Speculative Shortages in Agricultural Supply Chains: The Effect of Government Interventions

Essential agricultural commodities in many developing countries suffer from serious price volatility. In 2013, while inflation rate was only 6% in India, onion prices increased by 500% in some regions (Kapur and Riley, 2013). Similar has been the case of maize in Kenya where prices have soared periodically every year. Ample case studies and qualitative research highlight various factors that have contributed to this price volatility. In addition to supply shocks, hoarding of agricultural commodities by traders, lack of information transparency about total arrivals and non-competitive markets have been hypothesized to be major contributors (Chengappa et. al. 2012). Agricultural supply chains in developing countries are often dominated by a relatively small number of wholesalers who effectively control the supply. These wholesalers often use hoarding in order to create artificial shortage in the market. For instance, during the 2013 onion crisis in India, the Ministry of Consumer Affairs, Food and Public Distribution in India declared that they had seized 75,000 metric tons of pulses from a total of 6077 inspections all over the country (Gosh, 2015).

The essential nature of many of these commodities like onions and pulses mean that the government is forced to intervene to rein in prices. The government may respond in a variety of ways to improve consumer welfare and reduce shortage: 1) Randomized Allocation Policy (RAP): Government imports commodities from outside markets and starts selling them at a subsidized price through its own distribution channels. All consumers are free to buy from these channels and disbursement often continues till stocks last. 2) Prioritized Allocation Policy (PAP): Instead of selling to all consumers in the market, the government starts selling these commodities at a subsidized rate only to consumers in lower income groups. 3) Cash Subsidy (CS): In recent years, some governments adopt direct benefit transfer under which fixed cash subsidies are directly transferred into beneficiaries’ bank accounts. A CS scheme allows the government to prevent leakages that arise due to corrupt practices. In 2017 alone, the Indian government disbursed 1.8 billion USD under various subsidy programs (Sharma, 2018).

In this paper, we develop a game-theoretic analytical model to answer the following key questions: 1) How do various government interventions like RAP, PAP and CS affect equilibrium seller behavior and consumer surplus? 2) Which intervention is most effective in reducing effects of shortage and reigning in prices in the market? 3) What is the effect of increasing government’s budget on shortage in the market under various interventions? We leverage the analysis of the model to derive important and surprising insights that can inform policy makers to better address shortage risks.

This paper contributes to the literature on (1) design of optimal subsidy policies, and (2) agricultural supply chains. In the first stream, while previous research has looked at design of optimal subsidies (to increase access, affordability or usage) in a single-period setting (Levi et. al., 2017), we allow for strategic behavior of sellers in
a two-period setting. We also model consumer surplus related to essential products with repeated purchase and budget flexibility. In addition, we also contribute to the agricultural supply chains literature where previous work has analyzed the role of government interventions focused primarily on farmers (Alizamir et. al., 2015, Tang et. al. 2015). We differ from this stream by analyzing the effect of government subsidies on consumers (rather than producers) in the agricultural markets.

**Modeling approach.** We consider a monopolistic seller who sells an essential commodity to a group of customers over two periods. Each consumer has a privately known and heterogeneous budget \( b \) (for each period) for the product to start with. The seller only knows that \( b \) is uniformly distributed between \([0,1]\). We assume that the total market size is known and normalized to 1. The quantity released by the seller in the first period affects consumers’ perception of shortage in the market and consumers update their budget in period 2 in response to this perceived shortage. We analyze the seller’s, government’s, and consumers’ decisions under each intervention strategy separately. Given an intervention strategy, RAP, PAP, or CS, the sequence of events is as follows: (i) The seller releases some quantity in the first period and price in the market is accordingly determined. (ii) Consumers observe the first period quantity, make a purchase if affordable, and update their budgets for period 2 based on their perceived shortage. (iii) The government intervenes to reduce shortage and maximize consumer welfare. (iv) The seller releases period 2 quantity in the market. The seller’s objective is to maximize his total expected revenue in both periods.

We discuss two key modeling features in our setup. First, we model the effect of perceived shortage on consumers’ behavior in step (ii). Consistent with mental accounting (Pretnar et. al., 2016), consumers increase their purchase budgets as a response to the (perceived) shortage in the market. In addition, consumers mentally feel a loss due to overspending relative to their original budget. Second, we capture government intervention as a reactive action by the government. This setup is consistent with practice as many government interventions are implemented only after the shortage is already present in the market. This setup allows us to examine the seller’s strategic speculative behavior in anticipation of government interventions. We analyze and contrast three commonly observed intervention strategies and their respective effect on the seller’s speculation behavior.

**Results and insights:**

**Speculative shortage under no intervention:** Our analysis shows that in the absence of government interventions, the seller indeed creates artificial shortage to induce higher prices in period 2. In particular, although equilibrium quantity in period 2 is higher than period 1, equilibrium price in period 2 is also higher than that in period 1. This is because the perceived shortage in period 1 induced by the low period 1 quantity generates anxiety among consumers and results in the consumers raising their budget for purchase in period 2.

**The role of government interventions in mitigating speculative shortage:** We demonstrate how different government interventions may have very different impacts on the extent of speculative shortage in the market:
1. **CS policy:** We characterize a threshold such that if the total government budget for the intervention is greater than this threshold, the seller will in fact withhold even more inventory, and thus, create more artificial shortage in the market relative to the scenario with no government intervention. Since the cash subsidies from the government effectively increase the consumers’ budget in period 2, the seller finds it optimal to further increase the perceived shortage in period 1 and take advantage of the government’s “free” money.

2. **PAP Policy:** If the total government budget for intervention is less than a threshold, the equilibrium shortage in the market remains the same as in the scenario with no intervention. This is because under PAP, the government only provides product access to consumers with the lowest budgets. As a result, the higher-budget consumers continue to have to purchase from the seller. Hence, the seller continues to find it beneficial to withhold inventory and create shortage in the market. However, if the total government budget is greater than the threshold, then PAP indeed becomes effective in reducing speculative shortage in the market.

3. **RAP Policy:** In sharp contrast to the above two policies, RAP *always* mitigates speculative shortage in the market. In addition, the higher the total government budget, the more reduction in shortage. This is because RAP creates competition between the government and the seller for all consumers in the market, including the high-budget ones. Thus, the seller earns a lower expected revenue in period 2. To compensate for this loss of revenue, it is optimal for him to release a larger quantity and earn a higher revenue in period 1.

Our results highlight that to be effective, government interventions need to be carefully designed while taking into account potential strategic responses of other players (e.g., sellers and consumers) in the market. We take the first step toward this direction in the analysis of a market for essential commodities.

**References**


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