**Effects of Stock holding policy on Maize Prices: Evidence from Zambia**

**Yujun Zhou, Kathy Baylis**

**Abstract:** Public stockholding is prevalent among developing countries in the past decade. Governments intervene in grain markets by building strategic reserves directly through marketing boards. Despite the massive spending on those stockholding programs, little is known about their effectiveness in mitigating the retail price swings associated with domestic production shocks. This paper estimates the effects of the purchase and sales activities of the Food Reserve Agency (FRA) on maize market prices across more than thirty markets in Zambia using monthly price data from 2003-2008. To deal with the endogeneity in the actual purchase and sales targets, we use predicted FRA purchase and sales targets as instrumental variables. Controlling for other policies in place, we find evidence of stabilizing effects of FRA activities on retail prices in the major district markets. Results also show that FRA purchases raise local prices for surplus maize producers for 3% on average during the time of harvest and FRA sales help to lower the price during the lean season from 1%-7%.

**JEL classifications: Q11, Q18**

**Keywords:** Maize marketing board; Strategic grain reserve; Maize prices; Zambia

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1. **Introduction**

Public stockholding is widely used in developing countries to stabilize staple food prices. In Africa, stockholding regained its popularity among governments in the past decade and have become dominant players in Africa’s grain markets (Jayne, 2012).

Volatile food prices endanger the food security of households and can lead to social unrest and civil conflict (Bellemare 2015; Fjelde 2014). Numerous theoretical works have demonstrated the role of public storage to reduce fluctuations in food prices (Scheinkman and Schechtman (1983); Wright and Williams (1982), among others). Gouel and Jean (2012) proposed a theoretically optimal food price stabilization policy for a developing country by maintaining a public stock along with a subsidy on agricultural production. This is precisely the policy combination used in Zambia with its sizeable public stock and subsidy on farm input.

Equipped with ample storage facility in various district markets, the Food Reserve Agency (FRA) in Zambia purchases a substantial amount of maize from small households in various geographic regions since the 2003/04 marketing year (corresponding to the study period in this paper). The high pan-territorial buying price makes the FRA the dominant buyer in the market (Mason and Myers 2013). In 2006 and 2007, the FRA bought more than half of the surplus maize by smallholder farmers (Ricker-Gilbert et al. 2013). As a result, the national maize stocks reached historically high levels in 2009. These buffer stocks are intended to reduce variability in grain prices and to provide liquidity in the maize market (Govereh, Jayne, and Chapoto 2008). Mason and Myers (2013) show the FRA purchases raised mean price raised around 17% between 2003 to 2008 and show signs of a stabilizing effect. The authors point out that the welfare gains for the poor households from this policy seem rather small compared to the considerable financial cost to build and maintain the buffer stock. To support the high FRA purchase price, along with storage and logistics costs, the estimated total cost of FRA activities consists of 7% of the entire government budget in Zambia (Nkonde et al. 2011; IMF, 2012).

This paper seeks to provide empirical evidence on whether the FRA stockholding policies stabilize prices both across years and during a year in the lean season. Specifically, we ask: can FRA purchases increase the price that farmers receive during the time of harvest? Can FRA sales mitigate the retail price swings associated with domestic production shocks during the lean season?

Despite its popularity among governments, evidence on the effectiveness of stockholding policy on stabilizing prices is relatively scarce and inconsistent. Jayne et al. (2008) find the National Cereals and Produce Board (NCPB) in Kenya increases maize price by 20% between 1995-2004 but decreases price during the early 1990s. Pierre et al. (2018) do not find a significant effect of the National Food Reserve Agency in Tanzania on maizes prices except for a small decrease effect on market price in some markets. Despite the similarities in the policy between countries, the FRA in Zambia operates on a larger scale both financially and geographically and has a focus on smallholder farmers. The studies on the Zambia case are therefore, more relevant. Chapoto and Jayne (2009) find evidence of FRA sales reduce market price but no significant result on stabilizing effects. Similar to our study, they estimate a reduced form model on three wholesale markets and regard FRA activities as demand and supply shifters. Our study explores more spatial variation by expanding the study to over thirty markets and control for the endogeneity in identifying the effects. Mason and Myers (2013) apply a Vector Autoregression based approach and simulation results from the model suggests a stabilizing effect on the prices and an approximately 20% increase between 2003-2008.

