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Impacts of Export Bans and Seasonality on Maize Price Transmission Between Selected Deficit and Surplus Markets in Tanzania: Evidence from Sumbawanga Market

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Abstract

Using maize prices data from Tanzania's National Bureau of Statistics from 2002 through 2017, this paper analyses the impacts of export bans and seasonality on spatial domestic price transmission between deficit markets and the surplus Sumbawanga market; using a vector error correction (VEC) model with export ban and seasonality dummy variables. Results show that 45% of deficit markets converged in the long-run with the Sumbawanga market, with a significant negative sign at 10% level. Moreover, 64% of market pairs negatively impacted spatial domestic price transmission, while seasonality had significant impacts on the same between market pairs. A Granger causality suggests that 63%, 27%, and 10% of market pairs were bi-directional, unidirectional and no causality, respectively. Thus, government policies should incline towards increaseing maize production rather than imposing ad-hoc export bans, improving storage facilities, and mitigating climate changes to insulate seasonality: all of which will—through market mechanism—moderate consumer prices and ensure profitability among maize sellers.

Keywords: spatial price transmission, export bans, seasonality, vector error correction model, granger causality, dynamic equilibrium

JEL Classification: Q17, M38

1. Introduction

Worldwide, maize has been recorded as the second most produced crop after sugarcane (Santpoort, 2020). Mango et al. (2018) recorded maize as one of the major staple food crops in many Sub Saharan African (SSA) countries. Porteou (2017) finds maize as the most important staple grain produced and consumed in East and Southern Africa, with a large share of the basic biomass need for many people in the region. Data from these countries shows that every year there is an increased cropped land for maize production by smallholders to meet future food demands. According to Santapoort (2020), between 2007 and 2017 the area under maize cultivation in SSA increased by about 60%. In terms of income and expenditure, maize forms about 6–21% of total households' expenditure, and 5.5–21% of total households' income earning in East and Southern Africa (Kornher, 2018). Smallholder's household budget expenditure on maize for Tanzania is about 15.7%, while 18.2% forms its share of income earnings.

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Africa is one of the largest recipients of food aid in the world. To reverse the trend, country-driven and sustainable agricultural policy is imperative (David, 2017). It is from this that the Maputo declaration on agriculture and food security adopted the Comprehensive African Agriculture Development Program (CAADP) aiming at poverty alleviation and food security through strategic agricultural development policies. Each country was required to commit at least 10% of its national budgetary expenditure towards agricultural development programmes to realize the CAADP targets.

Despite the efforts to mitigate hunger and incidences of food insecurity in SSA, including Tanzania, scant successes have been realized. One drawback to this strategic development effort has been rapid population growth. This is more often recorded as comparatively larger in the region than in other continents (David, 2017; Santpoort, 2020). Secondly, the problems are accelerated by shortfalls in domestic production caused by frequent and extreme climate variabilities that trigger changes in production, hence seasonality. The most common mitigation measures that many SSA countries, including Tanzania, opt for against these problems are trade restrictions, and especially export bans.

Export bans are not considered as panacea for hunger and food insecurity as they increase trade uncertainty, favour some economic agents, and penalize others economic agents along the food value-chain. Thus, bans are unsustainable and are non-permanent solution to the problem (Trevor-Wilson, 2015; Makombe & Kropp, 2016). Several studies have revealed that export bans are expected to protect vulnerable domestic urban consumers and net food buyers in rural areas. For example, Diao and Kennedy (2016), Trevor-Wilson (2015), and Makombe and Kropp (2016) argue that maize export bans are hurtful to producers through unpredictable prices and markets, and increased transfer costs. Besides, KI (2011) finds government trade restrictions make farmers receive lower prices than consumers pay in urban areas. Similarly, Diao et al. (2013) found that maize export bans decreased maize producer prices by 7–26%, reduced wage rate for low-skilled labour and returns on land: all of which hurt the majority of poor rural households, thus ending with increased poverty among rural households.

To comprehensively tackle hunger and food insecurity, appropriate food production and market policies are the necessary conditions that need to be considered. Appropriate food policies are capable of improving food sufficiency and security despite rapid population growth dynamics under ceteris paribus of political stability, economic growth, and expanding agricultural sector (David, 2017). Contrarily, inappropriately designed and implemented policies—like food export bans amidst surplus domestic production—result into mixed impacts to consumers, producers and any economic agent aligned along the respective crop value-chain addition.

Maize is the only staple food in Tanzania that is more affected by export restrictions policies and seasonality than other crops (Kiminski et al., 2016). Addressing the issue further on maize and rice, Kiminski et al. (ibid.) note that seasonality in maize production was 33%. Baffes et al. (2017) find that maize price variations in Tanzania were more largely driven by internal factors than external ones. Their study further noted that only one-third of maize price changes in the country comes from regional external drivers, whilst two-third emanated from domestic drivers. Citing the factors, the study points out export ban policies, seasonality, and weather anomalies as the most influential domestic drivers of maize prices.

