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*Drivers of Maize Prices in Tanzania **

Maize is the most important food crop in Tanzania. It accounts for nearly 50 percent of total calories in the diet and 40 percent of cropped area. Maize production is concentrated in the Southern Highland regions of Iringa, Mbeya, Ruvuma and Rukwa; but occurs in all regions and by an estimated 85 percent of farmers. This SERA Research Brief summarizes a study that quantifies the domestic and external drivers of Tanzanian maize prices. The objectives of the study were to better understand the impacts of trade policies, as well as the influence of other domestic and external factors that drive maize prices.

An econometric error correction model (described in Box 1) was estimated to determine the price relationship between 18 markets in Tanzania (Figure 1) and regional and global prices using monthly data from July 2002 to July 2014. The study extends the literature on price transmission in several ways. First, it considers several external markets as drivers of Tanzanian maize prices. Second, it separates long-run co-movement from short-term price variability. Third, it measures the influence of harvest cycles, weather anomalies, export bans, inflation, and fuel prices.

The study finds that long-run Tanzanian maize prices are determined by external markets (proxied by Nairobi and other regional and global prices), but in the short run price movements are driven by domestic factors. The export bans delay the adjustment of domestic maize prices towards long-run equilibrium and lowers domestic maize prices. The short-run influences of weather shocks on domestic prices are more pronounced during periods in which an export ban is imposed. Harvest cycles have a strong influence on maize prices, signalling the importance of improving storage and transportation in order to reduce seasonal price variations which currently are 40 percent from trough to peak. Inflation and fuel prices were also found to influence maize prices.

Price Transmission

The study examined the relationship between the maize prices in the 18 regional Tanzanian markets and the maize prices in Nairobi, South Africa, and the United States. The econometric estimates showed that the relationship between Tanzanian maize prices and Nairobi were highly significant in all regions and the strongest of the three external markets considered. U.S. Gulf maize prices and South African maize prices were found to have a smaller influence on Tanzanian prices in the short run, and the influences were considerably weaker than the influence of Nairobi prices.

Three key conclusions emerge from the price transmission analysis. First, of the three external markets considered, only Nairobi exerts a significant influence on Tanzanian prices in the long run. Second, the southern regions are more closely linked to markets in northern Mozambique than Nairobi. Third, the markets that adjust most quickly to external price changes all are in proximity to Nairobi or have access to a port, and the speed of adjustment diminishes with the distance from Nairobi.

* Based on research conducted by the SERA Policy Project of the USAID Feed the Future Initiative and the Development Prospects Group of the World Bank. The full study can be obtained by contacting Don Mitchell at don.mitchell@tzsera.com or from the SERA website at www.tzsera.com.

The SERA Policy Project is a USAID funded project that seeks to improve agricultural policies and develop capacity for policy analysis and advocacy. The project is implemented by Booz Allen Hamilton.

Figure 1. Tanzanian Maize Markets

Export Bans

During 2002-14, the United Republic of Tanzania imposed five export bans (Figure 2). The first and second bans spanned January 2005 to January 2007 with only a 3-month hiatus at the beginning of 2006. A 5-month export ban was in place in 2008, and a ban which lasted almost 2 years was in effect during 2009 and 2010. The duration of the last ban during this period was less clear—it was announced in March 2011, but only became effective in July and its removal was announced in October 2011 but ended in December 2011. The export bans (with the exception of the first one) were usually introduced at times of high maize prices, and their removal took place when prices were low. This is consistent with the government imposing the export ban in response to food security concerns caused by production shortfalls or price increases in the region.

An export ban increases the seasonal price variability by depressing prices at harvest and limiting the seasonal price increase prior to the next harvest (Figure 3). The impacts of the five maize export bans were analysed together and then the most recent export ban was analysed separately in order to capture its unique characteristics. The combined analysis (Table 1) and separate analysis for the most recent export ban (Table 2) are shown by zones for brevity, but the estimates for all regions are shown in the full study. The results show that the most recent export ban had a much larger impact on maize prices than the previous export bans and exerted larger downward pressure on local maize prices. For the country as a whole, the most recent export ban caused the monthly price to be 8.8 percentage points lower for every month that the ban was in effect than they would have been without the ban. While the effect of the ban was relatively more muted in the Southern zone, all five zones experienced an impact that was large and significant.