Our study makes several contributions to previous studies on stockholding policies and FRA in Zambia. Different from the time series analysis commonly applied in the previous literature, our approach explores the spatial variation across thirty-two maize markets that vary in geography and economic status. The purchases and sales are made locally, and naturally, we would expect the effect of the program to vary over space as well. We also use an instrumental variables to deal with endogeneity in the quantity of FRA purchases and sales, which may lead to biased estimates.

The endogeneity issue of identifying the effects of the stockholding policy on maize prices is three-fold. First, since the FRA targets explicitly areas that are predicted to be in surplus as locations for their purchases, we need to control for endogeneity in the amount of FRA purchases. Otherwise, we tend to overestimate the stabilizing effect of FRA since these purchases are typically made in places of surplus maize and price there tend to be more stable. Second, a reverse causality issue exists as FRA tends to sell more maize when the price is higher. This drives the estimated effect of FRA sales to increase the price if not no effects at all. To tackles with these two issues, we use predicted FRA purchase and sales targets as instrumental variables for the actual purchase and sales as they are relevant to the stockholding activities but not directly correlated with production shocks of that year. Third, simultaneous policies are at play, and all to a certain degree endogenous to grain production, local grain production shocks, and maize prices. These policies include but not limited to temporary export bans, government subsided imported maize from South Africa and targeted fertilizer subsidy program for smallholder farmers. Without controlling for other policies, we are facing the risk of attributing the stabilizing effect only on the FRA stockholding policies, but it may be a combined effect of multiple policies. Any government program that involves buying or releasing cereals leads to the creation of public stocks” (Deuss 2014). However, most of the policies listed above are made at an annual level. We try to proxy them by adding agriculture-related weather shocks in each regression or directly explore monthly variations in price.

Identifying and quantifying the effects of stockholding policy matter to policy makers aiming at improving food security. Understanding both the benefit and cost involved in carrying out the stockholding policies can help evaluate policy alternatives in stabilizing the grain market.

The paper is structured as follows. Section 2 gives background information on the Zambia maize market and relevant policies. Section 3 illustrates the empirical strategy by describing the model. Section 4 includes a description of data and a discussion of the empirical results. Section 5 concludes with the main findings of the paper and the relevant policy implications.

1. **Background**

Zambia ranks 139 out of 188 countries in the 2015 UNDP Human Development Report and is classified as a lower middle-income country by the World Bank (Cammelbeeck 2015). With sixty percent of its population below the poverty line and almost fifty percent malnourished, the country suffers from widespread poverty and food insecurity (Sitko et al. 2011).

The agricultural sector in the country comprises of roughly 1.5 million smallholders and 2,000 large-scale farmers. More than ninety percent of maize productions and eighty percent of total maize sales come from smallholder farms (Tembo et al. 2009). Maize production is not evenly distributed across farms. Around two percent of the small and medium farmers generate roughly half of maize output. A large number of small farm households are still net buyers of maize (Sitko et al. 2011). The dependence on the volatile rainfall and a lack of irrigation systems make the agricultural output extremely unstable. Years of drought, flood, and insufficient input supply, which represent on average one year out of three, lead to deficient maize production to satisfy food demand at the national level (Dorosh, Dradri, and Haggblade 2009). Since weather shocks are localized, specific production regions experience more severe shocks than others. Substantial production shortages result in the domestic maize price rising to the Republic of South Africa’s maize import parity (Myers and Jayne 2012).