For Tanzania, examining the impacts of export bans and seasonality on maize price transmission is critical since the crop is inseparable from income earning and food security. Despite being the staple food in the country (Pierre et al., 2018; Minot, 2010; BOT, 2017; FEWNET, 2019), maize is also produced for cash by many poor rural farming households (Ihle & von Cramon-Taubadel, 2010; Katinila et al., 1998; Ihle et al., 2009). About 65% of Tanzanian farming households cultivate maize; a large share of whom are the poorest, making maize a very important crop in the area of poverty reduction strategies, particularly among the urban and rural poor sections of the population (Zorya & Mahdi, 2009). These dualistic values in maize-food security and income generation make the availability and affordability of maize play a pivotal role in strategic political spheres of Tanzania's economy.

Kornher (2018) notes that domestic trade policies are important for domestic price level determination, income inequality mitigation, and revenue collection to finance public activities. Additionally, Martin and Anderson (2012) find that export bans are imperative in the protection of domestic market from international price fluctuations. However, poorly instituted export bans and use of grain reserves are discredited for siphoning public resources that are critical to finance public activities. Moreover, such policy options are equally detrimental to market functioning by creating uncertainty for optimal long-run food production, employment and trade opportunities (Magrini et al., 2013).

Several research works (e.g., Anderson et al., 2013; Rutten et al., 2013) show that countries that apply trade restrictions such as bans to insulate domestic markets from soaring food price and preserve food security, are more affected by seasonal food price variability. Yet, others (Götze, Glauben & Brummer, 2010; Abbott, 2010; Liefert et al., 2012; Martin & Anderson, 2012; Welton, 2011; Djuric, 2011), in exploring the effects of export ban policies on domestic food price from international commodity prices, found that applications of quantitative export or import restrictions strongly impede price transmission levels between markets.

Moreover, other researchers (e.g., Diao & Kennedy, 2016) record that although maize export bans favour consumers, they simultaneously penalize producers and other intermediaries along the food value-chain. Examining trade policies impacts on price transmission, Akhter (2016) finds public policy interventions, non-competitive market behaviours, and informal cross-border trade have strong impacts on price transmission processes when markets are integrated. When markets are integrated trade policies will positively influence price transmission; while the reverse holds true for non-integrated markets. Thus, staple food trade policies, especially of maize in less developed nations, are counter-cyclical and too distortionary to benefit both consumers and producers at the same time. Stressing on trade policies, Brummer, von Cramon-Taubadel and Zorya (2009) observed the impact of export bans on Ukrainian wheat and wheat flour market, and found that unexpected government interventions affected the extent of price transmission.

Furthermore, according to Porteous (2012), export bans contribute to increasing world prices; and increase unintended repercussions like market price volatility, market malfunctioning, and skyrocketing domestic trade costs: all of which ultimately exacerbate regional prices differences. Moreover, restrictions increase spatial food price differentials, particularly when price transmission is limited following existing market integration. Export restrictions can also directly increase the cost of domestic trade, which could further exaggerate national spatial price pass through. Thus, for better policy prescriptions, it is important to empirically establish the impacts of export bans before their practical institution.

Seasonality may also be attributed by changes in transport/transfer costs which varies with season. At times of rain seasons and dry seasons, transport costs are expected to be higher and lower, respectively. Accounting for the major cause of seasonality von Cramon-Taubadel (2017) points that variations in transport costs due to changes in seasons affect the rate of price shocks and their respective transmission between any two spatial markets. Supporting their causes and effects, USAID and FEWNETS (2010) found that seasonality in food supply causes trade reversals or variations in transactional costs, which ultimately create differences in price transmission results. Spatial price transmission variation 'regimes' are established between markets over time through seasonality; where high and low price transmission segments are realized. This would lead to seasonal variations in the magnitudes of spatial price transmission parameters. Amikuzuno and von Cramon-Taubadel (2012) estimated a VECM with seasonally regime switching adjustment parameters to test for such variations in price transmission between tomato markets in Ghana. The findings indicated acceptable patterns in the seasonal interplay between the main producer and consumer markets for tomatoes in Ghana.

The impacts that maize crop export ban and seasonality have on the domestic food price transmission given a market integration levels are a critical issue to address since they have both positive and negative impacts on various actors along maize value-chains. Knowledge on their impacts help to understand who gain and who losses from the policies among variously located actors along supply value-chains, and between spatial markets. Many studies like Akhter (2016), Porteous (2012), Götze, et al. (2010), Abbott (2010), Liefert et al. (2012), Martin and Anderson (2012), Welton (2011), and Djuric (2011) have examined impacts of export bans between a domestic market and a foreign market. The current work instead, examines the impacts on domestic market's price transmission of maize export bans and seasonality in Tanzania between a surplus and deficit domestic market.

2. Conceptual Framework

In a free market economy, price acts as the efficient allocator and reflector of the scarcity of economic resources. The extent to which price information flows from surplus to deficit markets will depend on market integration, which also depends on the degree of spatial price transmission between markets. When markets are integrated governments target few strategic markets to implement trade policies that are transmitted to other markets (Gitau & Meyer, 2019). For poorly integrated markets, information flow from surplus producing markets to deficit markets is limited, and trade policies and spatial price transmission between markets are negatively affected. Determining maize price by market mechanism rather than policy and trade instruments, like export bans, increases competition and lower prices since more players (buyers and sellers) participate along the maize value-chain (Gitau & Meyer, 2019).