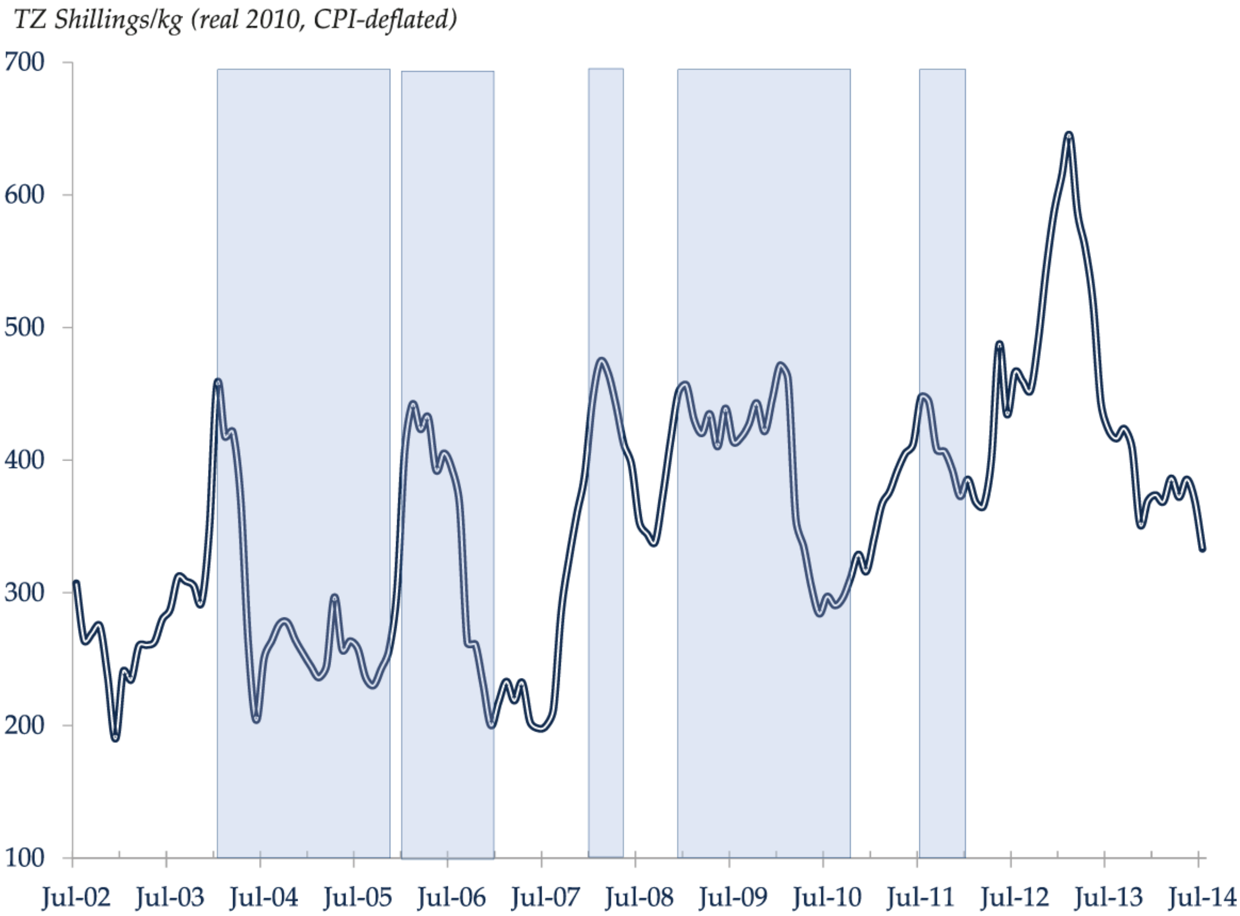
To illustrate the impact of the export ban, counter-factual estimates of maize prices in Dar es Salaam (Figure 4) and Songea were developed assuming there was no ban. These estimates show that for every month of the export ban maize prices would have declined by 9.2 percent in Dar es Salaam and 7.3 percent in Songea. By the last month of the ban, maize prices in Dar es Salaam would have been 38 percent higher without the ban, while maize prices in Songea would have been 31 percent higher. Further, even in the months following the removal of the ban, actual and counter-factual prices differ and take several months to converge because the adjustment to the Nairobi price is prolonged.