However, past maize price fluctuations and the consequent social unrest have led the government of Zambia to believe food prices are far too strategically and politically important to leave to the market (Chapoto 2012). The government mistrusts private traders in their ability to bring in enough maize to stabilize the market (Myers and Jayne 2012). Uncertainties in imports and the transmission of shocks from other countries make trade a less reliable tool to address domestic food shortage. Besides, storage is needed to supply the market before the imports arrive. Consequently, developing countries have been rethinking their policies on grain storage and dependence on international trade to secure domestic food security (Dorosh 2009).

The Food Reserve Agency (FRA) was established in 1996 with the aim of building and managing national grain stocks (Govereh, Jayne, and Chapoto 2008). The buffer stocks are intended to stabilize maize price and provide available maize supply to the market. The FRA purchases substantial maize from small households in various geographic regions since the 2003/04 marketing year (corresponding to the study period in this paper). The high pan-territorial buying price (uniform price in the entire country ) makes the FRA the dominant buyer in the market (Mason and Myers 2013). In 2006 and 2007, the FRA bought more than half of the surplus maize by smallholder farmers (Ricker-Gilbert et al. 2013), which helps to build higher maize stocks. In part to protect the dominant market position of the FRA, the government implemented a series of policies including export bans, import tariffs, and imports through the FRA (Tschirley and Jayne 2010). According to grain traders, millers also get subsidized maize stocks from FRA. These measures to build higher stocks have led the national maize stocks to reach historically high levels after 2009 (shown in Figure 1).

1. **Method**

To help explain how FRA purchases and sales affect retail maize prices, we set up the following model of demand and supply of maize in Zambia. Consider a system of demand and supply of maize as specified in equation (1) and (2):

Where is the supply of maize at district at time t, is the amount of net imports of maize at time t, and is the price of inputs and weather at district in the previous period respectively and is the farm gate price of maize in the previous year; is the demand for maize, affected by the current price of maize, the income of consumers and possible restrictions on export in place.

FRA activities are essentially smoothing price both over time and over space. Most of the FRA purchases are made during the harvest season between July to October from smallholdings in maize growing areas, then stored in the storage facilities in the major districts. Most of the sales are made doing December to March, at a subsidized price to commercial millers in cooperation with the FRA. This makes the distance to the districts that have milling companies in cooperation with the FRA an important factor as to influence of the sales. Equation (3) and (4) are factors associated with FRA sales and FRA purchase:

Where is the distance weighted FRA sales of market at time t for its nearest miller, and is the price at the nearby miller location at time t. is the cost of transportation. The FRA purchase can be modeled as a function of past grain stocks and estimated current excess harvest or total storage target. is the pan-territorial FRA buying price set for the year.

Consider retail maize price as a function of total supply and demand of maize on the market, where FRA purchases affect demand and FRA sales affect supply, as is shown in equation (5). Without the FRA, we would expect prices to go up by the cost of storage throughout the year and would be essentially the price of South African maize plus transport price in rural areas. The FRA purchase price is set once every year and stays the same in the entire crop year (May to April). The price is pan-territorial, meaning the price is the same for all districts in the country.

Solving a structural model consisted of a system of equation (3), (4) and (5), however, is difficult both theoretically and empirically. The reduced form can come in different forms resulting from different assumptions on the structural model. Also, we do not observe the quantity of maize bought and sold as broadly or frequently as we observe the prices in our data. Given the data limitation, we follow the approach used in Chapoto and Jayne (2009) to start with a reduced form framework with demand and supply shifters as regressors subject to the availability of data.

Because we do not have a very accurate estimate of production quantity either at the national or local level, we apply a vector of weather measures in the previous growing season as proxies of production shocks to the maize harvested by smaller holder farmers. Note that the primary district markets are in a certain degree connected through trade. As a result, the prices of these markets tend to drive towards the same driven by arbitrage. One would argue that the aggregated shocks at the national level matter more than local weather shocks because the arbitrage behavior would even out the shocks between markets. However, due to the incomplete infrastructure and a lack of market information system, the level of price integration in developing countries is not so much. Prices in markets far away from the primary production and consumer centers respond little to each other in the short term (see appendix on analysis on price integration) to prices shocks outside. We use local market weather as controls in the main specification and use weather shocks in the production region and aggregate national shocks as part of the robustness checks. By adding in the market fixed effect and month fixed effect in the model, we can compare regions that are less affected by FRA purchases and sales as controls (both unaffected by price arbitrage or by the FRA purchases) to reflect the effect of stockholding policy.