For trade and policy restriction scenarios, market mechanisms do not operate fully to allow the transmission of price signals for efficient food exchange across spatial markets (Gitau & Meyer, 2018; Davids et al., 2017). Nevertheless, restrictive policies through unpredictable export bans increase short-run domestic supply and reduce domestic maize price. Depending on the extent of market integration, the market signals are transmitted from surplus markets to deficit markets benefiting a majority of poor net buyers in rural and urban areas. In support of the same argument Aragie et al. (2018) show that export bans on maize do highly benefit the urban non-poor, but diminish incomes of poor farmers together with maize consumption levels in the long-run.

Maize seasonality follows harvesting and lean periods, and it is amplified or diminished by the two; and this form another aspect of influence to price transmission under a condition of market integration. During drought periods domestic maize prices are exceedingly high, and governments are incentivized to institute export ban to ensure enough domestic food supply. Conversely, governments do not use export bans at periods of favourable climatic conditions, hence maize markets are controlled by market forces. Export ban institution follows seasonality in production: it is imposed mostly at times of poor domestic food production (food insecurity), and waived at times of enough domestic food supply. Due to high competition among buyers and sellers in the latter scenario, maize price is depressed to lower optimal level and transmitted accordingly to the rest of other markets depending on the extent of market integration. Seasonality is more dominant in markets that are poorly integrated, have seasonal production, and have infrastructural and trade restrictions that diminished trader's ability to transport surpluses to deficit markets (Brown & de Beurs, 2013).

Seasonality in food production and price have significant impacts on agricultural price variation, peaking before harvesting and dropping immediately after harvesting (Gilbert et al., 2017). The cyclical nature of agricultural food crops, particularly maize, implies seasonality in production and harvesting. Ups and downs in production further translate into price variation over space and time.

Such variations will be upwards or downwards depending on market integration levels; as such speed of price transmission variations can be higher or lower. Gilbert et al. (2016) find that domestic food price volatility is caused by seasonality and its transmission depends on structural market settings that needs situational policy option to address. Thus, the impacts of seasonality and export ban on price transmission from surplus to deficit markets will largely be dependent on the nature of market integration.

3. Theoretical Framework

The most common elements upon which markets can be defined include locations, seasons, and products (Ifejirika et al., 2013). However, the most unifying factor with which markets can be integrated is commodity price. As per McNew and Fackler (1997), and Fackler and Goodwin (2001), market integration entails the extent to which price innovations at one market are transmitted to another market location. It is from this fact that market integration is studied with references to the law of one price (LOP). In its strongest assumption of perfectly competitive market structure conditions, the law states that a homogenous commodity will be sold at the same price amongst all market locations. However, by relaxing the assumptions, the law accounts for the presence of trade costs, which demand the existence of a dynamic equilibrium that depends on price differentials between markets that is equals to, less, or exceeds trade costs.

When price pass through is greater than trade costs between markets, there will be both trade and price adjustment after an innovation. Contrary, markets will not be considered integrated if price pass through exceeds the cost of trade between markets because they are not error-corrected. Under a situation of non-error correction, markets operate inefficiently due to lower price transmission extents, and the law of one price does not restore to equilibrium due to poor market integration. The use of the law of one price is based on the possibility of arbitrage opportunities between spatially isolated markets—namely surplus and deficit markets—when price difference is greater than transaction cost/transport cost.

4. Methodology of the Study

4.1 Research and Sampling Design

This study employs longitudinal research design; a design which enables a researcher to assess the degree of relationship that exists between two or more time series variables. Since this study analyses the relationship between maize price in surplus and selected deficit markets, and the extent their transmission dynamics are impacted by export bans and seasonality, the longitudinal research design was deemed appropriate for these objectives. The study used purposive sampling design since the researcher selected time series data spanning from 2002–2017 due to data availability, and the presence of several ad-hoc maize export bans during that time in Tanzania. The choice of surplus and deficit markets was also purposive: the markets were from respective surplus and deficit agro-ecological zones. Specifically, the study targeted an investigation of the impacts of export bans and seasonality on domestic spatial maize price transmission in Tanzania between a surplus market (Sumbawanga) and selected deficit markets.

4.2 Data Sources and Types

Data for the study was gathered through documentation from the Tanzania National Bureau of Statistics (NBS). We employed two secondary price datasets: monthly maize prices from Rukwa, and selected deficit domestic markets in Tanzania. The data spanned from 2002–2017 because of data availability; and it was also a period when the government was frequently instituting and uplifting several bans on grain exports, particularly maize. Similarly, in the same time-span the country largely experienced varied climate changes that possibly impacted maize price transmission between markets through seasonality.