The relatively larger impact of the 2011 export ban compared to the other export bans analysed was likely due to two factors. First, prices in Nairobi were especially elevated during this ban due to a production shortfall in Kenya. Second, there were significant investments in Tanzanian transport infrastructure during the 2000s and that may have resulted in lower trade costs. As a consequence, the most recent export ban may have exerted a larger influence on both maize trade flows and local maize prices. In the future, the reduction in trade costs are likely to make a maize export ban exert even greater downward pressure on local maize prices than in the past.

Seasonality

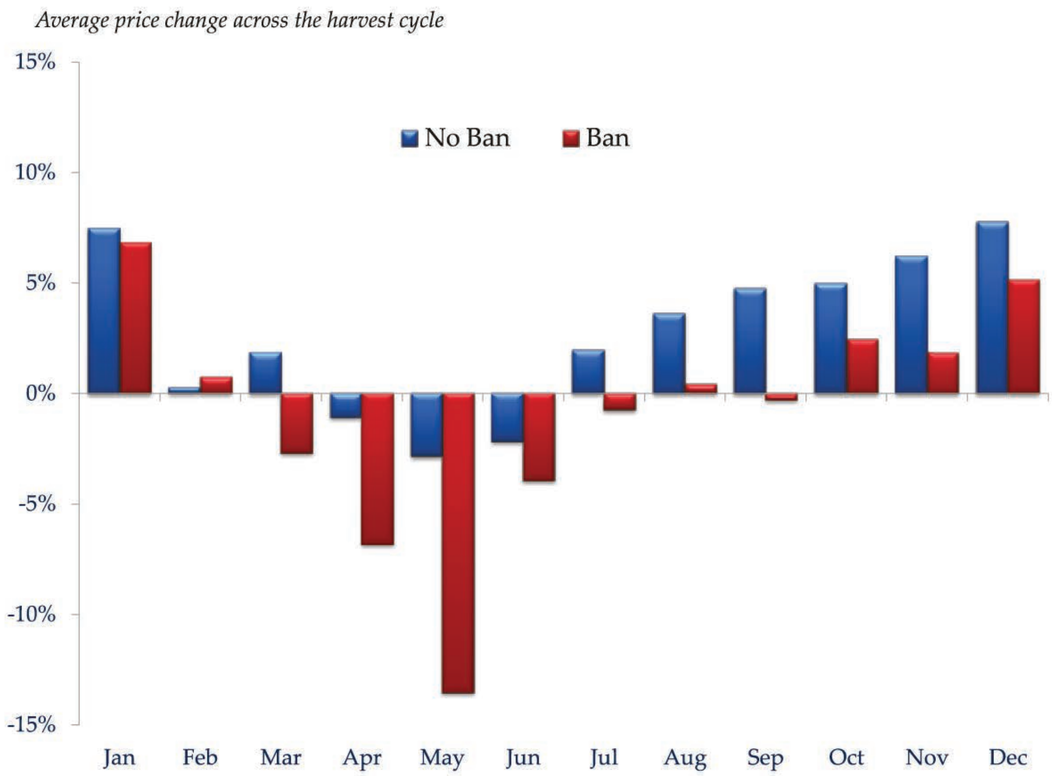
Because Tanzania's rural economy is characterized by limited storage facilities and transport bottlenecks, harvests are likely to have pronounced impacts on maize prices. To account for such impacts, the model controls for seasonal effect using trigonometric variables. In addition to capturing (cyclical) seasonal patterns by utilizing a priori information on cyclicality—strong negative (positive) impact on prices during harvest (lean) seasons—the trigonometric specification allows for a smooth transition from one phase of the cycle to another.

Figure 2. Maize Prices in Dar es Salaam and Export Bans (Shaded)



Source: FAO GIEWS, newspaper articles, and interviews with industry representatives

Figure 3. Average Price Changes during Ban and No Ban PeriodsT



Source: Authors' calculation based on *unadjusted* price data

Table 1. Parameter Estimates for Panel Specification with Simple Export Dummy

	Central	Coastal	Lake	Northern	Southern	National
μ	-0.02***	-0.02***	-0.00	-0.02***	-0.05**	-0.02***
	(8.38)	(3.20)	(0.68)	(7.54)	(4.66)	(5.33)
$(p^w_{t-1} - p^i_{t-1})$	0.13***	0.23***	0.20***	0.13***	0.12**	0.16***
	(8.26)	(5.76)	(4.93)	(19.82)	(7.02)	(9.23)
Δp^W_t	0.21***	0.12	0.26***	0.33***	0.21***	0.21***
	(6.90)	(1.52)	(5.23)	(21.13)	(4.52)	(6.75)
Δp^F_t	0.33***	0.01	0.32***	0.26***	0.09	0.20***
	(8.00)	(0.11)	(5.01)	(14.92)	(1.55)	(4.37)
Δp^I_t	2.78***	0.77	1.70***	2.40***	1.25***	1.68***
	(67.95)	(1.09)	(4.33)	(7.81)	(7.30)	(6.61)
I_{BAN}	-2.78***	-3.49***	-3.83***	-2.75***	-2.07***	-3.09***
	(15.77)	(6.93)	(17.23)	(11.13)	(2.75)	(12.72)
$SEASON^1_t$	0.04***	-0.07***	0.03***	0.04***	0.05***	-0.05***
	(15.43)	(4.30)	(7.14)	(2.64)	(9.68)	(8.20)
$SEASON^2_t$	-0.01	-0.01	-0.03***	0.02***	-0.03**	-0.01**
	(0.81)	(1.62)	(4.63)	(4.54)	(2.35)	(2.32)
$NDVI_t$	-0.23***	-0.38***	-0.19***	-0.48***	-0.65***	-0.31***
	(8.13)	(2.95)	(2.66)	(4.64)	(6.30)	(7.42)
R-square	0.28	0.22	0.24	0.32	0.18	0.20

Notes: The dependent variable is the change in the logarithm of the nominal price in market i. All regressions employ a (market) fixed effects methodology with bootstrapped standard errors (1,000 replications). Robust absolute z-statistics in parentheses, significance level, * = 10 percent, ** = 5 percent, *** = 1 percent; significance levels are different than typical due to clustering adjustment of the standard errors. The bootstrapped standard errors are clustered at the market level.

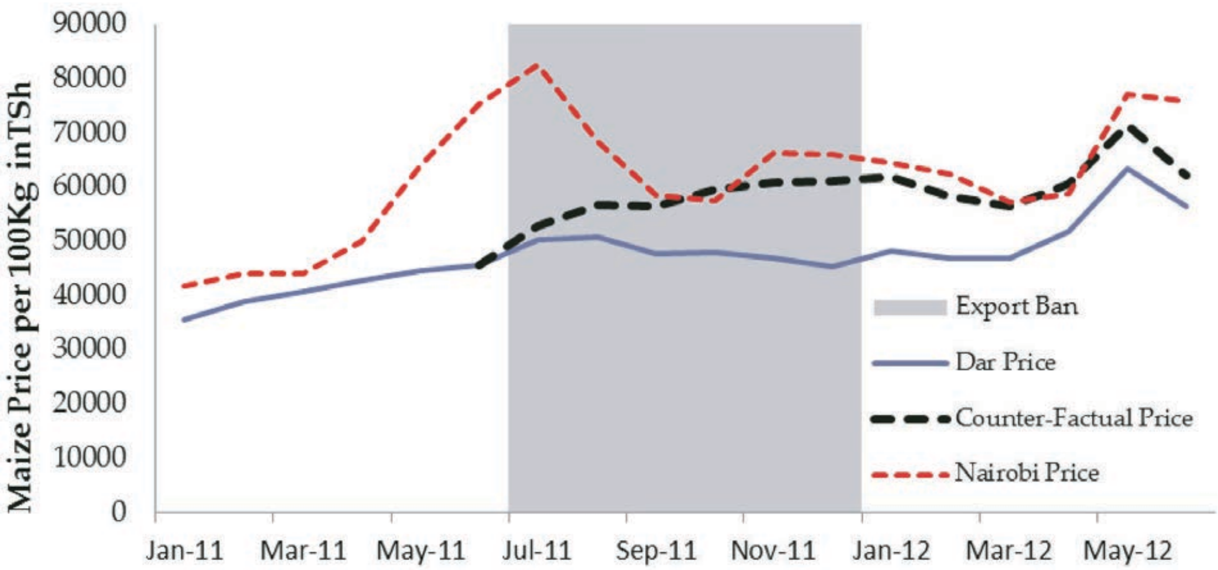
Table 2. Separating the Impacts of the 2011 Export Ban