With all these factors considered, we can estimate a reduced form model (equation 6) to evaluate the effects of FRA purchase and FRA sales on price levels and price stability:

where Yit is price and price deviations at district i at time t, is a vector of weather variables from the previous growing season, is a vector of other covariates of demand and supply shifters, and is a random error term. The coefficient of interest throughout the paper is , the effect of FRA purchase on the prices and for the effects of FRA sales. We employ district fixed effects models to control for unobserved time-invariant factors that might affect food production and food prices such as the geographical location and climate associated with it. We control for seasonal effects by adding month dummies in the model.

The potential problem with the above regression is the amount of current FRA purchase, and FRA sales are endogenous to current prices . As is discussed earlier, the OLS estimator of the coefficient of FRA purchase would overestimate the effects of FRA purchases since FRA purchase are typically made in places of surplus maize and price tend to be more stable. Similarly, the estimated coefficient on FRA sales would be the opposite, if not attenuated to zero, without considering the endogeneity contained in the sales.

Every year, the Central Statistics Office of Zambia conducts Crop Forecast Survey (CFS) during in the spring before harvest, to get an estimate of the local production for the major districts. The CFS collects a nationally representative sample to get an estimate of national harvest and are used as references for setting goals for FRA purchases and FRA purchase price. This gives us the opportunity to have an instrument for purchases by the predicted output from the CFS while controlling for actual district level production shocks that are weather-related. In this paper, we use an instrument for FRA purchases by using long-run shares of production for each district times the expected total crop harvest from the CFS to capture the annual purchase targets. The share is the average of production in district i as a percentage of the national harvest from 1999 to 2011.

We believe that this instrument is valid because the policy design makes the estimated production relevant to FRA purchase behaviors every year, but not the instrument does not directly affect prices in a certain year. Since we are interacting the production with long-run averages shares, the instrument is not strongly correlated to a specific year’s harvest and hence not impacting the current local prices directly. Also, the CFS estimate may not be entirely accurate in terms of actual harvest and hence not strongly correlated with the current prices.

We instrument for predicted FRA Sales at district i by weighting the predicted FRA stock of a particular year, weighted by the number of millers and weighted by the distance to the nearby districts with millers. The validity of this instrument lies in that the distance to districts with milling companies are relatively exogenous and tend to stay the same during the 5-year study period. The estimated production of a specific year is also dependent on long term shares and are not directly associated with shocks to food prices.

1. **Data and Variable**

Monthly Zambia maize prices observed from Jan. 2003 to Dec. 2008 from 32 different markets that spread out in different geolocations in Zambia (shown in Figure 1). There are considerable variations in the markets, including food demand, population, food production and cost of transportation. Price data were collected by the World Food Program and the Central Statistical Office in Zambia.

We generate measures of agriculturally-relevant precipitation from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset (Funk et al., 2015). We use the total amount of rainfall that fell during the October–April growing season. For the same season, we define the length of the longest dry spell as the number of continuous days with no rain. To measure the beginning of the rainy season, we calculate the number of days after October 1st in which rainfall more significant than 10 mm fell three days out of 5. These three variables are taken from the prior agricultural season to predict food availability for the June/July maize harvest.

Temperature data are from the African Drought Monitor, also limited to the maize growing season. We created average temperature during the growing season, growing degree days (number of days where the temp was between 8 to 32 C) and heat days (days temperature greater than 30 C) following Deschênes and Greenstone (2007). The weather measures used in this paper are more accurate and complete compared to only using precipitation as in Dorosh (2009) and Chaopoto and Jayne (2009b)

Annual Zambia FRA purchases from 2002 to 2009 by the district from the FRA. Yearly stock and crop acreage estimate from USDA. South African prices, net imports from South Africa from Johannesburg Stock Exchange and South African Reserve Bank. List of commercial millers working with the FRA from CSO.