4.3 Model Choice and Specification

The study employed the standard vector error correction (VECM) model to measure the impact of export ban and seasonality on price transmission between surplus and deficit markets. The reason for the model selection was based on the fact that the two market pairs were co-integrated after co-integration test. A two market setting bivariate model was applied for this study, with price in market A (P^A) and market B (P^B) forming one cointegrated linear combination Z_{t-1} if, and only if, (P^A) and (P^B) are non-stationary and individually I(1). Assuming the two markets prices relate such that $P^A = \alpha + \delta P^B + \varepsilon_t$, a linear combination of the two is written as $Z_{t-1} = P^A - \alpha - \delta P^B = \varepsilon_t$ is I(0). Thus, changes in prices of each market are:

$$\Delta P_{1t}^A = \omega_1 Z_{t-1} + \sum_{i=1}^{p-1}(c_{11i}\Delta P_{it-1}^A + c_{12i}\Delta P_{2t-1}^B) + \varepsilon_{1t} \quad (1)$$

$$\Delta P_{1t}^B = \omega_2 Z_{t-1} + \sum_{i=1}^{p-1}(c_{21i}\Delta P_{it-1}^A + c_{22i}\Delta P_{2t-1}^B) + \varepsilon_{2t} \quad (2)$$

The price changes above are presented as a VECM, which combines both short-term and long-term relationships of price variables in one equation. While short-term relations are indicated by the coefficient variables in first differences (c_1 and c_2), the long-term relationships are represented by the residuals of the estimated co-integrated relationship $Z_{t-1} = P^A - \alpha - \delta P^B$.

The parameter ω stands for the speed of adjustments to the new equilibrium after some short-term deviations away from the long-run equilibrium. In the case of a valid long-term relationship, the parameter ω need to be negative, so that in a deviation from the long-term equilibrium it will be diminished by ω in the next period. The complete adjustment time to long-run equilibrium is attained at $(1/\omega)$ period of time.

In a standard form, a VECM representation between any two markets, say *A* and *B*, is written in a matrix form as:

$$\begin{bmatrix}\Delta P_t^A \\ \Delta P_t^B\end{bmatrix} = \varphi + \begin{bmatrix}\alpha^A \\ \alpha^B\end{bmatrix}\hat{\varepsilon}_t + \sum_d \Gamma_d \begin{bmatrix}\Delta P_{t-d}^A \\ \Delta P_{t-d}^B\end{bmatrix} + \mu_t, \ \mu_{t \sim N(0,\Sigma\, 2X2)} \quad (1)$$

From equation (1), P_t^A is price on market A at time t; P_t^B is price on market B at time t; Δ is the difference operator; and φ is the drift vector. The symbol Γ represents a 2×2 matrix coefficients which relates current price changes to past price changes, and d is the number of optimum number of lags selected based on some information criterion.

We made a slight modification to account for the impacts of export ban and seasonality on spatial maize price transmission between a surplus market (Sumbawanga), and selected deficit markets in Tanzania. Engle and Granger (1987) demands that any two I(1) variables that are co-integrated react dynamically in a combination to reflect their common behaviours. One advantage of the model is its ability to segregate and directly indicate long-run steady state between variables, and guarantee returns to the same after a short-run deviation from the former. The value of the VECM model over the VAR model is its ability to isolate and indicate both short-run dynamics and long-run equilibrium after short-run deviation. Amikuzuno and von Cramon-Taubadel (2012) find that I(1) variables are co-integrated in behaviour; thus satisfying the use of VECM modelling which exactly distinguish long-run equilibrium from short-run deviations that return to steady state equilibrium.

The vector error correction model (VECM) was used by including export ban and seasonality as dummy variables. Export ban and seasonality were assumed as the only factors that can throw prices out of long-run equilibrium for short-run periods of time and back to long-run spatial equilibrium after factors' shocks have diminished. Borrowing from (Pierre et al*.,* 2017) export ban and seasonality are modelled as:

$$\Delta \begin{bmatrix} P_{sdmt} \\ P_{ddmt} \end{bmatrix} = \alpha\beta' \begin{bmatrix} P_{sdmt-1} \\ P_{ddmt-1} \end{bmatrix} + \mathrm{T}\Delta \begin{bmatrix} P_{sdmt-1} \\ P_{ddmt-1} \end{bmatrix} + \Theta \left[\mathrm{Cos}\left(\frac{t\pi}{6}\right) \mathrm{Sin}\left(\frac{t\pi}{6}\right) \mathrm{D}^{Ban} \mathrm{D}^{\text{No Ban}} \right] + \varepsilon_{t..} \quad (4)$$

Where P_{sdmt} is price in surplus domestic market (Rukwa) at time t; P_{ddmt} is price in deficit domestic market (a selected market); $\mathrm{Cos}\left(\frac{t\pi}{6}\right)$ and $\mathrm{Sin}\left(\frac{t\pi}{6}\right)$ are cosine and sine functions to capture the impacts of seasonality due to harvest cycle, cyclical nature of production, inadequate storage, and transport capacity; ε_t is the error term (behaving as $\varepsilon_t \sim \mathrm{N}(0, \sigma^2)$. Variable Θ is the vector that captures impacts of several exogenous variables such as harvest cycles, cyclical nature of production, inadequate storage, and transport capacity on short-run dynamics of maize price (Baffes et al., 2017). The variable D is the export ban trading policy dummy, taking the value of 1 for the presence of export bans, and 0 otherwise. Export bans are expected to have reduced pressure on maize in deficit domestic market due to an increase in total domestic maize supply.

According to Gilbert et al. (2016), seasonality is normally caused by the cyclical nature of production, which necessitates inter-temporal arbitrage that requires storage and transport costs. The presence of adequate storage and transport facilities help to reduce the seasonality of food price, and improves food security among net food consumers (Eldenman et al., 2015). On contrary, the absence or inadequate supply of these facilities trigger and amplify the magnitude of food price seasonality. It is through these factors that price differentials before and after harvesting initiate and perpetuate food price seasonality. When storage and transport systems are improved and properly fixed, they smoothen food price gaps; and reduce unpredictable and unexpected components of price volatility; thus increasing market integration given the possibility of temporal arbitrage in transaction (Eldenman et al., 2015; Gilbert et al., 2016). Implicitly, this affects the extent of market integration by influencing the level of price transmission between surplus and deficit markets.