	Central	Coastal	Lake	Northern	Southern	National
I_{BAN}	-2.78*** (15.77)	-3.49*** (6.93)	-3.83*** (17.23)	-2.75*** (11.13)	-2.07*** (2.75)	-3.09*** (12.72)
I_{BAN}, *excluding 2011*	-2.27*** (14.43)	-2.80*** (4.27)	-3.30*** (18.22)	-2.01*** (9.48)	-1.62*** (2.36)	-2.52*** (10.46)
2011 BAN	-7.94*** (10.28)	-10.57*** (4.09)	-9.00*** (10.92)	-9.17*** (12.47)	-7.28*** (3.31)	-8.87*** (12.25)

Notes: The dependent variable is the change in the logarithm of the nominal price in market i. All regressions employ a (market) fixed effects methodology with bootstrapped standard errors (1,000 replications). Robust absolute z-statistics in parentheses; significance level, * = 10 percent, ** = 5 percent, *** = 1 percent; significance levels are different than typical due to clustering adjustment of the standard errors. The bootstrapped standard errors are clustered at the market level. The first row shows the parameter estimates of the export ban reported in Table 1. The second and third rows provide estimates of the bans prior to 2011 and the 2011 ban, respectively, which were estimated together with a similar specification as the model reported in Table 1.

In most markets, at least one of the two seasonality parameter estimates was significantly different from zero at the 5 percent level (Table 3). Yet, the magnitude of the seasonal changes differs across markets and zones. Most Southern zone markets exhibited strong seasonal patterns. Yet, even within the Southern zone, the seasonality impact differs. Prices in Songea —a remote surplus market with pronounced seasonality—exhibit the greatest seasonal variability. Prices begin increasing in September, reaching their peak in February. As the harvest approaches, prices moderate falling rapidly in April-June (declining nearly 6 percent during those months). On a cumulative basis, seasonality induces prices to be 20 percent lower in June compared to February and 20 percent higher in December compared to August. Such cyclicality is consistent with approximately a 40 percent gap between the lean season's peak and the harvest season's low.

Figure 4. The Impact of the Latest Export Ban, Dar es Salaam



Source: Authors estimates.

Weather Anomaly

Weather anomalies (measured by a vegetation index) exert a strong impact on domestic maize prices, with favourable weather conditions resulting in larger harvests and lower prices, and vice versa. The weather anomalies variable, NDVI, is significantly different from zero in 14 markets, including several food deficit markets (Table 3). The Southern Highlands (Songea, Sumbawanga, Morogoro and Mbeya), exhibit the strongest price response (as a group) to weather shocks. A 10 percent anomalous increase in the NDVI index (for example, as experienced in December 2012) is associated with a 10.6 percent decline in prices in Songea. In contrast, Mbeya which is also a food surplus area, but has a better connected and developed market, would have experienced a price decline of 5.1 percent. This is because Mbeya benefits from greater absorption of surplus production by other markets while Songea does not. Consistent with this, seasonal price changes are larger in Songea than they are in Mbeya.

Table 3. Parameter Estimates for Panel Specification with Interaction Dummies, Nairobi