1. **Main Results (Not finished)**

For each regression models, we estimate four specifications as follows. Model (1) is a fixed effect (FE) model, which assumes that all variables are exogenous. Model (2) is a fixed-effects model with instrumental variables (IVs) (FE-IV) and is the preferred model because it controls for the endogeneity of various explanatory variables as described above. The coefficient of the instrumented FRA purchase is estimated via a two-stage-least-squares method. Models (3) and (4) are exploring monthly variation by including the monthly lag price in the model. Model (4) includes more control than the model (3)

In the regression analyses, we use the test to detect underidentification and use the Cragg-Donald Wald F statistic and the Wald rk F statistic to examine if the instruments are weak. Over-identification does not apply here because we have the same number of instruments as the endogenous variable

Controlling for other policies in place, we find evidence of stabilizing effects of FRA activities on retail prices in the major district markets (1%-4% decrease through FRA sales).

FRA purchases raise local prices for surplus maize producers during the time of harvest ( 1%-3% increase in price for an average amount of FRA purchase)

FRA sales help to lower the price during the lean seasons. ( 0.7%-7% decrease in price for an average amount of FRA purchase)

1. Conclusion

Other things to consider…

• Management and transparency: late payment

• Fiscal impact: worth it?

• Opportunity cost in investing other programs

• Crowding out of the private sector: government face a more prominent role, and

then more pressure on the budget

• International spillovers: for a large country, generates nervousness on the international markets; for a small country, impact neighboring countries

• Spatial lag

• Transportation cost

• Robustness checks

• Subset samples: by region, by distance

Table 1. Summary Statistics of Variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Mean | SD | Min | Max |
| **Dependent variables** |  |  |  |  |
| Maize Price (ZMK/ kg) | 573.8051 | 182.0592 | 235.3799 | 1555.6 |
| Price Deviation Squared | 26094.09 | 52640.71 | 0.029471 | 674142.8 |
| **Key variables** |  |  |  |  |
| FRA Purchase (MT) | 257.4658 | 845.5297 | 0 | 10310.93 |
| FRA Sales (MT) | 5.122118 | 31.83187 | 0 | 655.8752 |
| **Explanatory variables** |  |  |  |  |
| Days without rain | 27.453 | 11.520 | 1.000 | 56.000 |
| Precipitation(mm) | 1068.551 | 197.276 | 550.444 | 1640.263 |
| Mean Temperature (°C) | 24.918 | 0.837 | 23.220 | 27.064 |
| Heat days | 3.885 | 5.457 | 0.000 | 28.000 |
| SAFEX Price (ZMK/ kg) | 789.909 | 217.037 | 468.753 | 1279.758 |
| **Instrumental variables** |  |  |  |  |
| **Production Region** |  |  |  |  |
| Predicted purchase target | 3358.519 | 15746.14 | 0 | 216272 |
| Predicted sales target | 2016.894 | 6715.656 | 0 | 86699.47 |