This study is similar to—but also different from—Jayne et al. (2008) and Mason and Myer (2011). While the former applied vector autoregressive modelling (VAR) based on Kenyan and Zambian maize prices, the latter uses vector error correction (VECM) model. Besides, even if this study borrow from Pierre et al. (2017) by using selected Tanzania maize markets and prices, it differs from the two in some respects. Firstly, it is an inward-looking analysis based on the impacts of domestic maize export ban and seasonality on domestic maize price transmission. Secondly, it spatially compares maize price transmission between selected surplus and deficit markets, while Pierre et al. (2017) considered the effects of National Food Reserve Agency (NFRA) on maize price in Tanzania. Also, they used changes in local and Nairobi markets as endogenous variables; and kept export ban, seasonality, price crisis, buy and sell premium, and net quantity as exogenous variables. Thirdly, although both studies apply monthly maize price data, the time spans differ: the current study uses maize price data from 2002–2017, while the former used maize procurement price and associated quantities sold from 2010/11 to 2014/15.

In their study, Baffes et al. (2017) used panel data for maize price in Tanzania to examine the main drivers of monthly changes in maize prices across eighteen (18) Tanzanian markets. Although it included seasonality, the study compared it with domestic and foreign markets, namely regional (Nairobi) and international (US Ghulf) markets. Different from Baffes et al. (2017), this study examines the impacts of export ban and seasonality in Tanzania using modified standard bivariate VECM model specification to capture the influence of export ban and seasonality on spatial price transmission between domestic surplus and deficit maize markets.

5. Results and Discussion

5.1 Descriptive Statistics

Table 1 presents summary statistics for maize prices in the surplus market in Sumbawanga region and selected domestic deficit market for the period spanning from 2002 to 2017. Table 1 indicates that the surplus market (Sumbawanga) scored the lowest average monthly price, variance, and maximum price over all other markets in the time period. This was as expected since, as a surplus market, we should expect lower prices with lower price volatilities in the Sumbawanga market. The Tabora market, however, scored the lowest minimum price for all the market in the study period. This was expected, and might have been due to the presence of a market in a surplus producing zone in the country. Generally, the results further reveal that the minimum values of the average maize price varied from TZS75/kg in Tabora market to TZS200/kg in the Dar es Salaam market; while the maximum values of the average monthly maize price varied from TZS965/kg in (Sumbawanga) market to TZS2,000/kg in Moshi market during the study period.

Table 1: Descriptive Statistics for Monthly Maize Prices in Sumbawanga (Rukwa) market and selected deficit Markets

Statistics	Mean	Variance	Skewness	Kurtosis	SD	Min	Max
Rukwa	312.1	36980.1	1.2259	4.0655	192.3	88	965
Dodoma	427.1	77104.7	1.8495	7.0754	277.6	100	1500
Arusha	617.1	111551	0.6465	2.6671	333.9	188	1700
Tanga	428.5	54395.6	1.4319	5.5504	233.2	105	1300
Moshi	576.8	187265	1.0776	3.8291	432.7	122	2000
DSM	644.5	105665	0.7101	2.7556	325.0	200	1590
Mtwara	576	81406.7	0.6792	3.0983	285.3	100	1500
Tabora	515.4	131050	0.8765	3.0523	362.1	75	1588
Shinyanga	564.5	123765	0.5527	2.2331	351.8	101	1500
Bukoba	613.1	118545	0.3857	2.0854	344.3	93	1500
Mwanza	486.1	59696.9	0.5081	2.6243	244.3	113	1100
Musoma	452	61005.4	0.8337	3.5232	246.9	91	1300

Source: Author's own computation

Table 1 further shows the skewness values for Sumbawanga, Dodoma, Tanga and Moshi were greater than unit, meaning that the series is highly skewed than normal distribution. The skewness for Dar es Salaam, Mtwara, Tabora, Shinyanga, Bukoba, Mwanza, Arusha and Musoma maize prices nearly mirrors a normal skewness of 0. Moreover, the kurtosis values in other markets were greater than 3, indicating that the price series were leptokurtic. For the case of Moshi, Mtwara, Tabora and Musoma, markets price series nearly mirror a normal kurtosis value of 3.

5.2 Unit Root Test

Traditional practice in time series analysis have been testing for stationarity before further steps in co-integration tests and model selection between unrestricted VAR or restricted (VECM). This has been a common practice ever since Nelson and Plosser's (1982) seminal work, which established that most time series are not stationary over time. As such, the use of classical OLS and statistical inferences ends with spurious results. The Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) formulas were used to test unit roots of nominal maize price series both at levels and their first differences. While the ADF test takes care of serial correlation in white noise term by adding lagged difference term, the PP test uses a non-parametric approach to mitigate the same without a lagged difference term. Results for both the ADF and PP tests are presented in Table 2, and shows that all the twelve markets' nominal price series were non-stationary at levels, but stationary at first difference. Mtwara price series was exceptional as it was stationary at levels by the ADF test, non-stationary under the PP test at levels, and stationary at first difference by PP.

Table 2: Results of ADF and PP unit Root Test on Nominal Monthly Prices

Variable	Augmented Dickey Fuller		Phillips-Perron		Order of Integration
	At level	*At first difference*	*At level*	*At first difference*	
Rukwa	-2.01041	-11.87408***	-1.909262	-11.75156***	I (1)
Dodoma	-1.475945	-14.44682***	-1.557660	-14.44682***	I (1)
Arusha	-1.430157	-14.12148***	-1.544086	-14.13728***	I (1)
Tanga	-2.466240	-11.84461***	-2.402936	-11.83941***	I (1)
Moshi	-1.107379	-16.42686***	-1.212768	-16.41832***	I (1)
Dar es Salaam	-1.448668	-13.44338***	-1.461849	-13.44363***	I (1)
Mtwara	-2.577200*	-	-2.507840	-12.85465***	I (1)
Tabora	-0.095751	-8.881992***	0.029475	-12.44417***	I (1)
Shinyanga	-1.504633	-9.824729***	-1.532730	-14.00886***	I (1)
Bukoba	-0.789678	-9.145624***	-0.842074	-14.77421***	I (1)
Mwanza	-2.487300	-9.523854***	-2.472402	-13.67136***	I (1)
Musoma	-1.984393	-9.553949***	-1.984646	-13.70176***	I (1)

Source: Author's own computation

5.3 Cointegration Test

5.3.1 Bivariate Johansen Co-integration Test

Though the bivariate Johnsen co-integration test reveals that at r=0, the null hypothesis is rejected because trace statistics exceed their corresponding critical values in all market pairs. On the contrary, the trace statistics at r=1 in all market pairs is less than their respective critical values, therefore the null hypothesis of no co-integration relationship between maize price at Sumbawanga market and the corresponding deficit markets is rejected. Thus, there is a long-run relationship between maize price in Sumbawanga and the selected deficit market pairs in Tanzania. Similarly, in all market pairs, when r=2 all pairs of maize price are found to be non-co-integrated. These results are consistent with those of Mphumuzi (2013) in the co-integration analysis of oil (fuel) price and consumer price index in the South African economy. They are also similar to those of Singla et al. (2014) in their study on Indian major apple markets; Ahmed and Singla (2017) on price transmission of Indian major onion markets; and Akpan et al. (2014) on rice price transmission in Nigerian markets.

5.3.2 Pair-wise Granger Causality Test

Pair-wise Granger causality test in the framework of VECM was performed after confirmation on order of integration of price series. Sumbawanga (Rukwa) market price series were used as a benchmark against which to compare with other eleven (11) selected deficit market price series. Granger causality tested the null hypothesis of no causality between the Sumbawanga (Rukwa) market and a deficit market. The results in Table 3 showed that seven (7) market pairs (equivalent to 64%) —Sumbawanga (Rukwa)-Arusha, Sumbawanga (Rukwa)-Tanga, Rukwa-Dar es Salaam, Rukwa-Mtwara, Rukwa-Tabora, Sumbawanga (Rukwa)-Shinyanga, and Sumbawanga (Rukwa)-Mwanza—revealed a bidirectional Granger causality between them. Only 36% of the rest market pairs—Rukwa-Dodoma, Rukwa-Moshi, Bukoba-Rukwa, and Musoma-Rukwa—had a unidirectional Granger causality. In the first two pairs, Rukwa's maize price Granger caused those of Dodoma and Moshi; whereas Bukoba and Musoma Granger caused Rukwa's maize price. Economically, it entails that the past maize price values in Rukwa region helped to predict maize price in Dodoma and Moshi beyond information contained in their respective past price values. Conversely, past maize price values in Bukoba and Musoma had a predictive power on Rukwa's maize price beyond information contained in its own past price values (Verbeek, 2012).

Table 3: Pair-wise Granger Causality Between Rukwa (Sumbawanga) and a Deficit Market

Null Hypothesis:	Observation	F-Statistic	Prob.
DODOMA does not Granger Cause RUKWA	191	1.1506	0.2848
RUKWA does not Granger Cause DODOMA		25.8237	0.0000***
ARUSHA does not Granger Cause RUKWA	191	5.0265	0.0261***
RUKWA does not Granger Cause ARUSHA		9.7968	0.0020***
TANGA does not Granger Cause RUKWA	191	6.0756	0.0146***
RUKWA does not Granger Cause TANGA		10.7714	0.0012***
MOSHI does not Granger Cause RUKWA	191	1.6422	0.2016
RUKWA does not Granger Cause MOSHI		19.3478	0.0000***
DSM does not Granger Cause RUKWA	191	3.9822	0.0474**
RUKWA does not Granger Cause DSM		9.7006	0.0021**
MTWARA does not Granger Cause RUKWA	191	5.3470	0.0218**
RUKWA does not Granger Cause MTWARA		5.4792	0.0203**
TABORA does not Granger Cause RUKWA	191	2.8433	0.0934*
RUKWA does not Granger Cause TABORA		11.8903	0.0007**
SHINYA does not Granger Cause RUKWA	191	2.9734	0.0863*
RUKWA does not Granger Cause SHINYAN		4.1314	0.0435**
BUKOBA does not Granger Cause RUKWA	191	8.4965	0.0040**
RUKWA does not Granger Cause BUKOBA		0.9920	0.3205
MWANZA does not Granger Cause RUKWA	191	5.6149	0.0188**
RUKWA does not Granger Cause MWANZA		6.0226	0.0150**
MUSOMA does not Granger Cause RUKWA	191	21.9605	0.0000***
RUKWA does not Granger Cause MUSOMA		0.6712	0.4137

Source: Author's own computation

5.4 Econometric Results

Table 4 reports the parameter estimates from the VECM model specification, where the coefficients of the error correction terms for each bivariate equation, except Arusha markets, are negative. The results are congruent with Pierre et al. (2018), who studied the effects of the National Food Reserve Agency on maize prices in Tanzania; and also with Brummer et al. (2009) in Ukrainian wheat market; and Davids et al. (2017) on Southern African maize markets.

This findings indicated that nearly 45% of domestic deficit markets paired with Sumbawanga market dynamically converged to steady state or long-run equilibrium. The Arusha market's error correction coefficient was positive and significantly different from zero at 5% level, meaning the market was explosive in nature.

Table 4: Estimation Results for Impacts of Export Ban and Seasonality on Spatial Maize Price Transmission

		Dodoma	Arusha	Tanga	Moshi	DSM	Mtwara	Tabora	Shinya	Bukoba	Mwanza	Mason
Error Correction Model		-0.5346	0.039**	-0.8636	-0.209*	-0.266*	-0.7129	-0.5410	-0.6258	-0.642*	-0.563*	-0.645*
		(0.107)	(0.023)	(0.114)	(0.059)	(0.067)	(0.107)	(0.102)	(0.108)	(0.088)	(0.083)	(0.093)
Surplus Market (Rukwa)		-0.238*	-0.562*	-0.091*	-0.425*	-0.408*	-0.161*	-0.236*	-0.213*	-0.213*	-0.272*	-0.246*
		(0.082)	(0.063)	(0.079)	(0.067)	(0.067)	(0.078)	(0.079)	(0.080)	(0.070)	(0.067)	(0.071)
Deficit Market		-0.321*	0.3011	-0.380*	-0.198*	-0.267	-0.344*	-0.3006	-0.5017	-0.7837	-0.335*	-0.3817
		(0.078)	(0.129)	(0.079)	(0.083)	(0.120)	(0.084)	(0.101)	(0.112)	(0.125)	(0.089)	(0.104)
Export Ban		0.005**	0.014**	0.003**	-0.001**	-0.014**	-0.008**	-0.004**	-0.008**	0.032**	-0.009**	-0.005**
		(0.027)	(0.029)	(0.023)	(0.026)	(0.025)	(0.026)	(0.024)	(0.024)	(0.028)	(0.025)	(0.025)
Season	Sine	-0.01**	0.02**	0.007**	-0.02**	-0.002**	-0.04**	0.030**	-0.01**	0.02**	0.005**	-0.06**
		(0.043)	(0.032)	(0.045)	(0.029)	(0.030)	(0.034)	(0.031)	(0.029)	(0.027)	(0.043)	(0.041)
	Cos	0.00**	-0.02**	-0.02**	0.01**	0.01**	0.05**	-0.02**	0.006**	-0.07**	-0.03**	0.053**
		(0.028)	(0.033)	(0.028)	(0.024)	(0.030)	(0.030)	(0.024)	(0.026)	(0.030)	(0.030)	(0.029)
R-squared		0.3793	0.3085	0.4611	0.3358	0.3475	0.4337	0.3943	0.3985	0.4626	0.4396	0.4570
Adj. R-squared		0.3623	0.2896	0.4463	0.3176	0.3296	0.4182	0.3778	0.3820	0.4479	0.4243	0.4421
Sum sq. resids		7.4023	8.2467	6.4271	7.9211	7.7818	6.7537	7.2231	7.1734	6.4084	6.6828	6.4761
S.E. equation		0.2011	0.2123	0.1874	0.2081	0.2062	0.1921	0.1987	0.1980	0.1871	0.1911	0.1881
F-statistic		22.3644	16.3269	31.3114	18.5022	19.4889	28.0272	23.8273	24.2454	31.5091	28.7122	30.7974
Log likelihood		37.9968	27.7887	51.3468	31.5948	33.2722	46.6625	40.3126	40.9642	51.6214	47.6588	50.6288
Akaike AIC		-0.3386	-0.2306	-0.4799	-0.2708	-0.2886	-0.4303	-0.3631	-0.3700	-0.4828	-0.4408	-0.4723
Schwarz SC		-0.2357	-0.1277	-0.3769	-0.1679	-0.1857	-0.3274	-0.2602	-0.2671	-0.3799	-0.3379	-0.3694
N		**191**	**191**	**191**	**191**	**191**	**191**	**191**	**191**	**191**	**191**	**191**

Short-run price equilibrium deviations did not show return to long-run equilibrium for convergence. Possibly, the scenario could be explained by the deficit nature of the Arusha market and boarder proximity with Kenya, a country which depends on maize imports from Tanzania. Nonetheless, informal trade across the border might have triggered the explosive nature of the market, especially during times of export bans. This supports the results of Pierre et al. (2018), which characterized Arusha—a town near a Kenyan boarder—as a maize deficit market in Tanzania, whose prices tend to be higher than the rest of the markets in Tanzania. Also, Minot (2010) finds Arusha's maize prices as the most co-integrated with international prices in relation to other markets in Tanzania due to boarder proximity and cross-border trade. Other markets like Dodoma, Tanga, Mtwara, Tabora, and Shinyanga scored negative insignificant error correction terms.