	Central	Coastal	Lake	Northern	Southern	National
M	-0.04*** (9.10)	-0.03*** (5.83)	-0.02*** (4.01)	-0.04*** (18.49)	-0.05** (4.34)	-0.04*** (8.80)
$(p_{t-1}^{w} - p_{t-1}^{i})^{*}I_{BAN}$	0.10*** (6.46)	0.18*** (5.40)	0.14*** (7.09)	0.12*** (12.58)	0.10** (4.11)	0.13*** (7.98)
$(p_{t-1}^{w} - p_{t-1}^{i})^{*}I_{NO\_BAN}$	0.17*** (10.80)	0.31*** (5.89)	0.25*** (5.03)	0.19*** (70.44)	0.15*** (7.62)	0.21*** (9.30)
$\Delta p_t^{W*}I_{BAN}$	0.22*** (6.56)	0.15 (1.58)	0.26*** (5.65)	0.34*** (27.60)	0.23*** (4.69)	0.23*** (7.60)
$\Delta p_t^{W*}I_{NO\_BAN}$	0.22*** (6.73)	0.14 (1.51)	0.26*** (5.68)	0.35*** (27.00)	0.22*** (4.71)	0.23*** (7.51)
Δp_t^{F}	0.36*** (9.60)	0.04 (0.29)	0.35*** (4.70)	0.29*** (15.11)	0.17** (2.27)	0.23*** (4.82)
Δp_t^{I}	2.89*** (9.99)	0.40 (0.43)	1.75*** (3.84)	2.76*** (8.46)	0.65*** (3.15)	1.61*** (4.97)
$SEASON_t^{1*}I_{BAN}$	0.04*** (13.09)	0.08*** (3.43)	0.03*** (3.84)	0.05*** (2.72)	0.06*** (5.95)	0.05*** (7.45)
$SEASON_t^{1*}I_{NO\_BAN}$	0.04*** (6.23)	0.09*** (5.24)	0.03*** (5.58)	0.04** (2.57)	0.06*** (8.10)	0.05*** (7.54)
$SEASON_t^{2*}I_{BAN}$	0.00 (0.10)	-0.02 (1.24)	-0.02*** (3.35)	0.04*** (7.22)	-0.03** (2.33)	-0.01 (1.07)
$SEASON_t^{2*}I_{NO\_BAN}$	-0.02*** (3.66)	0.00 (0.36)	-0.03*** (5.56)	0.00 (1.14)	-0.03** (2.58)	-0.02** (3.47)
$NDVI_t{}^{*}I_{BAN}$	-0.28*** (8.16)	-0.37*** (3.07)	-0.27* (1.74)	-0.59*** (5.55)	-0.86*** (3.98)	-0.38*** (6.18)
$NDVI_t{}^{*}I_{NO\_BAN}$	-0.19*** (3.17)	-0.40** (2.37)	-0.13** (2.01)	-0.43*** (3.73)	-0.21 (1.36)	-0.27*** (5.03)
R-square	0.27	0.23	0.24	0.30	0.21	0.20
Chi-square tests						
Difference in adjustment	0.07	0.14	0.11	0.07	0.05	0.08
Diff in Adj-Chi	29.56***	20.92***	11.16***	70.93***	21.05***	47.58***
Difference in NDVI	0.09	0.03	0.14	0.17	0.65	0.11
Diff in NDVI-Chi	1.31	0.05	0.95	6.39***	3.36**	3.30*

Notes: The dependent variable is the change in the nominal price in market i. All Regressions employ a (market) fixed effects methodology with bootstrapped standard errors (1,000 replications). Robust absolute z-statistics in parentheses, significance level, * = 10 percent, ** = 5 percent, *** = 1 percent; significance levels are different than typical due to clustering adjustment of the standard errors. The bootstrapped standard errors are clustered at the market level. The Diff in Adj-Chi and Diff in NDVI-Chi provide the Chi-squared statistics from a Wald test of the difference in the values taken by the adjustment coefficient and the NDVI anomaly, respectively, under Ban and No ban regimes.

Conclusions

The study summarized in this Research Brief found that Tanzanian maize prices are primarily influenced by Nairobi prices in the long run, but short-run price movements are governed by a constellation of domestic factors. Discretionary trade policies delay the adjustment towards long-run equilibrium. Weather shocks have a strong short-run influence on local prices. Harvest cycles matter as well, indicating the limitations of storage and transportation facilities. Fuel prices also exert a short-run influence.

The study also found that responses to weather shocks are less pronounced in local markets that are connected to regional and international trade networks. That suggests that trade mitigates the influence of local shocks. An export ban amplifies local price movements. Consequently, markets (such as Songea and Sumbawanga) with pronounced seasonality and greater sensitivity to weather anomalies are likely to be more seriously affected if climatic changes intensify.

An important policy conclusion from the analysis is that Tanzanian maize prices are not closely linked to South African maize prices while they are more closely linked to Nairobi. This distinction could afford a source of supplies during periods of high prices in Tanzania since price increases in one market are not likely to be affected in the other market.

Greater price uncertainty creates a disincentive for smallholder farmers to make investments that raise their agricultural productivity. This study points to two mechanisms that may reduce uncertainty arising from domestic sources. First, policies that encourage a shift away from traditional agrarian techniques (with the attendant problems associated with low input use as well as poor seed quality, storage, and irrigation) and towards more modern production and marketing methods may serve to partially mitigate the impact of domestic weather shocks. Second, and perhaps more importantly, a predictable trade policy regime will lessen the influence of a major source of price uncertainty.