Table 2: IV Regression of Maize Price

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | (1) | (2) | | | | | (3) | (4) | |
| Price | | | FE | FE+IV | | | | | FE+IV | FE+IV | |
| FRA Purchase | | 0.016\*\*\* | | | 0.024\*\* | | | 0.020\*\*\* | | | 0.021\*\*\* |
|  | | (0.004) | | | (0.010) | | | (0.006) | | | (0.007) |
|  | |  | | |  | | |  | | |  |
| FRA Sales | | -0.520\*\*\* | | | -8.891\*\*\* | | | -4.531\*\*\* | | | -5.522\*\*\* |
|  | | (0.142) | | | (1.719) | | | (1.004) | | | (1.203) |
|  | |  | | |  | | |  | | |  |
| Days without rain | | 1.294 | | | 1.922 | | |  | | |  |
|  | | (0.882) | | | (1.180) | | |  | | |  |
|  | |  | | |  | | |  | | |  |
| Precipitation | | 0.182\*\* | | | 0.165\*\*\* | | |  | | |  |
|  | | (0.076) | | | (0.051) | | |  | | |  |
|  | |  | | |  | | |  | | |  |
| Mean Temperature | | -85.213\*\*\* | | | -157.380\*\*\* | | |  | | |  |
|  | | (16.124) | | | (26.540) | | |  | | |  |
|  | |  | | |  | | |  | | |  |
| SAFEX Price | | -0.414\*\*\* | | | -0.425\*\*\* | | | -0.113\*\*\* | | | -0.204\*\*\* |
|  | | (0.054) | | | (0.036) | | | (0.019) | | | (0.045) |
|  | |  | | |  | | |  | | |  |
| Heat Days | | -1.591 | | | -0.491 | | |  | | |  |
|  | | (3.440) | | | (2.497) | | |  | | |  |
|  | |  | | |  | | |  | | |  |
| L.price | |  | | |  | | | 0.554\*\*\* | | | 0.441\*\*\* |
|  | |  | | |  | | | (0.026) | | | (0.033) |
| N | | 2304 | | | | | 2304 | 2232 | | | | 2232 | |
| Cluster | | 32 | | | | | 32 | 32 | | | | 32 | |
| *Anderson canon. corr. LM statistic* | | - | | | | | 30.819 | 31.851 | | | | 27.983 | |
| *Cragg-Donald Wald F statistic* | | - | | | | | 15.279 | 15.823 | | | | 13.845 | |

Notes: Standard errors in parentheses. \* *p* < 0.10, \*\* *p* < 0.05, \*\*\* *p* < 0.01

Specifications of the models: (1): FE, (2): FE-IV (Instrumental variables), (3) Cragg-Donald Wald statistic and Kleibergen-Paaprk Wald statistic are distributed as chi-squared with degrees of freedom of 1.

Table 3: IV Regression of Maize Price Deviation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) |
| Price Deviation | FE | FE+IV | FE+IV  Production Region | FE+IV  Consumer Region |
| FRA Purchase | 2.528\*\* | 2.597 | 1.575 | 3.662\* |
|  | (0.904) | (2.421) | (2.044) | (1.914) |
|  |  |  |  |  |
| FRA Sales | -49.578\* | -1691.198\*\*\* | -1279.669\*\*\* | -1042.131\*\*\* |
|  | (26.388) | (425.684) | (351.438) | (338.846) |
|  |  |  |  |  |
| Days without rain | 949.699\*\* | 1055.863\*\*\* |  |  |
|  | (299.168) | (292.168) |  |  |
|  |  |  |  |  |
| Precipitation | 64.142\*\*\* | 60.264\*\*\* |  |  |
|  | (12.890) | (12.716) |  |  |
|  |  |  |  |  |
| Mean Temperature | 4773.891 | -9956.181 |  |  |
|  | (3812.777) | (6572.339) |  |  |
|  |  |  |  |  |
| SAFEX Price | -45.457\*\*\* | -46.778\*\*\* | -20.145\*\*\* | -32.210\*\*\* |
|  | (8.046) | (9.004) | (6.531) | (12.460) |
|  |  |  |  |  |
| Heat Days | -174.802 | 3.478 |  |  |
|  | (803.148) | (618.254) |  |  |
|  |  |  |  |  |
| Annual import |  |  | 0.396\*\*\* | 0.319\*\*\* |
|  |  |  | (0.025) | (0.024) |
| N | 2304 | 2304 | 2232 | 2232 |
| Cluster | 32 | 32 | 32 | 32 |
| *Anderson canon. corr. LM statistic* | - | 30.819 | 32.608 | 29.493 |
| *Cragg-Donald Wald F statistic* | - | 15.279 | 16.205 | 14.603 |

Table 4. Robustness Checks for Determinants

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |

Table A1. Autocorrelation tests

Table A2. First stage results for

Figure 1. Map of Major District Markets in Zambia

A close up of a map

Description generated with high confidence

Figure 2. Monthly shares of FRA purchase and sales

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |