two components, one of which is disbursed through INGOs directly in programs jointly approved by the government and development partners[12];
R^{g} and R^{v} = domestic procurement by government and private sector respectively;
D^{v} = Market-based domestic demand met by private sellers;
D^{g} = monetized off-take, sold through PFDS at administered price;
O^{g} = Off-take, non-monetized, which is all by the government;
X = Export.
L = Loss during storage, handling and transportation – both public and private.

We include processor/miller in the group of private arbitrageur; and the producers/ farmers are assumed to have no storage demand as producer-cum-consumers, while their storage demand for the purpose of arbitraging is aggregated with private arbitrageur[13]. We differentiate between government and private traders/processors, in case of domestic procurement – thus, retention by 'farmers' from current production is assumed to be fully consumed. In other words, the output net of seed & wastage, and after sales to government and private buyers, is consumed by the producers[14]. This is captured in equation (3), which also sets limits to the combined size of domestic procurements by the government and the private sectors.

(3) $D^{o} = (Q^{v} - E^{v} - R^{g} - R^{v})$

where,
D^{o} = Consumption met out of own (local) production;
Q = Domestic Production, which is assumed to be all private; and
E = Retention on account of seed for following seasons and wastage;

[12] For simplicity, the analytical exercise will assume that the whole of M^{F} passes through government channel.
[13] If one considers farm households, such an assumption is unacceptable. On the contrary, much interest exists to understand farms' storage and off-take behavior – amongst private traders & millers as well as from the government/policymakers keen on anticipating flows into the market. We recognize the multiple roles of a farm household: we abstract from its endogenous role as producer by considering output as exogenous; and aggregate consumption from own production is functionally estimated. However, its storage demand for the purpose of temporal arbitraging is (conceptually) aggregated with the aggregate demand for such storage by private traders & millers. In a setting of no difference in static (non-temporal) transaction costs, *ceteris paribus*, storage demand of a farm household would be no different than that of a private trader. For the purpose of operational simplicity, and since considerations are made at aggregate levels, we have made this assumption.
[14] Reference is made to producer-consumer roles of 'farmers'. One may assume that the 'producer-cum-consumer' farmer sells to the 'arbitrageur-farmer', and the latter is one of the private traders. Please also see previous footnote.

Total food consumption during t-th period is given by:

(4) $FC = D^o + D^v + D^g + O^g$

Substituting equations (3) and (2) into (4) give us,

$FC = Q^v - E^v - R^g - R^v + S^g_{-1} + S^v_{-1} + M^g + M^v + M^F + R^g + R^v - X - S^g - S^v - L$
Or,
(5) $FC = Q^v - E^v - (\Delta S^g + \Delta S^v + L) + M - X$
where,
$M = M^g + M^v + M^F$

Since it is a convention to report on national (total) food availability, it may be of interest to find its relation with FC defined above. In a given period t, food availability may be defined as:

(6) $A = Q^v - E^v + S^g_{-1} + S^v_{-1} - L + M - X$

The above may be expanded to show that

$A = Q^v - E^v - (\Delta S^g + \Delta S^v + L) + S^g + S^v + M - X$
$= FC + (S^g + S^v) \geq FC$ (since $(S^g + S^v) \geq 0$).

The above puts aside empirically observed inconsistency between national food balance statistics and the consumption data estimated from household income expenditure surveys.[15] One may also note that a part of the food aid received (M^F) goes directly to INGOs in kind and is not recorded in the PFDS's inventory. Rest of the food aid goes to government stock for which the government has to make available 'counterpart funds' to Programs, equivalent to book value of the 'aid', approved jointly by the external partner and the government. Thus, food aid involves budgetary cost that is shown as allocation under the heading of social sector. While some of the details will be addressed during designing of the template, the minor aberrations are ignored at this stage.

Within the larger balance defined in equation (2), several relations ought to be fulfilled separately for the government and the private sectors. These are shown in equations (7) and (8):

(7) $S^g_{-1} + M^g + M^F + R^g - D^g - O^g = S^g + L^g$ (government's stock-flow balance)

(8) $S^v_{-1} + M^v + R^v - D^v - X_t = S^v + L^v$ (private providers' stock-flow balance)

[15] In years when reported FC > A, it is necessary to revisit the quality of data. The latter further points to the need for a general framework that cross-checks consistency across various series.

III.3 Balancing the Stocks and Flows – constraints made transparent

Equations (7), (8) and (3) capture all stocks and flows of the foodgrain market described in this paper. Information on all variables in equation (7) are known *ex post*. Unfortunately, other than M^v and X, no information is available on equation (8). Finally, in case of equation (3), Q^v and R^g are known. The list of unknowns cannot be uniquely determined with the information one regularly has and therefore, D^o and E in equation (3) are estimated exogenously using the following specifications:

$$(9) \qquad D^0 / Q = e^{(a_0 + d_1)} (p_c / cpi)^{a_1} .(p_r / p_m)^{a_2} .(p_{nf} / cpi)^{a_3} .Q^{a_4} \quad \text{and}$$

$$(10) \qquad E / Q = h_0 + h_1 \ln(time) + d_2 (season)$$

where,
p_c, p_r, p_m and p_{nf} are respectively prices of cereals, procurement and market prices, and prices of non-food;
cpi stands for consumer price index;
a_i's are parameters associated with elasticity parameters; h_1 captures time trend and dummies d_1 and d_2 differentiate between seasons (wet and dry).

It is important to note that one may choose any specification for determining D^o and E; and the two mentioned above are only for the purpose of illustration that are later used in the excel-based template. Given that government procurement (R^g) is known, estimated values of D^o and E allow one to estimate private domestic procurement by private traders each year (R^v) from equation (3). There still remain four unknowns in equation (8) – private stocks at the beginning and end of a period, loss incurred by the private arbitrageurs in the process of arbitraging, and demand for cereals met through market with no price supports. The current exercise proposes to identify appropriate specifications for two of these unknowns – L^v and D^v. Though the excel-based template developed can accommodate any specification, for the purpose of illustration, L^v is assumed to be a constant fraction (say, c) of total volume of cereals handled by the traders in a given year and D^v is derived from the following equation, which is a reduced form of the Linear Almost Ideal Demand System (LAIDS)[16]:

(11)

$$w = \alpha + d_3 Dum3 + d_4 Dum4 + \gamma_1 \ln(pc / cpi) + \gamma_2 \ln(pnc / cpi) + \gamma_3 \ln(pnf / cpi) + \beta_1 (gnipc / cpi)$$

Where,

$w = ((p_m / cpi) * D^v) / (gni - \text{income from rice and wheat})$; and therefore,

$D^v = (w * cpi / p_m) * (gni - \text{income from rice and wheat})$

[16] In cross-section demand estimation, nominal prices are used. We substitute those with real prices defined by consumer price index (CPI).

The estimate of D^v using reasonable parameter values of a given specification of demand function (of which LAIDS is one) allows one to generate a time series on private stock (S^v) with any initial value assigned using equation (8).

In summary, three important variables, D^v, D^o and E are calculated using given specifications and *priors* on parameter values. A relatively minor fourth variable is the private loss during arbitraging. Once the specifications are fixed, values of important parameters may be changed within intuitively reasonable ranges to generate alternative 'histories' of all (previously) unknown variables. Some of the critical ones considered as potential indicators for verification are per capita consumption of cereals (given a population series), private and total stock, and consumption as a percentage of net domestic output. One could draw analogy with simulations based on macro numerical models. In case of the latter, model specification and parameters are validated against past actual data before considering a set of exogenous variables for projections. In contrast, the current exercise takes a part of the history (variables for which values are reported) as given and generates another part of the history which has no benchmark to validate. However, once a 'history' is considered acceptable[17] and the values of corresponding parameters are incorporated, the future of some of the outcome variables may be projected given a set of actions and exogenous variables.[18] The actions to be chosen however depend on the preferences of the 'decision-maker' and the assumptions the latter makes about other actors in case of strategic role – all these are taken up in the rest of this section, acknowledging that the actual choices are not attempted in the excel-based template.

III.4 Behavior of Private Arbitrageur – extended constraints

Private sector is assumed to be motivated by profit sought by procurements at times and places of low prices and sale of the commodity when (and where) prices are high. The two aspects of this engagement are described by two arbitrage conditions.

Spatial Arbitrage condition across national boundaries (external) is normally given by the condition that domestic price is restricted to evolve in a moving band defined by world price, trade costs, and trade taxes if any:

$$(12) \qquad p^w - \tau - \nu^X \leq p^m \leq p^w + \tau + \nu^M ;$$

where,

[17] Rigors in acceptability may be introduced in several ways. An example would be, attaining least error sum of squares when one runs regression of an estimated series (say, opening private stock) on (say) future market prices. However, choice of such criterion would imply (often rigid) assumption on the behavior of agents.

[18] As noted earlier, econometric estimates on demand parameters are considered only as *priors*; though, estimates consistent with the aggregate data are generated through constrained convergence rules applied using excel-provided 'solver'. The methodological departure allows one to assess the consistency of recorded data as well.

p, τ and ν are respectively, price, per unit export or import cost (transport/shipping and other handling cost) and per unit taxes (positive) or subsidy (negative) on imports and exports;
Superscripts with prices, w and m, stand for world and domestic market respectively;
Superscripts X and M stand for export and import respectively; and
As before, time subscripts are omitted.

Inter-temporal arbitraging in simplified models is given by;

(13.a) $S_t \geq 0$, if $(1+r)^{-1} E_t (p_{t+1}) - p_t \geq k$;

(13.b) $S_t = 0$, if $(1+r)^{-1} E_t (p_{t+1}) - p_t < k$

Where r is the interest rate and k is fixed marginal cost of storage (assumed in some literature), and E_t is the expectation conditional on information available at time t.

With positive lead time in procuring foodgrain from the world market, and given the influence of expectations in storage decisions, domestic price in equation (12) is an expected variable, and errors in expectations may lead to violation of spatial (cross-border) arbitrage condition described in the equation (12) - that is, the condition may not be fulfilled at certain times[19].

For informed decision-making, it is expected that the government as a provider in the foodgrain market will account for the size of the private providers and their behavior. The latter is assumed to generally follow the arbitraging conditions described in equations (12) and (13). By the same logic, monitoring of actions of private providers, one may make meaningful guesses on their expectation on future prices.

III.5 Government's Objective Function and corresponding Operational Measures

The earlier review of policy objectives and decision processes revealed that there are primarily three objectives that decision-makers may like to emphasize upon while engaging in foodgrain market. These are:

- Price stabilization,
- Ensure that the engagements do not create disincentives to domestic food production; and
- The most important of all objectives in a food-deficit developing country is, attend to the (basic) needs of people who are unable to avail food from the market,

The first may be considered equivalent to reducing variance in market price, $V(p^m)$, which is difficult to be included in a recursive discrete short term decision model. It is

[19] It would be interesting to verify if such outliers were preceded by more than average share of 'market-disrupting' policies.

proposed that a proxy of it be considered, and actions in period t are taken to ensure fulfilling the following condition[20]:

(14) $|p^m_{t+1} - p^T_t| < u;$

where u is either an absolute number or is expressed as a percentage of p^T_t, which stands for trend value of price at time t.

Fulfilling the second objective requires ensuring a minimum price to producers, given a regime of input market interventions. Historically, such a minimum price is perceived to include a markup over the cost of production. Thus, decisions during period t are expected to ensure that

(15) $p^m_t \geq (1+\alpha).c^q_t,$

where, $\alpha > 0$, c^q_t is per unit cost of production in period t (with appropriate adjustments where processing is involved).

There are potential conflicts between (14) and (15). For instance, with sudden increase in cost of production, fulfilling (15) may lead to violation of (14). If such price increases are perceived temporary, having no or insignificant positive effect on subsequent production, the government may choose to protect the interest of the consumers, in which case (14) will over-ride (15). There may however be times when general price level increases are expected to sustain; and there is a need to ensure supply side incentives in the market of essentials. In such cases, the government may forego short term interests of consumers for their long term benefits. Barring for such fine-tuning, government's objective function may be captured by the third objective, subject to several constraints, which may include (14) and (15) as well, with a conditional statement on the operational validity of each in setting. At an operational level, the two conditions may be put up as one algorithm defined as follows:

(16.1) if $(1+\alpha).c^q_t \leq p^T_t$,
$(1+\alpha).c^q_t \leq p^m_t \leq p^T_t$ and
$(p^T_t - p^m_t) \leq u.$

and

(16.2) if $(1+\alpha).c^q_t > p^T_t$:
$p^m_t = p^T_t$; if consumers' interest is emphasized; and
$p^m_t = (1+\alpha).c^q_t$; if producers' interests are emphasized[21].