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Note: For more information please visit SERA Policy Project website www.tzsera.com

Box 1. Econometric Model

This study estimates the following regression model specification:

$$\Delta p_t^i = \mu + \gamma_1 (p_{t-1}^W - p_{t-1}^i) + \gamma_2 \Delta p_t^W + \gamma_3 \Delta p_t^F + \gamma_4 \Delta p_t^I$$

$+ \gamma_5^S SEASON_t^1 + \gamma_5^C SEASON_t^2 + \gamma_6 NDVI_t + \gamma_7 I_{BAN} + u_t^i$, where

Δp_t^i , p_{t-1}^W , p_{t-1}^i, Δp_t^W, p_t^F and p_t^I denote the percent change in the local maize price in market i in month t, the world price in month t-1, the market price in month t-1, the percent change in the world price in month t, the percent change in the price of fuel in month t and the percent change in urban consumer price index in month t, respectively. I_{BAN} is the export ban taking the value of one when the ban was effective and zero otherwise. $SEASON_t^1$ and $SEASON_t^2$ denote seasonality and are set to $SINE[2\pi t/12]$ and$COSINE[2\pi t/12]$, respectively. $NDVI_t$ represents the Normalized Difference Vegetation Index anomaly.

The parameter estimates of the lagged price difference between external and domestic markets are expected to be positive (or not significantly different from zero in the absence of co-integration). Fuel (a key cost of production and transportation) price changes have a positive impact on maize price changes. The consumer price index, which captures other cost pressures such as increases in rural wages and costs of intermediate materials, is also expected to have a positive impact on maize prices. The export ban is expected to exert downward pressure on domestic prices since it increases availability of supplies that would have otherwise been exported. The trigonometric variables capture seasonal influences on food prices arising from the interaction of harvest cycles and inadequate storage and transport capacity. Finally, the NDVI, which could take non-zero values during the growing season, November-April, and zero in the remaining six months, is expected to have a negative impact on prices since a larger than expected harvest is associated with more supplies and vice-versa. In sum, the expected signs of the parameter estimates of equation (6), noted as superscripts, are: γ_1^+, γ_2^+, γ_3^+, γ_4^+, $\gamma_5^{S?}$, $\gamma_5^{C?}$, γ_7^+.

In the study, the effect of trade policy is examined and its interaction with the adjustment process, seasonality, and weather anomaly by re-parameterizing (6) as follows.

$$\Delta p_t^i = \mu + \gamma_1^T (p_{t-1}^W - p_{t-1}^i) * I_{No\_BAN} + \gamma_1^B (p_{t-1}^W - p_{t-1}^i) * I_{BAN} + \gamma_2^T \Delta p_t^E * I_{No\_BAN}$$
$$+ \gamma_2^B \Delta p_t^E * I_{BAN} + \gamma_3 \Delta p_t^F + \gamma_4 \Delta p_t^I + \gamma_5^{ST} SEASON_t^1 * I_{No\_BAN}$$
$$+ \gamma_5^{SB} SEASON_t^1 * I_{BAN} + \gamma_5^{CT} SEASON_t^2 * I_{No\_BAN} + \gamma_5^{SB} SEASON_t^2 * I_{BAN}$$
$$+ \gamma_6^T NDVI_t * I_{No\_BAN} + \gamma_6^B NDVI_t * I_{BAN} + u_t^i.$$

I_{NoBAN} takes the value of 1 when maize exports take place (zero otherwise) and I_{BAN} takes the value of 1 when an export ban is in effect (zero otherwise). It is expected that during no-ban periods the adjustment to external price shocks will be faster compared to export ban periods, thus $\gamma_1^T > \gamma_1^B$. Moreover, the effect of weather anomaly will be more pronounced during export bans, i.e. $|\gamma_6^T| < |\gamma_6^B|$. In the study, the results from this specification are reported and provide additional evidence to show that export bans both delay adjustments to the equilibrium with Nairobi and also exacerbate the impacts of anomalous weather events (see also Figure 3).

Note: Complete references and tables (including stationarity tests) are included in the full report.