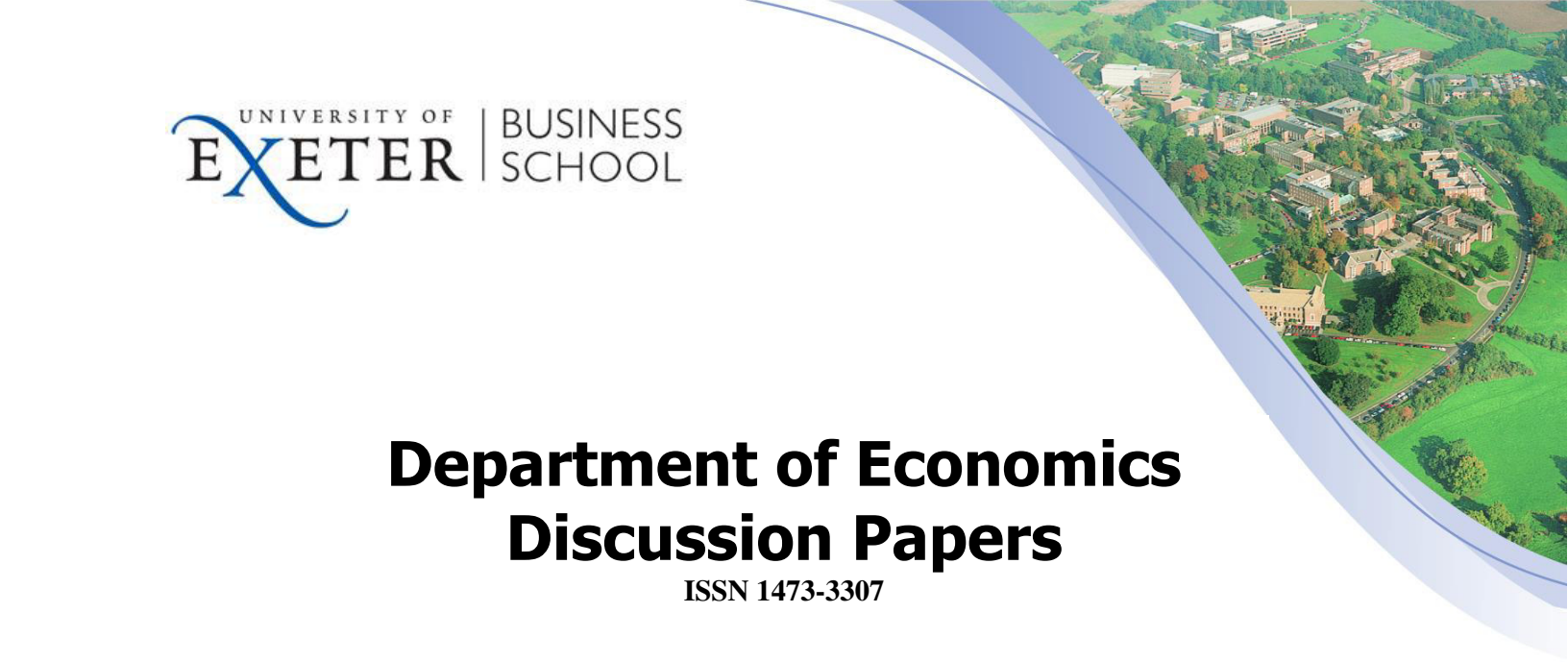

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Steve McCorriston and Donald MacLaren

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Market Intermediaries, Storage and Policy Reforms

Steve McCorriston (University of Exeter, England, UK)
Donald MacLaren (University of Melbourne, Australia)

Abstract: Intermediaries play a crucial role in the functioning of agricultural and food markets through linking production, imports and storage with consumption. They may be either private firms or parastatals, each type with a different objective function. In this paper, we develop a theoretical framework in the context of a small open economy subject to an exogenous and stochastic world commodity price and analyse how competition in the intermediary sector and alternative forms of intermediaries determine the incentives for storage and market outcomes more generally. We apply this framework to the Egyptian wheat sector as an illustrative case study, a country where food security is a priority and where both forms of intermediaries co-exist. Through stochastic simulation, we analyse two changes in government policy where we account for different characterisations of the intermediary sector: the first is the effects of changing the policy instruments; the second relates to market reforms where the private sector replaces the storage function of the parastatal.

Keywords: Private Intermediaries; Parastatals; Storage; Food Security.
JEL Classification: Q13; Q1

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Market Intermediaries, Storage and Policy Reforms

Introduction

Intermediaries play a crucial role in the functioning of agricultural and food markets. In a recent survey Barrett *et al.* (2020) identified the need for more research on this issue particularly with reference to developing and emerging economies. If intermediary markets were competitive and absent other market frictions, intermediaries would not impact on the distributional effects of government policy reforms. On the other hand, if the competitive assumption does not hold, then the presence of intermediaries will influence the extent to which consumers and producers (often constituting the poorest sections of the population) will gain or lose from policy changes as well as affecting exchequer costs. In this context, we contribute to growing research on intermediaries in developing country agricultural and food markets from two perspectives.

First, noting that intermediaries in developing countries come in different forms, we compare market outcomes of private intermediaries and parastatals. This is an important issue from several perspectives. With reference to private firms in agricultural and food markets in developing countries, concerns arise with respect to the extent of competition in intermediary markets which departs from the textbook assumption that intermediary markets are perfectly competitive. In a recent assessment of competition issues in agricultural and food markets in African countries, a World Bank review noted that the prices of 10 key staples including bread and flour were 24 per cent higher than in the rest of the world, even after controlling for transportation costs, geography and other factors and it was concluded that, more generally, African countries have lower levels of competition than other countries around the world (World Bank, 2016). Bergazo and Nymen (2015) summarise some of the concerns associated with competition and poverty in developing countries. However, in many developing and emerging economies, parastatals-not private firms-continue to play a key role in the procurement, trade and distribution of agricultural and food products. The issue of parastatals is a crucial dimension for understanding intermediary markets insofar as they involve the direct manipulation by governments of the intermediary market either by bestowing monopoly/monopsony status on the parastatal or by the exclusion of private firms in certain marketing functions[1]. As we detail below, the issue of parastatals as intermediaries extends beyond the monopoly/monopsony status with which they are often associated.

Identifying the role and alternative forms of intermediaries in agricultural and food markets is not only of relevance in appropriately characterising market structure but also in recognising that an

[1] This may include, for example, exclusive rights bestowed on the parastatal to export or import agricultural commodities or placing limits on storage by private firms.

assessment of government reforms of food and agricultural policies will be dependent on the characterisation of these markets. Furthermore, government reforms may either eliminate or limit the role of the parastatal. Removing barriers to the functioning of intermediary markets aim to encourage greater participation of private firms with a view to increasing the competitiveness and efficiency of these markets or at least in some segments or activities in them. Such reforms can often be contentious. For example, the recent marketing reforms in India attracted widespread attention, a key part of which centred on limiting the role of the state and increasing the role of private intermediaries in the supply chain in 'essential' commodity sectors[2].

Second, we allow intermediaries to store agricultural commodities. This is a relevant feature of many intermediary markets since such markets are characterised by the stochastic nature of production and prices and storage can play a role by ameliorating the effects of market volatility. However, the role of storage by intermediaries has been largely set aside in the literature on commodity storage and has not featured in the recent line of research on intermediaries in developing country agricultural and food markets. Yet, storage is an important feature of markets particularly for staples and it is undertaken by intermediaries. In the example we outline below (relating to the bread sector in Egypt), both the parastatal and private intermediary sectors store commodities. In the case of the marketing reforms in India noted above, an aspect of them is to remove limits on how much private intermediaries could store. In the extant literature, where the link between market structure and storage has been addressed, it has typically focussed on the supply of storage (the agency responsible for storage is not responsible for procurement and/or distribution) and on the extremes of monopoly and competitive markets. The issue of competition between intermediaries and how alternative forms of intermediaries affect storage has not featured. Yet, in many developing and emerging economies, storage is an important aspect of agricultural and food supply chains and, as we show below, government policies either in the form of changing policy instruments or in marketing reforms (e.g. increasing the role of the private sector in storage activities) is an important feature in the overall assessment of government policies, the outcomes of which are influenced by, and also determine the incentives for, storage.

In this paper, we focus on the linkages between alternative forms of intermediaries, the role of storage and government reforms which promote food security, and a market structure in which private firms take over some of the functions of the parastatal. We begin by developing a framework where we highlight how the characterisation of the intermediary sector impacts on the levels of storage. We then

[2] The marketing reforms in India related to three pieces of legislation: the Farmers' Produce and Commerce Bill (2020), the Farmers' Produce (Empowerment and Protection) Agreement of Price Assurance, Farm Services Bill (2020) and the Essential Commodities (Amendment) Bill (2020).Narayanan (2020) provides an overview of these reforms. Reflecting the strength of opposition by farmers to the proposed marketing reforms, at the time of writing, the Indian government announced it was abandoning the legislation.

extend the framework to take account of specific government policy instruments and the market reforms that alter the role of the private sector. Though the issue of storage and the characterisation of the intermediary sector are generic, we are motivated by, and calibrate the model to, the bread sector in Egypt. Food security is a politically-sensitive issue in Egypt, a country in which the costs of supplying bread at subsidised prices has been shown to have a considerable impact on public finances, thereby making it a priority for reform (FAO, 2015). In terms of investigating how the structure of the intermediary market (with storage undertaken by both the parastatal and private intermediaries) influences the outcomes of potential government reforms, the Egyptian bread sector serves as an ideal illustrative case study for the theoretical framework we set out.

Specifically, the Egyptian wheat market is segmented into the processing of (*baladi*) bread, which is subsidised by the central government, and the bakery (*fino*) sector which is not. Intermediaries characterise each segment of this market with public agencies functioning in the *baladi* bread segment and private firms in the *fino* segment. In each segment, intermediaries have storage facilities. We conduct a range of simulations relating to potential reforms of government policy in the bread sector (e.g. using per unit consumer subsidies as an alternative to fixed consumer prices to ensure access to cheaper staples) as well as simulations which give a greater role to the private sector in the segment where the government agency currently functions (e.g. private intermediaries taking over the storage function of the parastatal). The main insight that comes out of these policy simulations is that in markets where storage is important in ameliorating volatility, the nature and functions of intermediaries also have a significant impact on the costs and effectiveness of those government policies which are aimed at promoting food security. In addition, the levels and profits from storage have an important influence on the distributional effects of these policy reforms. The headline contribution of the analysis is that, in line with recent research on market structure more generally, accounting for intermediaries in markets where commodity storage has a role is important in determining the costs and benefits of agricultural policies and the delivery of food security outcomes.

The paper is organised as follows. In Section 1, we tie our contribution with the relevant literature. In Section 2, we detail the theoretical framework that compares procurement, storage and distribution where the intermediary sector is characterised by either private profit maximising firms or a weighted-welfare maximising parastatal. We calibrate the model to the Egyptian wheat sector, the background to which is given in Section 3. Details of the calibration and the treatment of stochastic variables are provided in the Appendix. We explain in Section 3 how the theoretical model is amended to accommodate the specific features of the Egyptian wheat market as well as the policy instruments employed by the Egyptian government. We show in Section 4 how changes in market structure may affect the outcomes from potential policy reforms. In Section 5, we summarise and conclude.

1. **Related Literature**

The industrial organisation of agricultural and food markets in developing and emerging economies is complex and, in many countries, is undergoing significant change. These markets do not fit with the standard textbook model where intermediaries are absent or are assumed perfectly competitive. Specifically, high levels of market concentration characterise many sectors (see, McCorriston (2015) and Porto *et al*. (2011)). There is the increasing growth of agribusiness and the use of contracting as a means for small producers to access export markets (Swinnen *et al.,* (2015) and Macchiavello and Marjaria (2019)). There is an increasing presence of retail food chains (Reardon, 2015). On the supply side, there are large numbers of small producers co-existing with a small number of large commercial farms. De-regulation of parastatals and/or enhancing the role of the private sector has been on the reform agenda of many countries (Barrett and Matumbatsere, 2008). These issues give rise to a number of concerns regarding the distributional effects from trade reform, the impact of retail chains on consumers and the outcome of de-regulation on producer welfare. Research addressing the impact of the industrial organisation of food and agricultural markets in developing countries suggests an important research agenda (Barrett *et al.,* 2020).

From the extant literature, we have an indication why the intermediary market matters. Sexton *et al*. (2008) show that, in the context of a developing country exporter that is faced with both seller and buyer power in the agri-food value chain, the gains to farmers who have increased market access to developed country markets are considerably less from that increased market access than would be the case where stages of the value chain were competitive. Similar insights arise with respect to Porto *et al*.'s (2011) assessment of the gains from exporting across a number of sectors for selected African countries. If the downstream intermediary sector were competitive, the gains to farmers would be greater compared with the imperfectly competitive case. Atkin and Donaldson (2015) using food price data for Ethiopia and Nigeria show that the gains to consumers are determined by the presence of intermediaries. More broadly, Bergazo and Nymen (2015) provide a summary of the wider concerns associated with competition issues and poverty in developing countries.

Parastatals are also an important aspect of the structure of intermediary sectors. Less formal attention has been given to parastatals and the different forms in which they come. McCorriston and MacLaren (2007, 2016) show that the issue of parastatals is not confined to the potential monopoly/monopsony status, other issues matter too. These include the nature of the parastatal's pay-off function, the exclusive rights that apply to the parastatal's ability to function in certain segments of the market; the coexistence with the private sector; and the relative (in)efficiency of the parastatal compared with private firms. Moreover, government reforms have altered the structure of the intermediary market in many developing countries through de-regulation. For example, Ganesh-Kumar *et al.* (2010) highlight market reforms of parastatals in Asian countries and Jayne *et al.* (2006) highlight similar issues with respect to African countries; McCorriston and MacLaren (2016) show that de-regulation need not

improve food security; Cadot *et al*. (2015) assess the outcome of the disbandment of the vanilla state marketing board in Madagascar and report a positive outcome for producers; Dhingra and Tenreyro (2020) focus on the growth of agribusiness following the liberalisation of the state in Kenya and how those small producers who were tied with agribusiness experienced lower incomes compared with those who engaged with traditional traders.

Research addressing competition and alternative forms of intermediaries has been primarily addressed in a static environment, yet agricultural markets, both domestic and international, are characterised by volatility. Storage is also as characteristic of these markets though the issue of storage and market structure has been largely unexplored. Our focus in the framework we present below is on the incentive of alternative forms of intermediaries to store commodities in an importing country setting where the government employs additional policy instruments to promote food security. This motivation for storage is distinct from storage as part of buffer stock schemes to manage price bands or for strategic reserves[3]. Of the limited research on market structure and storage that does exist, a range of factors that matter in determining the links between competition and storage have been highlighted. These include whether monopoly power relates to storage only (Williams and Wright, 1991) and whether producers also have market power (see, Newbery (1984), McLaren (1999) and Thille (2006)). These alternative approaches give rise to some ambiguity on whether storage and price volatility is higher under monopoly or competitive markets. Thille (2006) also shows that the effects of storage on price volatility depend on the source of shocks in a specific market[4]. Common to research addressing the links between market structure and storage is the focus on closed economy settings (see, for example, Bieri and Schmitz (1974) for an early analysis of the effects of market structure on storage and price instability in a closed economy)[5]. In open economy contexts, fluctuations of world market prices are also a source of domestic price volatility that storage can help ameliorate (Gouel and Jean, 2014) though the issue of domestic market structure is not addressed.

2. Theoretical Framework

In this section, we set out the main features of an open economy commodity market that is characterised by intermediaries and storage. The intermediaries are taken to be either private firms that maximise profits or a parastatal that maximises a weighted social welfare function. The country is always less than self-sufficient. This assumption is made partly to reflect the reality in several developing countries and partly to simplify the analysis by preventing the country from switching

[3] Coverage of these issues can be found in Williams and Wright (1991).

[4]The industrial organisation literature focuses on the strategic use of inventories in determining interactions between limited numbers of firms (see, for example, Avram, (1984), Allaz (1991) and Rotemberg and Saloner (1989)) though these insights are less pertinent to the price volatility that is induced by the random harvests which typify many commodity markets.

[5] Newbery (1984) is an exception where storage relates to a setting where commodity exporters can exercise control in specific markets.

between importing and exporting or being at times fully self-sufficient. The cost of imports for consumption and storage depends on the exogenously given world market price. Intermediaries, therefore, cannot exercise buyer power in procurement from domestic production or imports, nor can they price discriminate across these sources of procurement. While world prices determine procurement costs, consumer prices also depend on the structure of the intermediary market. For example, if there was a single intermediary that maximised profit, it would have a monopoly mark-up and consumers would pay prices in excess of world market prices. On the other hand, if the intermediary had a bias towards consumers, then it would procure more and reduce the consumer price (though potentially still in excess of the world market price) compared with a profit-maximising intermediary.

The essential features of the model are developed in the following example which is intended to show that, in contrast with the extant literature on storage in an open economy, intermediaries may find it profitable to procure for storage. Let the private intermediaries be *n* identical Cournot firms. They are responsible for domestic procurement, for imports, for storage and for distribution to consumers. The domestically produced and imported commodities are homogeneous. This is one justification for using the Cournot assumption. Domestic production is stochastic, it is consumed but not stored, and it is undertaken by a large number of atomistic risk-neutral producers. There is a one-period lag between production decisions and realisations of production. Thus the market period inverse supply function is vertical at realised production.

The world price has a stationary probability distribution with given moments. Procurement by the intermediaries from both sources takes place at the world price. We assume for the moment that there are no storage losses. The inverse consumer demand function is stationary and deterministic. These assumptions allow us to focus on the implications of the structure of the intermediary sector on outcomes for consumption, storage and consumer prices, i.e. on food security. Of course, governments can also use other policy instruments to promote food security; we address this issue in Section 3.

Consumers

Consumers are risk-neutral with an inverse demand function given by:

$$p_t = \alpha - \gamma C_t \tag{1}$$

where at time *t*: p_t is the consumer price; C_t is the quantity consumed; $\alpha > max\ p_t^w > 0$ and $\gamma > 0$ are parameters; and $max\ p_t^w$ is the upper support for the probability distribution of the world price.[6]

Domestic Production

The representative *j*th risk-neutral, atomistic domestic producer of the commodity makes planning decisions at time *t*-1 for production which is realised at time *t*.[7] The quantities of production planned (h_{t-1}^j), and realised ($h_{t-1}^j(1+\varepsilon_t^j)$), are assumed to differ because of the effects of weather and the incidence of pests and diseases. These effects are represented by the term ε_t^j. It is assumed to be an i.i.d. stochastic term with mean zero and constant variance. In addition, it is defined on $-1 \leq \varepsilon_t^j \leq \bar{\varepsilon}$ where $\bar{\varepsilon}$ is such as to ensure that the country remains less than self-sufficient taking into account stock carry-in.

The producer's expected profit function is determined by discounted expected revenue and by the total costs of production:

$$E_{t-1}\pi_t^j = \beta E_t p_t^w\left(1+\varepsilon_t^j\right) - \phi(h_{t-1}^j)$$

where: E_{t-1} is the expectations operator conditional on the information available at time *t*-1; $\beta = 1/(1+\rho)$ is the discount factor when the interest rate is ρ; p_t^w is the procurement (i.e. import) price received by producers; and ϕ is the total cost function with all costs assumed to be incurred at *t*-1.

Maximisation of this function with respect to planned production, h_{t-1}^j, gives:

$$\beta E_{t-1} p_t^w\left(1+\varepsilon_t^j\right) = \phi'(h_{t-1}^j)$$

The producer sets the marginal cost of production equal to the discounted value of expected unit revenue. Aggregate planned production is then $h_{t-1}^j = \sum_j h_{t-1}^j$. Given the one-period production lag and the stationarity of the world price distribution, the market supply function is perfectly price inelastic at time *t*, and planned production, h_{t-1}, is the constant *h* for all *t*.

Private Intermediaries

The *i*th intermediary has the profit function:

$$\pi_t^i = (p_t - p_t^w)c_t^i + [\beta E_t p_{t+1} - p_t^w - K]s_t^i \qquad (2)$$

[6] The linear functional form will influence the pass-through of world market prices to consumers and the change in the mark-up in the intermediary sector. As long as the demand function is not too convex, there will be imperfect pass-through and mark-up adjustment due to the change in world market prices. As such, the linear functional form has the advantage of providing the basis for the insights on the interaction between distribution and storage but should be consistent with the impact on alternative sources of profits with other functional forms.

[7] If the producer were risk-averse, planned production would be smaller than if risk neutral but this would not change the basics of the model because the intermediaries would import more to satisfy consumption and stocks.

where: c_t^i is its sales to consumers comprising procurement from domestic production (h_t), imports (m_t) and stock carry-in (s_{t-1}^i), i.e. $c_t^i = h_t^i + m_t^i + s_{t-1}^i$; p_t^w is the exogenous world price which is the procurement price for both domestic production and imports; β is the discount factor; K is the unit cost of storage for one period; and s_t^i is stock carry-out. For a given level of consumption, with domestic production and stock carry-in both pre-determined, imports are the residual procurement required to satisfy optimal consumption.

Maximisation of equation (2) with respect to consumption (sales) gives:

$$c_t^{i*} = \frac{\alpha - p_t^w}{\gamma(n+1)} \tag{3}$$

and substitution of $nc_t^{i*} = C_t^*$ into equation (1) gives the corresponding consumer price:

$$p_t^* = \frac{\alpha + np_t^w}{(n+1)} \tag{4}$$

For a given n, both optimal sales and the consumer price are functions of the current world price only. The effect of n on optimal sales by the ith firm is found by totally differentiating the first-order condition, which gives $\frac{dc_t^{i*}}{dn} = -\frac{c_t^i}{(n+1)} < 0$. The effect of the number of firms on aggregate consumption is given by $\frac{dC_t^{i*}}{dn} = \frac{C_t}{(n+1)} > 0$. As we show below, an important implication of the latter result for storage is that as the consumer price decreases with increasing n, the profitability of storage is also reduced.

Maximisation of equation (2) with respect to stock carry-out gives:

$$s_t^{i*} = \begin{cases} \frac{1}{\gamma}[E_t p_{t+1} - (p_t^w + K)/\beta], & s_t^{i*} > 0 \\ 0, \text{otherwise} \end{cases} \tag{5}$$

Taking the expectation of equation (4) advanced by one time period, the firm's optimal carry-out can be re-written as:

$$s_t^{i*} = \begin{cases} \frac{1}{\gamma}\left[\frac{\alpha + nE_t p_{t+1}^w}{(n+1)} - \frac{p_t^w + K}{\beta}\right], & s_t^{i*} > 0 \\ 0, \text{otherwise} \end{cases} \tag{6}$$

The first term in the bracket is constant for a given n, while the second term varies according to the realised value of the world price. Thus optimal stock carry-out depends negatively on increases of n, of p_t^w, of K and on decreases of β. The maximum value of the import price at which stock carry-out will be positive can be obtained from rearranging equation (6): $p_t^w < \beta(\alpha + nE_t p_{t+1}^w)/(n+1) - K$. It is a decreasing function of the number of firms for given K and β. Stock carry-out, just as with consumption, is a function of the world price only, it is not dependent on consumption or on consumer

prices or on the realised world price at time t+1.[8] Optimal stock carry-out for the intermediaries in aggregate is $ns_t^{i*} = S_t^*$.

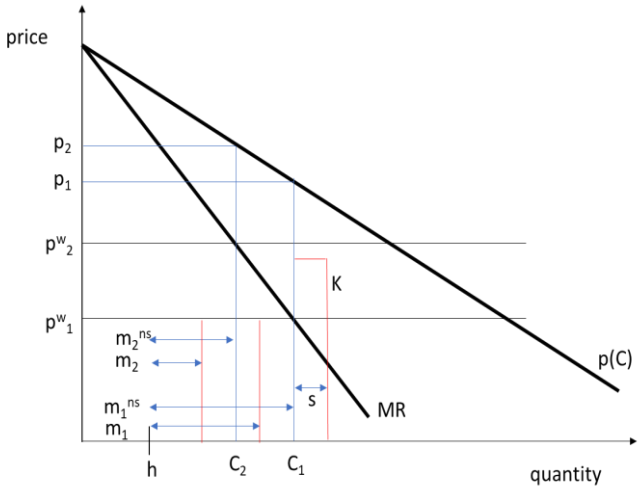
Totally differentiating the first-order condition for equation (6) gives the sign of the change in stock procurement by the ith firm as n increases. It is given by $\frac{ds_t^{i*}}{dn} = \frac{-(\alpha - E_t p_{t+1}^W)}{\gamma(n+1)^2} < 0$, and the change in aggregate procurement is: $\frac{dS_t^*}{dn} = \frac{1}{\gamma}\left[\frac{\alpha + (2n+n^2)E_t p_{t+1}^W}{\gamma(n+1)^2} - \frac{p_t^W + K}{\beta}\right]$, the sign of which is ambiguous.

A summary of the model is shown in Figure 1 for n = 1 in which the world price takes one of two values with equal probability. Positive storage has two implications: first, it provides an additional source of profits in addition to those derived from sales to consumers; and second, it displaces an equal quantity of imports, thereby reducing the cost of procuring imports when the world price is p_2^W.

Suppose at time t, there is no stock carry-in from time t-1 because $p_{t-1}^W + K > \beta E_{t-1} p_t$ (from equation (5)). Then, if the world price is p_2^W, consumption is $C_2 = h + m_2^{ns}$, the consumer price is p_2 and profit is $\pi_2^{ns} = p_2 C_2 - p_2^W(h + m_2^{ns})$. If the world price is p_1^W, consumption is $C_1 = h + m_1^{ns}$ at the consumer price of p_1 and profit is $\pi_1^{ns} = p_1 C_1 - p_1^W(h + m_1^{ns})$. Then expected profit at time t is $\pi^{ns} = 0.5(\pi_1^{ns} + \pi_2^{ns})$. On the other hand, suppose there is stock carry-in from time t-1. The cost of procurement for this stock was incurred at time t-1. If the world price is p_2^W, then consumption is $C_2 = h + m_2 + s$, the consumer price is p_2, there is no carry-out stock, and profit is $\pi_2 = p_2 C_2 - p_2^W(h + m_2)$. If the world price is p_1^W, then consumption is $C_1 = h + m_1 + s$, the consumer price is p_1, there will be stock carry-out of s at a cost of $(p_t^W + K)s$, and profit of $\pi_1 = p_1 C_1 - p_1^W(h + m_1) - (p_1^W + K)s$. Expected profit is then $\pi = 0.5(\pi_1 + \pi_2)$. To determine whether storage is profitable, take the difference between the two expected profits. Noting that $m_j^{ns} = m_j + s,$ for $j = 1, 2,$ then $(\pi - \pi^{ns}) = 0.5(p_2^W - K)s > 0$. Therefore, if the difference between the higher of the two import prices and the carrying cost of storage is positive, then storage for the private intermediary is profitable.

[8] This characteristic of the model differentiates it from many storage models, e.g. those involving a large country in which the world price is endogenous, and those models specified in a closed economy. In both cases, backward induction is used to determine the solution. Such a solution procedure is not required in the framework here because optimal stock carry-out depends only on the static mean of the world price distribution.

Figure 1: Storage and Imports with Varying World Prices



Parastatal

Consider now the alternative market structure, one in which there is a risk-neutral parastatal in place of private intermediaries. For the moment, we assume that the parastatal has the same cost structure as the private intermediaries, an assumption that is relaxed in section 3. Following McCorriston and MacLaren (2007, 2016), we specify the parastatal's payoff function as a politically-weighted social welfare function which reflects the bias of government policy towards consumers only:[9]

$$W_t = \omega CS_t + (1-\omega)\pi_t \tag{2'}$$

where at time t: CS_t is consumer surplus, conventionally defined; π_t is profit as defined in equation (2), except that the i superscript is no longer relevant; and ω is the political weight chosen by government that is attached to consumer surplus, with $0 \leq \omega \leq \bar{\omega}$. The restriction on the upper value of the policy weight is to ensure that the parastatal continues to put some weight on profit. At the same time, if food security is an objective, then having some consumer bias will ensure that greater consumption at more affordable prices is achieved compared with the situation in which $\omega = 0$.

The parastatal maximises its payoff function with respect to sales to consumers and to stock carry-out. The maximisation of equation (2') with respect to C_t gives:

$$C_t^* = \frac{(1-\omega)(\alpha - p_t^W)}{\gamma(2-3\omega)}, \text{for } 0 \leq \omega < 2/3 \tag{3'}$$

and substitution into equation (1) gives the corresponding equilibrium price:

$$p_t^* = \frac{(1-2\omega)\alpha + (1-\omega)p_t^W}{(2-3\omega)} \tag{4'}$$

[9] The parastatal cannot affect producer surplus unless it were to choose a procurement price that is different from the world price.

Thus optimal consumption and price depend on the world price and on the size of the bias towards consumers. If $\omega = 0$ and n=1, then equations (3) and (3') would be identical as would equations (4) and (4'). In other words, a private monopoly and a parastatal with no consumer bias represent identical market structures in terms of outcomes.

Optimal consumption needs to be positively related to this weight if the parastatal's objective of enhanced food security is to be achieved, given that it cannot affect domestic production. Totally differentiating the first-order condition gives $\frac{dC_t^*}{d\omega} = \frac{\alpha - p_t^W}{\gamma(2-3\omega)^2} > 0$. A consumer-biased parastatal will indeed create greater food security than a monopoly but, in the absence of simulation, we do not know whether an n-firm oligopoly will generate even greater consumption than that of a consumer-biased parastatal. We explore this issue below.

Storage is obtained by maximising equation (2') with respect to S_t. The result is:

$$S_t^* = \begin{cases} \frac{1}{\gamma}\left[\frac{(1-2\omega)\alpha + (1-\omega)E_t p_{t+1}^W}{(2-3\omega)} - \frac{p_t^W + K}{\beta}\right], & S_t^* > 0 \\ 0, \text{ otherwise} \end{cases} \qquad (6')$$

Again, with $\omega = 0$ and n=1, storage will be the same with the parastatal and a private sector monopoly. To investigate the relationship between optimal storage and the consumer bias, totally differentiate the first-order condition to get: $\frac{dS_t^*}{d\omega} = \frac{-(\alpha - E_t p_{t+1}^W)}{\gamma(2-3\omega)^2} < 0$. Thus, the greater the bias towards consumers, the lower is the level of storage. The intuition is that, by increasing consumption through having a positive consumer bias and thereby decreasing the consumer price, there is a reduced likelihood of making a profit from storage.

Comparisons between Private Firm and Parastatal Intermediaries

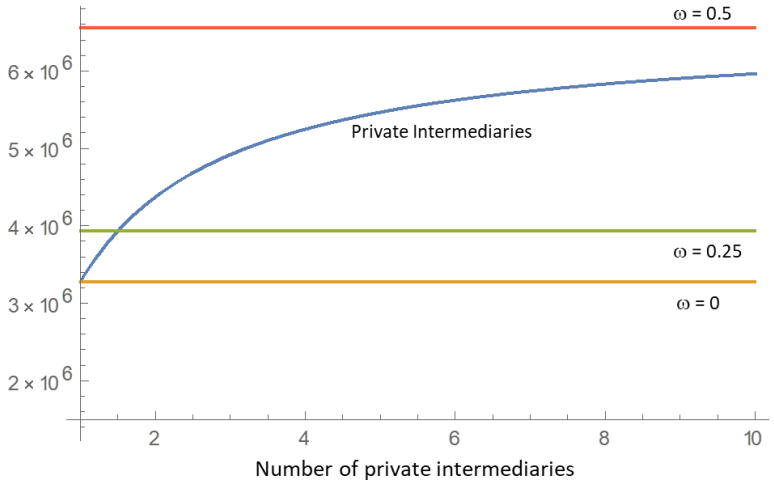
We have now derived expressions for optimal consumption and storage under different market structures. The key variable that affects these structures is n for private firms and ω for the parastatal. This difference makes a direct comparison between the two market structures less than straightforward. Rather than choose a small set of specific values for these two key variables, we use instead a calibrated example to explore the relationships in greater detail. In the Appendix, we describe a dataset and calibrated parameters that were constructed using data from the Egyptian wheat market. Making use of the parameters which were calibrated to the *fino* (bakery products) data, we calculate values for consumption, consumer prices, storage and profits.

There is some critical value of the procurement price as a function of the number of intermediaries at which storage becomes zero. This value can be found from equation (6) for the private firms by setting S_t to zero and solving for the procurement price, i.e. critical $p_t^W = \beta(\alpha + nE_t p_{t+1}^W)/(n+1) - K$.

For n = 1 the critical world price is EGP3,036 and for n = 10 it is EGP2,611. A lower procurement price of EGP2,500 was chosen. This price satisfies the critical value for storage to be positive. The higher value of the procurement price was set at EGP3,500 which makes storage unprofitable. For the parastatal (from equation (6')) the critical value is EGP3,102 if ω = 0 and is EGP2,650 if ω = 0.5. Thus the parastatal will procure for storage at the lower price but not at the higher.

The effects of market structure on consumption (see equations (3) and (3')) are shown in Figure 2 with the procurement price set at its mean value. The results from the comparative statics given earlier are borne out: optimal consumption increases with the number of private intermediaries (consistent with the Cournot assumption) and with the size of the policy weight. Given the values of the calibrated parameters and the value of the procurement price chosen, private intermediaries with n of at least 2 will permit greater levels of consumption than a parastatal with policy weights of 0 and 0.25. On the other hand, if the consumer bias is 0.5, then the parastatal will procure more than the private intermediaries. Therefore, the choice of market structure in the context of food security depends either on the extent of competition amongst private intermediaries or on the size of the consumer bias if there is a parastatal[10].

Figure 2: Optimal Consumption with Private Intermediaries and a Parastatal (mmt)

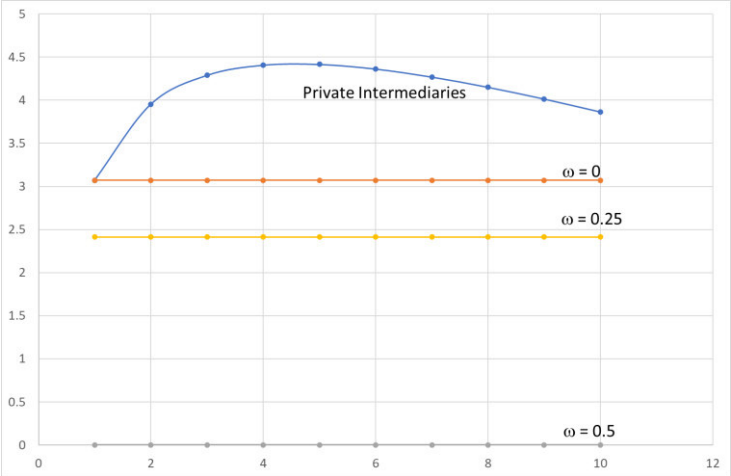


Storage was calculated from equations (6) and (6') using the lower of the two procurement prices; there is no storage at the higher price. The effects of market structure on storage are shown in Figure 3. For the private intermediaries storage increases until n =5 and then it declines thereafter. This is consistent with the ambiguous sign of the change in storage with n shown earlier. For the parastatal, however, as the consumer bias increases, the level of stock holding decreases. This outcome is also

[10] Equivalently, consumer prices decrease as the intermediary market becomes more competitive and with an increase in the consumer bias of the parastatal. Using the data as above, with a consumer bias equal to 0.5, the consumer price is lower compared with a private intermediary market with n=10.

consistent with the change in storage with respect to the consumer bias shown earlier. As n or as ω increases, the consumer price falls and with it the size of the mark-up, thereby making storage less profitable (see equations (6) and (6').

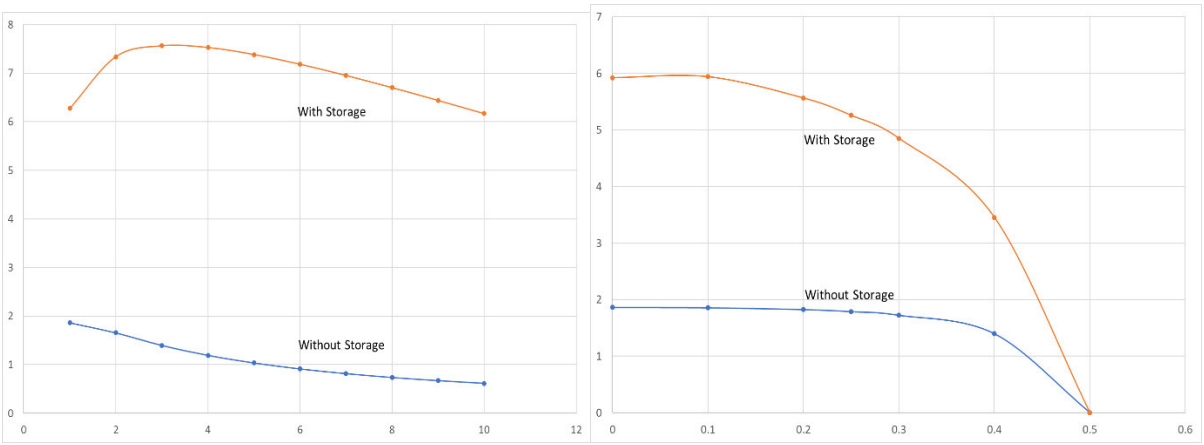
Figure 3: Optimal Storage with Private Intermediaries and a Parastatal (mmt)



Finally, we have noted that the incentive to store potentially offsets for profits the negative consequences of higher import prices. Profits with and without storage are shown as a function of the number of private intermediaries (Figure 4a) and as a function of the policy weight (Figure 4b). For each of the market structures, profits were calculated at each of the two values of the procurement price and then averaged. From Figure 4a, it can be concluded that profits initially increase until $n = 3$, but then decline thereafter as the number of private intermediaries increases further. Average profits with storage exceed profits when there is no storage thus being consistent with the algebra given prior to Figure 1. From Figure 4b, storage makes a decreasing contribution to profits as the consumer bias increases.

Figure 4: Profits with and Without Storage (EGP)

Figure 4a: Private Intermediaries **Figure 4b: Parastatal**



Summary

The headline insight from the analysis in this Section is that the structure of the intermediary market plays an important role in determining consumption, storage, food security, profits and by implication, social welfare. The choice of that structure is determined by government policy through either competition policy in the case of private firms, or in its choice of the policy weight in the case of the parastatal.

3. Applying the Theoretical Framework: The Egyptian Wheat Market

We use the Egyptian wheat market as a case study to illustrate the insights from the theoretical model. In doing so, we extend the framework to take account of policy instruments that the Egyptian government employs and to consider the potential effects of reforms that have been proposed recently in FAO (2015). The application is not intended as a comprehensive assessment of the interaction between market structure and government policies in the Egyptian wheat market but only as an illustrative case-study highlighting the interaction between different types of intermediaries, government policies and storage.

The Egyptian wheat sector is characterised by both parastatal and private intermediaries, albeit functioning in different segments of the wheat supply chain. Rich detail is provided in a recent report (FAO, 2015) on the structure of this supply chain and on government policies in it. In particular, data are provided on storage costs for the parastatal and the private intermediaries. To analyse the effects of specific government policies, we require some amendments to the theoretical framework which we detail below.

Background

The Egyptian wheat sector comprises two segments: one which produces *baladi* bread and is focused on guaranteeing access to subsidised bread through government intermediaries; the other is the *fino* bread sector comprising private intermediaries which mill higher quality wheat for bakery products, including bread. Egypt also relies on imports from the world market. The use of storage is an important feature of the supply chains with government agencies and private firms owning storage facilities in their respective segments. This segmented market allows us to consider policy issues where one segment is characterised by a state intermediary and the other by private firms. It also allows us to evaluate government policy options in the presence of intermediaries and storage, and to investigate alternative scenarios relating to changes in market structure.

Wheat is the most important grain crop in Egypt. It accounts for approximately 10 per cent of the value of agricultural output and 20 per cent of the value of imports (FAO, 2015). The government employs various policy instruments to promote food security. These are targeted at both consumers of

bread and producers of wheat. With more than one quarter of the Egyptian population below the poverty line, a food subsidy programme provides access to low-priced bread at a fixed maximum price. The final product, *baladi* bread (a form of flat bread), is available at 5 *piastres* per loaf (equivalent to 458 EGP/tonne of wheat[11]) which compares with a free market price of 36 *piastres* per loaf [12]. Reform of the *baladi* bread system remains a government priority because of its budgetary cost. Direct price intervention is also targeted at wheat producers for whom the government supports the procurement price. This price has been well in excess of import prices (on average by 32 per cent between 2008 and 2017) adding considerably to the budgetary cost of government policies in the wheat sector[13].

However, the role of government extends beyond these policy instruments. Through state agencies, the government is entirely responsible for the procurement of domestically produced wheat and is partially responsible for the procurement of wheat imports. These agencies include: the General Authority of Supply Commodities (GASC), which is responsible for around 40 per cent of total wheat imports; the Principal Bank of Development and Agricultural Credit (PBDAC); and the Egyptian Holding Company for Silos and Storage (EHCSS). In what follows, we treat all these parastatals as a single entity. The state also controls almost all inland storage, most notably the flat storage system in jute bags known as *shona*. It is known that this form of storage is wasteful, and thus costly, because it is prone to inefficiencies in handling and to physical losses caused by pests, disease and weather (FAO, 2015). On the other hand, private firms use silos for storage.

Private sector involvement in the Egyptian wheat-bread supply chain relates mainly to the supply of *fino* bakery products. *Fino* products involve finer extraction of wheat to flour compared with the *baladi* system (72 per cent for *fino* compared with 82 per cent for *baladi* bread). Private firms import from world markets and are involved in storage, milling and distribution of *fino* products where greater efficiency and the lower costs of storage, milling and distribution are reflected in higher margins. This segmented market structure is the basis for an application of the framework of Section 2. We consider two reforms. The first relates to subsidised *baladi* bread and the second to a change to market structure. Our principal focus is on how the interaction of intermediaries and the existence of storage help to determine the costs of government policies and the provision of food security.

[11] See the Appendix for details of the calculation of this equivalence.
[12] The food subsidy programme has become increasingly expensive with 80 per cent of the Egyptian population having ration cards that permit them access to subsidised bread.
[13] The costs associated with subsidised bread and high procurement prices (and fertiliser subsidies) amounts to 1 per cent of Egyptian GDP (FAO, 2015).

Amendments to the Theoretical Framework

To accommodate price policy instruments, we amend the basic theoretical model of Section 2. In all other respects, the basic set-up remains the same with regard to domestic production, to exogenous world prices, and to the pay-off functions for private intermediaries and the parastatal.

As noted above, the wheat value chain is segmented between *baladi* bread and *fino* products. We highlight this distinction by superscripts b and F respectively. In addition, the storage costs of the parastatal and the private intermediaries are different because of the different types of storage facility that each employs. In place of K (see Section 2), we let K^b be the one-period storage cost of one tonne of wheat for the parastatal and K^F for the private intermediaries, with $K^b < K^F$. The difference in the type of storage facility is also reflected in storage losses as a proportion of stock carry-out. In Section 2, we ignored these losses altogether but here we account for them in λ^b and λ^F with $\lambda^b > \lambda^F$. The third amendment is the incorporation of the inefficiency of the parastatal in procuring imports and we do this by introducing ι as the additional cost per tonne imported.

Current Instruments: Fixed Consumer and Producer Prices

Current policy instruments in the wheat sector involve a fixed and (implicitly) subsidised *baladi* bread price for poorer consumers and a fixed procurement price in excess of world market prices for domestic wheat producers. The parastatal is the sole procurer from domestic wheat producers. Procurement in excess of domestic production for distribution and storage is from imports. Private intermediaries are involved only in the *fino* segment and they source wheat for distribution and storage solely from imports. The data for the Egyptian wheat market given in the Appendix reflect these instruments and market structure, and they provide the base from which we measure the effects of changes in the policy instruments and market structure.

Alternative Instruments: Fixed Consumer and Producer per Unit Subsidies

In the case of fixed consumer and producer prices, the costs of the (implicit) consumer subsidies are determined by world prices and the corresponding level of consumption. In the case of producer subsidies, the costs are determined by world prices and by realised domestic production. Therefore the government has little control over the budgetary costs. As an alternative means of limiting these costs, the level of explicit unit subsidies could be fixed. These instruments are still targeted towards the objectives of food security and livelihood security although, by not fixing prices, a degree of variance in prices for consumers and unit returns to producers is introduced. By assuming that consumers and producers are risk neutral, the induced variability in prices will not be of concern, although changes in the mean level of prices will be. This change of instruments affects the level of imports needed to meet variable consumption levels and storage. The consumer and producer unit subsidies enter into

the parastatal's pay-off function. Since these instruments apply only in the *baladi* segment, the characterisation of the intermediaries in the *fino* segment remains unchanged.

Inclusive of the per unit consumer and producer subsidies, the parastatal's profit from sales to consumers is now given by:

$$\pi_t^b = \left[p_t^b + s_c - p_t^w - s_p\right]h_t + \left[p_t^b + s_c - p_t^w - \iota\right]m_t^b + [p_t^b + s_c](1-\lambda^b)S_{t-1}^b \quad (7)$$

where: s_c is the unit consumer subsidy, and s_p the unit production subsidy. The parastatal's complete objective function remains that given in equation (2'). Substituting equation (7) into equation (2') and differentiating gives the optimal level of consumption:

$$C_t^{b*} = \frac{(1-\omega)(\alpha^b + s_c - p_t^w - \iota)}{\gamma^b(2-3\omega)} \quad (8)$$

the corresponding consumer price being given by:

$$p_t^{b*} = \frac{\alpha^b(1-2\omega) + (1-\omega)(-s_c + p_t^w + \iota)}{(2-3\omega)} \quad (9)$$

Using equations (2') and (9), the corresponding decision to store is given by:

$$S_t^{b*} = \begin{cases} \frac{1}{\gamma^b(1-\lambda^b)}\left[\frac{(1-2\omega)(\alpha^b + s_c) + (1-\omega)E_t p_{t+1}^w}{(2-3\omega)} - \frac{(p_t^w + K + \iota)}{\beta}\right], S_t^{b*} > 0 \\ 0, \text{otherwise} \end{cases} \quad (10)$$

The per unit subsidy provides an incentive to store through increasing the realised unit return and it offsets the negative bias towards storage in the pay-off function given by ω (see Figure 4b). Note that the per unit producer subsidy does not affect the storage decision. However, it does affect the parastatal's profits and the budgetary costs of the programme. We therefore include it in the assessment that follows in Section 4.

In the *fino* segment, there are *n* private intermediaries. Procurement for consumption and storage in this segment comes from imports only as given by $C_t^F = m_t^F + (1-\lambda^F)S_{t-1}^F$. The inverse demand function for *fino* bread is given by:

$$p_t^F = \alpha^F - \gamma^F(m_t^F + (1-\lambda^F)S_{t-1}^F) \quad (11)$$

The expressions for aggregate consumption, price and aggregate storage corresponding to (3), (4) and (6) are given by:

$$C_t^{F*} = \frac{n(\alpha^F - p_t^w)}{\gamma^F(n+1)} \quad (12)$$

$$p_t^{F*} = \frac{\alpha^F + np_t^W}{(n+1)} \tag{13}$$

$$S_t^{F*} = \begin{cases} \frac{n}{\gamma^F(1-\lambda^F)}\left[\frac{[\alpha^F + nE_t p_{t+1}^W]}{(n+1)} - \frac{[p_t^W + K]}{\beta}\right], \; S_t^{F*} > 0 \\ 0, \text{otherwise} \end{cases} \tag{14}$$

Private Intermediaries in the Parastatal Sector

In the FAO review of the Egyptian wheat sector (FAO, 2015), there was a proposal to allow private intermediaries engaged in the *fino* segment to supply wheat to the parastatal in the *baladi* segment. Specifically, the parastatal would continue to absorb all domestic production but wheat in excess of this quantity that is required for consumption (denoted by G_t) would come from the private intermediaries rather than from imports. This change would reduce the cost of imports by ι per tonne. In contrast to the previous case, the parastatal does not hold stocks either, thereby decreasing overall losses in storage. We assume that the private intermediaries would only have the incentive to supply the parastatal if they received the same price as they would obtain by selling to consumers of *fino* products. We also assume that the per unit consumer and producer subsidies still apply.

The inverse demand function facing the parastatal in the *baladi* segment is now given by:

$$p_t^b = \alpha^b - \gamma^b(h_t + G_t) = \alpha^b - \gamma^b C_t^b \tag{15}$$

with profits from sales, inclusive of the cost of procurement from private intermediaries, given by:

$$\pi_t^b = \left[p_t^b + s_c - p_t^w - s_p\right]h_t + [p_t^b + s_c - p_t^F]G_t \tag{16}$$

Substitution of equation (16) into equation (2'), making use of equation (20) (see below), and differentiating the result with respect to G_t, gives:

$$(1-\omega)(\alpha^b + s_c) - \gamma^b(2-3\omega)h_t - \left[\gamma^b(2-3\omega) + \frac{(1-\omega)\gamma^F}{n+1}\right]G_t - (1-\omega)p_t^F = 0 \tag{17}$$

Letting $\gamma^b(2-3\omega)h_t \equiv \theta_{2,t}$ and $\left[\gamma^b(2-3\omega) + \frac{(1-\omega)\gamma^F}{n+1}\right] \equiv \theta_1$, equation (17) can be rewritten as:

$$\theta_1 G_t + (1-\omega)p_t^F = (1-\omega)\left(\alpha^b + s_c\right) - \theta_{2,t}.$$

The *fino* market remains segmented so the inverse demand function remains as in (11) but profits for intermediaries will now also include sales to the parastatal. The profit function for a representative private intermediary is given by:

$$\pi_t^{Fi} = (p_t^F - p_t^w)m_t^{Fi} + (p_t^F - p_t^w)g_t^i + p_t^F(1-\lambda^F)s_{t-1}^{Fi} + (\beta E_t p_{t+1} - p_t^w - K)s_t^{Fi} \tag{18}$$

where g_t^i are sales by the *i*th intermediary to the parastatal. Maximising equation (18) with respect to c_t^{Fi} and aggregating over the number of private intermediaries gives aggregate consumption and the associated price as:

$$C_t^{F*} = \frac{n(\alpha^F - \gamma^F n g_t^i - p_t^w)}{\gamma^F(n+1)} \tag{19}$$

$$p_t^{F*} = \frac{\alpha^F + \gamma^F n g_t^i + n p_t^w}{(n+1)} \tag{20}$$

Equations (17) and (20) include the two unknowns, G_t and p_t^F. Rewrite equation (20) as $(n+1)p_t^F - \gamma^F G_t = \alpha^F + np_t^w$. Then in matrix form the two equations are:

$$\begin{pmatrix} \theta_1 & (1-\omega) \\ -\gamma^F & (n+1) \end{pmatrix} \begin{pmatrix} G_t \\ p_t^F \end{pmatrix} = \begin{pmatrix} (1-\omega)(\alpha^b + s_c) - \theta_{2,t} \\ \alpha^F + np_t^w \end{pmatrix} \tag{21}$$

with the solution:

$$\begin{pmatrix} G_t \\ p_t^F \end{pmatrix} = \frac{1}{\gamma^F(1-\omega)+\theta_1(n+1)} \begin{pmatrix} (n+1)[(1-\omega)(\alpha^b + s_c) - \theta_{2,t}] - (1-\omega)(\alpha^F + np_t^w) \\ \gamma^F[(1-\omega)(\alpha^b + s_c) - \theta_{2,t}] + \theta_1(\alpha^F + np_t^w) \end{pmatrix} \tag{22}$$

The key insight from this changing role of private intermediaries is that, even although the consumers of *baladi* bread and *fino* products are segmented, the *fino* price depends nevertheless on the bias in the parastatal's pay-off function, and sales in the *baladi* segment depend on the *fino* price. In addition, with the private intermediaries solely responsible for storage, their storage decision is also influenced by the weight in the parastatal's pay-off function.

To see this, consider the intermediaries' storage decision which is given by equation (14). It can be rearranged and re-expressed for the *i*th intermediary to get:

$$s_t^{Fi} = \begin{cases} \dfrac{\beta E_t p_{t+1} - p_t^w - K^F}{\gamma^F(1-\lambda^F)}, s_t^{Fi} > 0 \\ 0, otherwise \end{cases}$$

Take the second equation in (22), advance time by one period and take expectations with respect to time *t* to obtain:

$$E_t p_{t+1}^F = D^{-1}\{\gamma^F\left[(1-\omega)\left(\alpha^b + s_c\right) - E_t\theta_{2,t+1}\right] + \theta_1(\alpha^F + nE_t p_{t+1}^w)\} \tag{23}$$

where $D = \theta_1(n+1) + \gamma^F(1-\omega)$, and θ_1 and $\theta_{2,t}$ are given as above. Define $E_t\theta_{3,t+1} \equiv \{\gamma^F\left[(1-\omega)\left(\alpha^b + s_c\right) - E_t\theta_{2,t+1}\right] + \theta_1(\alpha^F + nE_t p_{t+1}^w)\}$. Then the storage decision for a private intermediary is given by:

$$s_t^{Fi*} = \begin{cases} \frac{1}{\gamma^F(1-\lambda^F)}\left[\beta D^{-1}E_t\theta_{3,t+1} - p_t^w - K^F\right], s_t^{Fi*} > 0 \\ 0, \text{otherwise} \end{cases} \tag{24}$$

with aggregate stocks given by $S_t^{F*} = ns_t^{Fi*}$. Given the definitions of θ_1, $\theta_{2,t}$ and $\theta_{3,t+1}$, the higher weight the parastatal places on consumer welfare and the higher per unit subsidies on *baladi* bread, the higher the level of storage. This conclusion is substantiated by the results given in Table 2.

Summary

In this section, we have drawn on the theoretical framework of Section 2 to analyse the specifics of the role of private intermediaries and a parastatal in an application where intermediaries of both types co-exist and where the government uses additional policy instruments to promote food security objectives. We now have a basis for providing an assessment of these applications to proposed policy reforms in the presence of intermediaries.

4. Data, Calibration and Results

Data and Calibration

The FAO report provides details about the levels of procurement by the parastatal and private firms from domestic farmers and imports, on storage capacity in each sector including data on costs, and information on the level of *baladi* subsidies and domestic procurement prices. We complement these data with data on domestic production, consumption, world and domestic prices from AMIS (2020). Details on demand and supply elasticities used in the calibration of the parameters and the treatment of the stochastic variables are provided in the Appendix.

Results: Changes in Policy Instruments

We report in Table 1 the outcomes of one potential reform to the current policy of fixed consumer and producer prices. We replace these instruments with per unit consumer and producer subsidies. The benchmark pre-reform simulated values are reported in the first column[14]. In terms of gauging the impact of the change to a per unit consumer subsidy, as noted in Section 3, the outcome will depend on the consumer bias in the parastatal's pay-off function. We therefore report three alternatives: one where the parastatal is equivalent to a profit maximising monopoly (i.e. $\omega = 0$) and two cases where there are different levels of bias towards consumers (i.e. $\omega = 0.25$ and $\omega = 0.5$).

Reading across the three columns relating to the policy weight, the values show clearly the significance of the parastatal's pay-off function in determining the outcomes of the consumer subsidy. In terms of the level of consumption and consumer prices, the results are in line with expectations (see Section 2): the greater the consumer bias, the higher the levels of consumption and the lower the consumer price. Similarly, the consequence is that the incentive to store decreases as is evident by the

[14] Note that we do not consider changes to the fixed price for *baladi* bread because the storage rule cannot determine the level of stocks with fixed consumer prices.

changes in the levels of storage as the consumer bias increases with the level of stocks when ω=0.5 being 11 per cent of the level estimated when ω=0.

The parastatal's profits, although higher than in the fixed-price consumer policy, decrease as the consumer bias rises. With ω=0**,** profits from storage accounts for around 58 per cent of the parastatal's profits; when ω=0.25, storage profits account for 48 per cent of parastatal profits. Note that the share in overall profits is largely determined by the combination of the decline in the consumer price as the pro-consumer bias increases and size of the fixed per unit consumer subsidy. In terms of other changes arising from the change in the policy instruments, imports increase by around 44 per cent over the range of values of the policy weight. Importantly, the cost of the consumer subsidy policy increases significantly with increases in the pro-consumer bias because of the increase in consumption.

However, the level of storage will also depend on the level of the consumer subsidy (see equation (24)). If the government were concerned about the budgetary cost of the consumer subsidy programme, it could choose to reduce the unit subsidy while having to accept the consequent reduction in food security as measured by consumption. The effect of reducing the unit subsidy from its value in the data (EGP2440) to EGP1500 is shown in the final column in Table 1. As would be expected, a reduction in the unit subsidy, at the same value of the policy weight (0.25), will increase the consumer price and decrease consumption. Despite this increase in price, stock carry-out decreases and with it the parastatal's profits while profits from storage now accounts for around 45 per cent of parastatal's profits. The most significant effect of the reduced unit subsidy is on the budgetary cost of the consumer subsidy policy, which falls to two-fifths of its previous level. Thus a decrease of two-fifths in consumption is associated with the budgetary savings of three-fifths.

The overall headline to take away from Table 1 is not *per se* the accuracy of specific metrics but rather that the interaction of instrument choice and the parastatal's pay-off function generate substantial differences in outcomes for the variables shown. There are two reinforcing effects. First, as the bias in the parastatal's pay-off function tends towards consumers, the incentive to store declines. Second, lower (higher) levels of the per unit consumer subsidy discourage (encourage) storage. Taken together, the scenarios presented above highlight the role that profits from storage can play in determining the overall outcomes from policy reforms that interact with the characterisation of the objectives of the parastatal.

Table 1: Outcomes from the Use of Alternative Policy Reforms (Mean Values)

		Fixed per Unit Consumer and Producer Subsidies			
		Producer Subsidy: EGP655.5/tonne			
		Consumer Subsidy			
		EGP2440/tonne			EGP1500/tonne
Variable	***Simulated Pre-Reform Levels***	**ω=0**	**ω=0.25**	**ω=0.5**	**ω=0.25**
Consumption (mmt)	7.31	5.614	6.751	11.240	4.162
Production (mmt)	3.11	3.058	3.058	3.058	3.059
Imports (mmt)	4.33	5.709	5.438	8.295	3.252
Stocks (mmt)	2.355[1]	4.993	3.814	0.559	2.321
Consumer Price (EGP/tonne)	458	870	622	107	1,186
Procurement Price (EGP/tonne)	2,800	2,587	2,580	2,583	2,582
Parastatal's Profits (m.EGP)	-2,095	7,783	6,272	4,998	2,297
Profits from Storage (m.EGP)	-	4,543	2,994	411	1,396
Budgetary Cost of Consumer Subsidy (m.EGP)	11,577	13,701	16,476	27,431	6,243
Budgetary Cost of Producer Subsidy (m.EGP)	2,327	2,004	2,004	2,004	2,005

[1] As noted above, with fixed consumer prices, the storage rule does not apply. The pre-reform level of stocks is therefore taken from the share of storage capacity accounted for by the parastatal which is estimated at 53.76 per cent (FAO, 2015). On average, total storage capacity over the 2008/09 and 2017/18 period is 4.38mmt which gives parastatal stocks as (0.5376*4.388) 2.355mmt.

Results: Changes in Market Structure

As noted above, the case we explore here is one in which the parastatal continues to purchase all domestic production, but it no longer holds stocks nor imports, and instead it procures wheat from private firms which source exclusively from world markets to make up the difference between optimal consumption and realised domestic production.

The effects on a range of metrics are reported in Table 2. The evaluation of these effects depends jointly on how competitive the *fino* sector is and the bias in the parastatal's pay-off function. We consider three permutations for each characterisation of the private firms and the parastatal. These allow for alternative characterisations of the extent of competition in the private intermediary sector and the pro-consumer bias in the parastatal's pay-off function. In addition to the changes brought about by these characterisations, there is also the impact on storage that is brought about by the private firms being relatively more efficient than the parastatal (in the sense of having smaller storage losses) which consequently increases profits from storage. In terms of explicit policy instruments targeted at food security, we assume the fixed per unit subsidies are at the initial values in Table 1. As the results in Table 2 show, reforming market structure generates a wider range of effects compared with the previous reform scenarios reported in Table 1.

Consider, first of all, the case where n=5. As the consumer bias increases, consumption rises and the consumer price falls. With the parastatal no longer storing nor importing, the private firms correspondingly increase the levels of storage and imports because they are supplying the *baladi* bread segment as well as consumers of *fino* bread. This change in the procurement pattern results in positive profits for the parastatal despite it having to pay *fino* consumer prices for part of its procurement, albeit offset by the unit consumer subsidy. In addition, it no longer experiences storage losses nor is it procuring imports at a price which includes the costs of its inefficiency (ι). Unless the parastatal is equivalent to a private monopoly resulting in high prices for *baladi* bread, the change in the procurement pattern increases the budgetary cost of providing consumer subsidies by around 17 per cent (when ω=0.25) and 80 per cent (when ω=0.5) , due to the *fino* prices that the parastatal has to pay for procurement to the private firms. It can be concluded that a combination of a change in policy instruments together with the change in market structure does not achieve the objective of reducing expenditure on the consumer subsidy. However, this combination does reduce the fiscal cost of the consumer subsidy when compared with the change in policy instrument alone (compare the corresponding entries in Tables 1 and 2).

Profits for the private intermediaries are higher than in the benchmark and they are increasing as the consumer bias increases, largely due to the increasing levels of consumption in the *baladi* bread sector and the assumption that the private firms are paid their consumer price by the parastatal. However, and consistent with the theoretical framework, these outcomes turn out to be sensitive to the characterisation of the parastatal's pay-off function and the extent of competition in the *fino* sector. In comparing the results for n=5 with those of n=20 across the values of the consumer bias, it is noticeable that the effects of the policy weights are dampened in the more competitive case. This dampening affects each of the variables but especially the private firms' profits.

Note specifically the effects on storage in this reform scenario: as the bias in the parastatal's pay-off function rises, the level of storage increases even although consumption in the *fino* sector decreases. This is contrary to the outcomes reported in Table 1 where storage fell as the consumer bias rose. Profits from storage as a share of total profits vary with the parastatal's pay-off function. In the scenario with n=5, with ω=0**,** storage profits account for 35 per cent of private firms' profits; with ω=0.5, this share declines to around 30 per cent. Overall, the effects on storage in policy reforms therefore depend on a number of factors including market structure.

Summary

The central takeaway from this section is that the theoretical framework which we set out in Sections 2 and 3 can be used to analyse the consequences of policy reforms in a stochastic, open economy, small-country environment where the role of storage is accommodated. In the context of the policy reforms, we have shown that the pay-off function of the parastatal and the extent of competition in the private sector matter in determining the outcomes across a range of metrics. We have also shown that the interaction of these types of market intermediaries is important in evaluating alternative policy instruments. In short, what this illustrative case-study highlights is that the characterisation of the intermediary market plays a crucial role in the effectiveness of reforms. Clearly, we can employ different permutations of the policy instruments used, the pro-consumer bias of the parastatal and intensity of competition between private sector firms, but the scenarios presented above highlight the insights from the theoretical framework and give some guide to their relative importance. Notably, the effect on storage of this policy reform depends on the bias in the parastatal's pay-off function, the extent of competition in the private sector and on the specifics of the interaction between the parastatal and the private sector. In terms of the overall assessment of policy reforms, this illustration shows that accounting for the role of profits from storage contributes an important insight into the distribution of welfare changes.

Table 2: Impacts of Changing Procurement Patterns (Mean Values)

Baladi Sector							
		$n = 5$			$n = 20$		
Variables	***Simulated Pre-reform***	$\omega = 0$	$\omega = 0.25$	$\omega = 0.5$	$\omega = 0$	$\omega = 0.25$	$\omega = 0.5$
Consumption (mmt)	7.5	5.006	5.864	8.983	5.678	6.763	10.955
Procurement from Private Firms (mmt)	-	1.895	2.758	5.877	2.569	3.658	7.848
Consumer Price (EGP/tonne)	458	1,003	815	235	856	619	101
Parastatal's Profits (m.EGP)	-2,095	5,094	4,881	2,145	5,812	5,506	4,372
Budgetary Cost of Consumer Subsidy (m.EGP)	12,187	12.217	14,312	21,924	13,858	16,506	26,737
Budgetary Cost of Domestic Procurement (m.EGP)	2,327	2,036	2,036	2,036	2,036	2,036	2,036

Fino Sector								
		$n = 5$				$n = 20$		
Variables	***Simulated Pre-Reform***	$\omega = 0$	$\omega = 0.25$	$\omega = 0.5$	***Simulated Pre-Reform***	$\omega = 0$	$\omega = 0.25$	$\omega = 0.5$
Consumption (mmt)	9.727	9.409	9.256	8.745	11.102	10.989	10.937	10.722
Imports (mmt)	8.353	14.361	15.142	18.05	11.124	16.006	17.081	21.146
Stocks (mmt)	1.402	2.938	2.999	3.257	1.113	2.372	2.277	2.493
Consumer Price (EGP/tonne)	2,249	2,301	2,327	2,412	2,020	2,039	2,048	2,083
Private Firms' Profits (m.EGP)	4,032	6,520	7,023	9,196	1,705	4,230	4,428	5,244
Private Firms' Profits from Storage (m.EGP)	-	2,263	2,359	2,697	-	1,262	1,488	1,584

5. Conclusion

Intermediaries play a crucial role in the functioning of agricultural and food markets and can be important in determining the effectiveness of government policies designed to promote food security. In the form of parastatals, they are also an important instrument in the delivery of government policy objectives including that of food security. Aside from procurement and distribution, they are also involved in commodity storage. We have compared parastatals with private sector intermediaries where parastatals are differentiated from private firm intermediaries by the nature of their pay-off function. These features add complexity to determining whether parastatals store more or less than private firm intermediaries and, therefore, which form provides relatively greater or lesser food security. We have applied the framework to an illustrative case study of the Egyptian bread-wheat market where food security is an over-riding government concern and we have analysed how price instruments interact with market structure and commodity storage to determine outcomes.

There remain several avenues for future research. We have assumed risk-neutral market intermediaries, risk-neutral consumers and a risk-neutral government. These assumptions have served the purpose of providing a framework in which we can readily generate some insights about the importance of market structure and especially how the outcomes from policy choices may depend on the characterisation of that structure. Extending the framework to incorporate aspects of risk aversion on the part of market intermediaries, consumers and government would be important to explore. Private intermediaries may be concerned about the variance of profits because these can affect the intensity of competition (Asplund, 2002). Aside from the more obvious aspect of consumer risk aversion, if a government is also concerned about consumer risk, this would be reflected in the specification of the parastatal's pay-off function which would also include a term for the variance of consumer surplus. Another extension worth exploring would be to change the parastatal's pay-off function to have it based instead on loss aversion or on safety-first criteria.

APPENDIX

In this Appendix we describe the data that were used to calibrate the parameters of the inverse demand and supply equations. We also explain how the stochastic variables (domestic production and the world price) were generated and how the simulations were conducted in Mathematica®.

Inverse Demand Equations

The calibrated, linear inverse demand function for *baladi* wheat was obtained in the following way. The amount of wheat used in making *baladi* bread is 7,502,000 tonnes (FAO 2015, p.54) and it sells at a subsidised price of EGP 458.15 per tonne. This price of wheat was calculated by taking the subsidised price of one *baladi* loaf of 5 *piastres* (EGP 0.05) and converting it to EGP/tonne of wheat. One tonne of wheat converts to 1016 kg of flour which is equivalent to 833 kg of 82 per cent milled flour (FAO 2015, p. 58). With the 1,000 kg of wheat flour producing 11,000 loaves, 1,000 kg of wheat will produce 9,163 loaves. With each loaf selling for EGP 0.05, the equivalent price of wheat is EGP 458.15 per tonne.

The price elasticity of retail demand is given by $(dC^b/dp)(p/C^b)$ = 0.28 from which, after rearrangement, $\frac{dp}{dQ^b} = \gamma^b = 7.502 \times \frac{10^6}{0.28} \times 458.15 = 0.000218109$ and $\alpha^b = p + \gamma^b Q^b = 458.15 + \gamma^b \times 7.702 \times 10^6 = 2094.4$. This value of the price elasticity of demand was chosen to ensure that the calibrated price and quantity approximated the data as closely as possible. The resulting inverse consumer demand equation for *baladi* wheat is:

$$p_t = 2094.4 - 0.000218109 C_t^b$$

For *fino* wheat, the quantity is 5,815 million tonnes (FAO, 2015, p.54) and the price is EGP 2898.72. This price was calculated as follows. One tonne of wheat converts to 1016 kg of flour which is equivalent to 732 kg of 72 per cent milled flour (FAO, 2015, p. 58). With the 1,000 kg of wheat flour producing 11,000 loaves, 1,000 kg of wheat will produce 8,052 loaves. With each loaf selling for EGP 0.36, the equivalent price of wheat is EGP 2898.72 per tonne. The value of the price elasticity of demand was again chosen to ensure that the calibrated equations reproduced the price and quantity in the data as closely as possible. The resulting inverse demand function for *fino* wheat has a price elasticity of demand of 3.0 and the calibrated equation is:

$$p_t^F = 3864.96 - 0.000166163 C_t^F$$

Inverse Supply Equation

In Section 2 there was no short-run inverse supply function because the procurement price distribution was that of the world price distribution which is assumed to be stationary. Producers equated

marginal cost with the expected world price. However, to accommodate a change in the procurement price distribution brought about through the introduction of the fixed unit subsidy scheme from that of the fixed procurement price, which is reflected in the data, some supply response needs to be built in to allow for a change in the expected price received by producers.

The short-run inverse supply function of domestic wheat was calibrated to average annual production of 8,174 million tonnes (2008/09 to 2017/18) (AMIS (2020) and a government-determined procurement price of EGP 2,800 per tonne. As before, the price elasticity of supply was chosen to match the calibrated parameters with these data, the value of which is 0.2. From the data, the parastatal purchases approximately 38 per cent of annual production which is the quantity that it sells to domestic consumers. The residual is on-farm use for food, feed and seed. Letting h_t be the quantity procured by the parastatal from farmers, the inverse domestic supply function is:

$$p_t^A = -11200 + 0.001712769h_t/0.38$$

Other Parameters

Parameter	***Baladi***	***Fino***
Storage costs (EGP/tonne) (K)	82	125
Rate of interest (ρ)	0.03	0.03
Discount factor (β), $1/(1+\rho)$	0.952	0.952
Storage losses (λ), $0 \leq \lambda \leq 1$	0.2	0.02
Import inefficiency (ι) (EGP/tonne)	156	0

Note: The parameters for storage costs, storage losses and import inefficiency were obtained from (FAO, 2015).

The Stochastic Variables

The domestic production data for the sample period have a range of 7.2 to 8.5 million tonnes, a mean of 8.174, a standard deviation of 0.3978, coefficient of variation of 0.0487, and negative skewness. A Beta distribution was fitted to these annual production data using the Method of Moments (https://www.real-statistics.com/distribution-fitting/method-of-moments/method-of-moments-beta-distribution/). The value of production corresponding to 0 in the Beta distribution was chosen to be 6.5 million tonnes and the value corresponding to 1 was 9.5 million tonnes. Then the shape parameters of production distribution were estimated to be 7.269369 and 5.758952. The fitted production distribution has a mean of 8.0491 million tonnes, a standard deviation of 0.389318 million tonnes, and a coefficient of variation of 0.0484 and negative skewness. These fitted statistics are very close to the corresponding values of the data.

The world price distribution, measured in EGP, for the sample period has a range of EGP 1,259 to EGP 2,063, a mean of EGP 1,926, a standard deviation of EGP 517, a coefficient of variation of 0.2682, and positive skewness. The estimated shape parameters for the fitted Beta distribution are 1.694312 and 2.217101. The fitted price distribution has a mean of EGP 1,926.7, a standard deviation of EGP 570.3, and a coefficient of variation of 0.296. Again, these fitted statistics are very close to the corresponding values of the data.

Simulations

The time period chosen for each simulation was ten years. For the first period there is no stock carry-in and for the final year there is no stock carry-out. The values of the variables in the model were calculated for each of the 10 years, and their means calculated. The exercise was repeated 10,000 times and the overall mean was calculated for each variable. These values provide the results given in the tables in the text.

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