One may note that in both cases, the range within which p^m ought to lie is defined by common end points. The difference however lies in the inflexible choices (corner

[20] One may choose to include cyclical element in p^T, or consider the latter to be pure (linear) trend only.

[21] As will be noted later, switch in priority over the two concerns is seasonal in nature, and may not arise in case of annualized decision framework. For instance, the government normally engages in OMS to stabilize prices when price hikes are observed during months prior to harvest; and no off-takes occur during harvest seasons.

solutions) offered to decision-makers under (16.2) when costs of producing cereals increase at a faster pace than that of the price of cereals.

In order to formalize the third (and the most important) objective, let us express access to food as a proportion (or, percentage) of some perceived requirement. One may note that such an approach has historically dominated thinking within national government as well as among international agencies (such as, FAO and WFP) engaged in promoting food security (or, reducing the extent of food deprivation). Given the four different types of food consumption identified above, one may define such a proportion as,

(17) $z = FC/(N.q) = (D^o + D^v + D^g + O^g)/(N.q)$

where, N is the number of people and q is a pre-determined average consumption need per capita (or some other proxy to capture state obligation).

In the above, z may be considered a proxy for the effective proportion of people[22] able to get the average required amount of food from market and non-market sources. Note that z is a measurable number and different political authorities may associate different ordinal value to those numbers. For some, attaining z=1 may over-ride all other priorities in resource allocation, while others may not feel that way. At a general level, such a valuation, benefits perceived from increase in z (or, equivalently, cost perceived from increase in z) may be expressed as,[23]

(18) $V(z) = B(z,\theta) - C(z,\theta)$

where, z is defined in equation (17) and θ is a measure of distribution (say, one minus Gini coefficient in consumption) taking values between 0 and 1 with higher value associated with higher equity. Without further elaboration, signs of the partial derivates denoted with subscripts are given below[24]:

$B_1 > 0,\ B_{11} < 0,\ B_2 > 0,\ B_{22} < 0,\ B_{12} = B_{21} \geq 0$

$C_1 > 0,\ C_{11} > 0,\ C_2 > 0,\ C_{22} > 0,\ C_{12} \leq 0,\ C_{21} \leq 0,$

[22] Eventually, one would like to formally include a given distribution of consumption. However, as a first step, working with averages and considering (1-z) as proxy for food deprivation allows one to avoid complicacies.

[23] V(z) representing government's engagement in food market is relevant only beyond a (positive) proportion the society and economy can attain independent of government intervention; and the threshold is identified as z^p in Figure 2. In a more meaningful version, one may consider $V(z, \theta, p_m)$ and allow the government to strategically influence p_m so as to raise z^p (and thereby reduce government's disbursement to attain a given z) which would call for using stock (at a cost) to deter undesired increases in market prices.

[24] The first derivative (B_1) is assumed to be positive since an increase in the value of z reduces the extent of (national level) 'food deprivation', thus increasing the value of perceived benefits ('feel good' factor within the government or for reasons of enhanced stability and peace translated to economic benefits). As the size of z continues to increase approaching unity, there may be fewer voices raised in favor of the deprived ones and therefore perceived marginal benefit from an additional unit of z may also be on decline – thus, $B_{11} < 0$.

One may note that,

$V_z = B_1 - C_1 > 0$ only if $B_1 > C_1$; and
$V_{zz} = B_{11} - C_{11} < 0$.

Under the extreme assumption of uniform distribution in consumption, all people would get the required basic amount of foodgrain if z is greater or equal to unity. Alternatively expressed, given a distribution in consumption, increase in z is associated with increased fulfillment of government's commitment to provide basic (food) needs to people.[25] Once formally recognized and addressed, the tradeoffs may be brought to fore in choices made on food market interventions. Subsequently, one may fine tune specifications and translate those into numerical exercises for incorporation in templates.

III.6 Cost of engaging in food grain market

The cost incurred by the government is given by,

(19.1) $C_t = D^g.(c^g - p^g) + O^g.c^g$
where,
$c^g = (c^R_{-1} + c^S_{-1}).(1+r)$; and
$c^R = \{(p^w .M^g) + (p^R .R^g) + (c^F.M^F)\}/(M^g + R^g + M^F)$

In the above, two major types of cost are considered, cost of procurement (c^R) and cost of storage (c^S); and the cost of finance is accounted for by adjusting cost by interest rate (r). Since a part of the cost is recovered from monetized off-take (D^g), appropriate adjustment is made. We choose to ignore the tangible benefits (say, in the form of rural roads, or excavation of canals) associated with non-monetized off-take (O^g).

Equation (19.1) may be rewritten as,
$C = D^g.c^g - D^g.p^g + O^g.c^g$
Or, $C = c^g (D^v + D^o + D^g + O^g) - D^g.p^g - c^g (D^v + D^o)$
Or,
(19.2) $C_t = c^g.N.q.z - p^g_t D^g - c^g.(D^v + D^o) = C(z)$

Note that at $z = (D^v + D^o)/Nq$, there is no government involvement, and $D^g = O^g = 0$. Thus, C = 0, if one ignores the fixed cost associated with storage (not formally included in this exercise). Let us define this threshold as,

$z^p = (D^v + D^o)/Nq$,
and the government does not have to incur any cost to attain this level of z (see Figure 2 below).

[25] Equation (18) is newly introduced and the author is not aware of its inclusion in the existing literature. There is a trade-off between budgetary expenses on off-takes and benefits from higher *z*. One may use *(1-z)* as a proxy for the extent of "food deprivation" prevailing in a country, which is also contingent upon having a given distribution in consumption. One may note that independence of *z* and θ is assumed within reasonable ranges.

Beyond $z = z^p$, concavity of the cost function with respect to z is implicit in the relation between c^g and z. Given a θ, per unit cost (c^g) is expected to increase at an increasing pace as z approaches unity.

III.7 Government decisions – selected questions on allocations

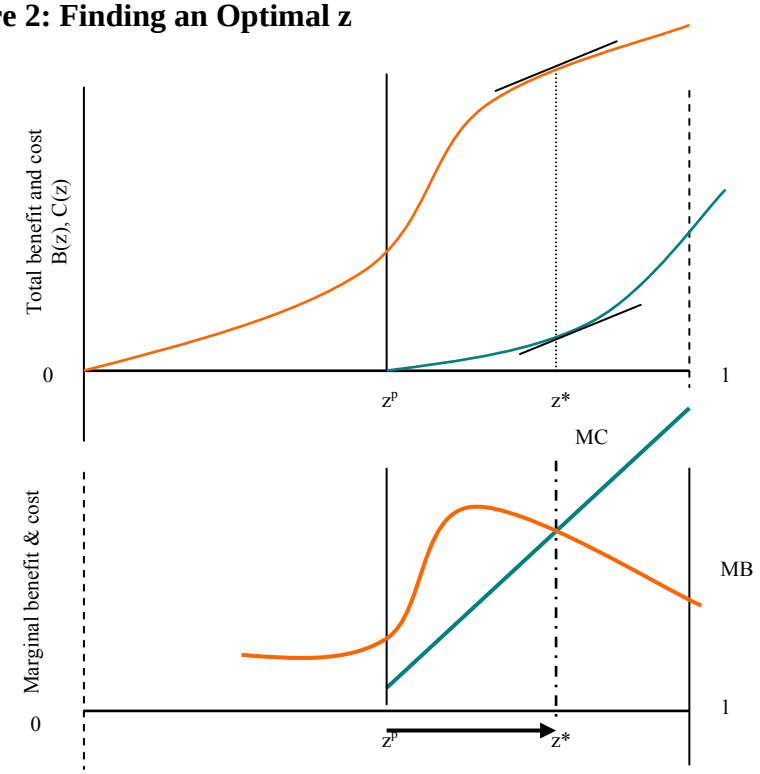
Given equations (17), (18), (19.2) and the identities identified earlier for balancing stocks and flows of cereals in government and private hands, the government's decision problem may be summarized as follows:

(20) Maximize *V(z)*

Subject to, fulfillment of equations (16.1), (16.2), (17), (19.2) and subject to the budgetary constraint (if any)[26].

Figure 2 describes solution in a choice set that considers all other things as given and the government is a passive actor. However, as mentioned in footnote 23, the government intends to act strategically, all the above conditions as well as how the private sector reads government's action (such as, stocks) need to be duly considered. A simple equilibrium is illustrated below with brief extension on comparative static. The last part raises selected questions on instruments at the disposal of the government and relative merits in their usage.

Figure 2: Finding an Optimal z



[26] One may consider an absolute figure below which the total expense should be confined.

Figure 2 describes an interior solution at z* with $B_1 = C_1$, and MC > MB at z > z*. There is no guarantee that such an interior equilibrium exists. However, government's choice set is bounded, $1 \geq z^* \geq z^P$. In an extreme situation, if social cost is perceived to outweigh total benefit at $z = z^P$, and all attempts by government to increase z beyond z^P lead to increase in the net cost. Thus, the optimal solution will be at the corner $z^* = z^P$, that is, government will refrain from any intervention in the food grain market. Alternatively, z may equal unity if society values highly all citizens' right to food and a government chooses to translate that aspiration into reality.[27]

Given that $V(z) = B(z) - C(z)$

$$= B((D^o + D^v + D^g + O^g)/(N.q)) - C((D^o + D^v + D^g + O^g)/(N.q)),$$

One may make use of the following additional information to derive the comparative static related to change in optimal choice of z as a result of change in any of the independent variables[28],

(18.1) $D^v = f^v(p_m, p, I)$; $\quad f^v_m < 0, f^v_{11} > 0, f^v_2 < 0, f^v_3 > 0$

(18.2) $D^o = f^o(p_m, p_g, p, Q, I)$ $\quad f^o_1 \leq 0, f^o_2 < 0, {}^o_3 > 0, f^o_4 > 0, f^o_5 \leq \geq 0$

(18.3) $D^g = f^g(p_m, p_g, p, I)$ $\quad f_g{}^1 > 0, f_g{}^2 < 0, f_g{}^3 > 0, f_g{}^4 \leq \geq 0$

Since the cost of procurement is perceived same, the most cost-effective choice of government distribution would be zero off-take at zero price (that is, $O^g = 0$) and emphasis on monetized sale close to perfect discrimination if market segmentation with adequate supply is feasible. However, the historical evidence does not lend support to such behavior from the government. In stead, one observes certain patterns in the timing and mix of monetized and non-monetized distribution. For example,

- Monetized sale is meant to stabilize potential price increases during months preceding the two major harvests. Thus, monetized off-takes occur during mid-September to mid-December and during February to May periods.
- Bulk of non-monetized off-take is during February-June when development work (such as, FFW) can take place. Such disbursements (often in cash out of food account) are also made to complete committed project activities before the budget year is over, and thus, coincides with the period of development work. In all such development programs, cash payment is a perfect substitute of payment in kind, and is quite often resorted to.
- Disbursements through both the channels are also guided by the urge to ensure outflows that will allow fresh inflows of post-harvest grains through procurements upon ensuring a minimum level of stock.[29]

[27] Note that realized z may often be higher than unity, and we abstract from such empirics.

[28] In (19.1) to (19.3) and elsewhere, superscript 'i' to a functional notation implies first-order partial derivative with respect to the i-th argument in the function under consideration, while superscript 'ii' implies second-order derivative with respect to the i-th argument.

[29] For all imported rice, a maximum of six months holding period is considered; while it is nine months for grains produced locally.

Thus, for planning purpose, attempts to increase z may follow any (or a mix) of the following three means[30]:

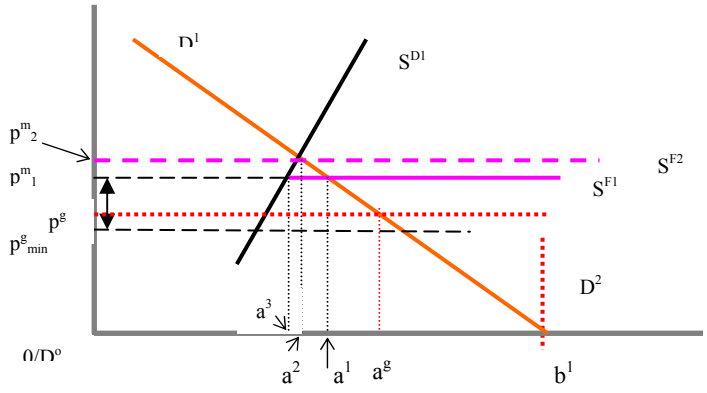
(1) Open Market Sales (OMS),
(2) Emergency relief, and
(3) Program supports/development work (such as, VGD, VGF, FFW); regular relief (such as, GR and TR) and supports in kind to LE and disbursements through EP/OP to support essential and other priority agencies.

Two primary concerns of the government are:

- Ensure that there is adequate foodgrain to meet the needs of the population. It is safe to assume that the private sector will be driven by profit motive and will sell at prices that are not affordable by all people. Thus, the government would supplement the private supply so that non-market routes may be availed (if necessary) to provide food to the needy.
- Unanticipated shocks arising from either domestic or external sources may not be adequately handled by the private sector. And, even if it does, a high risk premium may be tagged to it that is borne by the consumers. Thus, the government may like to ensure that it has sufficient leverage to address emergency situations.

Figure 3 illustrates various static scenarios on government interventions in the food grain market, which are equally applicable to other essentials[31]. The demand curve D^1 is assumed to remain stable, and domestic and foreign supplies are represented by S^{D1} and S^{F1}. Initially the import parity price is at p^{m1} which is below the domestic equilibrium price under a protected regime. In such a situation, domestic production is $0a^3$, private import is a^3a^1, and demand equivalent to a^1b^1 will remain unfulfilled.

Figure 3: Illustration on alternative government choices



[30] It is necessary to recognize that a part of 'emergency cereal' is often sold through OMS if there is no major need. Moreover, a part of the grain in stock, initially allocated for non-monetized off-take, may also have to be sold (through OMS) and the proceeds go for program support.

[31] Figure 3 assumes that an individual demands only one unit of the commodity so that the axis in the Figure also represents number of people. Since D^o is implicit in the supply function, the axis originates from D^o. Thus, the total population is assumed to be equal to $D^o + 0b^1$, or more, if there are people with no ability to pay for their food..

Within the above scenario, the government faces several decision problems:

- if it intends to ensure food to all of $0b^1$, what are the options to avail?
- If there is a supply shock, what choices does the government have?

On the first, the government may,

(1) Procure the a^1b^1 amount and distribute those through non-market routes and upon ensuring that those left out of the market are the only ones receiving the transfer.

(2) Sell some amount at a price, say p^g, such that $p^m_t > p^g \geq p^g_{min}$ = production cost. However, this covers (in Figure 3) only a^1a^g number of people. Thus the government has to find a way to reach rest of the population who are unable to buy food grain at prices p^g or above.

(3) The government may undertake targeted development programs to transfer resources in kind to the poor (such as FFW), or undertake (targeted) development programs where cash transfers are made to the poor who may then buy the grains at going market prices.

Ideally, if the production incentives are not to be tampered with, the second choice is less-distorting for the grain market. The problem of segmenting the market in ensuring transfers to the desired ones remain, and design of development programs provide additional instruments to segregate markets. In the presence of adequate supply of food grains in the domestic private market, cash transfers (in stead of transfers in kind) through targeted development programs will be desirable. However, at other times, such transfers may push the prices up and may fail to ensure poor's access to food. Thus a mix of three initiatives to increase z is found to be more rational an approach to adapt: (i) OMS, (ii) targeted programs with resource transfers in kind, and (iii) targeted development programs with cash transfers to increase purchasing power of the poor so that they may avail the grains from private market. A decision tool (going beyond the current decision support tool) that also links with the budgetary planning ought to take these into cognizance and develop appropriate algorithms to make *a prior* allocation under the three heads.

Figure 3 assumes stable demand in the short term, which is in conformity with current food planning practices. The second question is thus most relevant, and two important sources of supply shocks are: sudden shortfall in domestic production, and sudden increase in international price (and therefore import parity price having positive influences on domestic price). In the presence of former risk, the choice would be procurement from external sources. In the latter case, providing adequate incentive to local production and thereby reduce dependence on imported cereals is the obvious choice.

Ex ante decisions on all the above-mentioned matters need prior information and structured decision-making in a strategic manner. The template developed draws upon the earlier analytics and does not directly address the actual choices, but helps in understanding the implications of alternative choices within the logical environment laid out by the set of equations presented in this paper.

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