Moreover, Table 4 shows that previous monthly prices at the Sumbawanga market had a negative impact on current monthly maize price in the market at 10% level of significance. This result was expected due to arbitrage and speculative behavioural reasons of different actors in the maize value-chain. When previous monthly prices were higher, through this information traders might have expected that the next month's price will fall. Higher prices in the previous month might have motivated many arbitrageurs (sellers) to offer more maize supply in the market, leading to lower price in the next current month. Lagged price in Dodoma had negative effects on current prices at the Sumbawanga market: a unit percent change in Dodoma's maize price led to a 0.3205 reduction in price at the Sumbawanga market. This might have been caused by a higher maize transfer cost from Sumbawanga in relation to other nearby surplus markets, such as Iringa, and its own level of production at Kibaigwa.

The export ban coefficient scored a positive and significant impact value at 5% level of significance. This result contradicted that of Pierre et al. (2018), who found maize export ban to have negative impacts in both surplus and deficit market prices in Tanzania. Economically, this might have been caused by the central location of the Dodoma market in relation to other maize markets in Tanzania. Transport costs from Dodoma to the rest of domestic deficit markets is relatively lower compared to the well-known traditional surplus markets. Similarly, maize from Dodoma (Kibaigwa) has bigger domestic demand in relation to other markets. It is more preferred by many consumers in big domestic markets like Dar es Salaam for human consumption and animal feeds industries due to its quality. Thus, export ban on maize might have no reducing effects on domestic demand and price.

Seasonality was measured by a trigonometric function, which was used due to its ability to execute smooth transition cyclical phases of low and high. The results indicated the presence of seasonality in price transmission as revealed by alternative positive and negative sine and cosine coefficients in each market pairs. Additionally, the coefficients were almost equal in absolute terms, but different in sign; indicating a smooth and symmetrical price movement between periods. Sine coefficient had a negative impact on change in price at the Sumbawanga market, while a cosine coefficient had a positive sign regarding the same price. Coefficient of determination for the Dodoma-Sumbawanga market price was 0.3793, and had an insignificant speed of adjustment to long-run equilibrium following shocks from exogenous variables. Similar results were recorded in other earlier studies (USAID, 2014; Baffes et al., 2017; Pierre et al., 2018). This result implies that all the variables included in the bivariate model between Dodoma and Sumbawanga markets were able to explain nearly 38% of the variation in prices between the two markets, though the speed of short-run adjustment to long-run after deviations of the former was insignificant.

The Arusha-Sumbawanga market pair scored positive 5% insignificant error correction term coefficient. The export ban coefficient was positively related with the Sumbawanga current monthly prices; which contradicts the results in USAID (2014), and Pierre et al. (2018). Seasonality was measured by positive coefficient of sine and negative cosine functions, which were all statistically different from zero at 5%: meaning that seasonality influenced price transmission significantly between the two markets. Moreover, the extent to which the model explained maize price at Sumbawanga was 0.3085, meaning 31% was an explained variation. The results are consistent with other studies, such as USAID (2014), and Pierre et al. (2018).

The vector error correction model in the Tanga-Sumbawanga market pair revealed a negative speed of adjustment to long-run equilibrium, but not statistically significant even at 10% level. The lagged monthly maize price for both markets had negative effects with the current monthly maize prices at the Sumbawanga market. The sine and cosine coefficients show negative and positive impacts with current prices at the Sumbawanga market. Furthermore, about 46.11% of the model explained the variations with existing variables.

The Moshi-Sumbawanga market pair indicated that the speed of adjustment to long-run stead state equilibrium was 20.92% per month, and significant at 10% level, which is similar to the findings by Nikolic and Zaroja (2016), and Acosta et al. (2019). Previous monthly prices in both markets negatively affected the current monthly maize prices at the Sumbawanga market. Similarly, the export ban coefficient reduced maize price at the Sumbawanga market by 0.0013; a result that is in line with studies by Van Campenhout (2007), and Baffes et al. (2017). A seasonality impacts of negative 0.0187 and positive 0.0142 were recorded for the sine and cosine coefficients of the trigonometric function, with 0.3358 coefficient of determination; meaning that nearly 33.58% of the variations in current monthly prices in the Sumbawanga market was explained by the model. Similar study findings—such as by Nikolic and Zaroja (2016), Davids et al. (2017), and Pierre et al. (2018)—support this finding of the current study.

For the Dar es Salaam and Sumbawanga markets, it was found that the speed of adjustment to long-run stead state equilibrium was 26.664% per month, and the negative impacts from the lagged monthly price at the Sumbawanga market were both at 10% level of significance. Our empirical finding is in good agreement with Nikolic and Zaroja (2016), and Acosta et al. (2019). Previous monthly maize prices in Dar es Salaam negatively affected current monthly prices at the Sumbawanga market, though not statistically different from zero. The export ban coefficient scored a negative value, meaning that a monthly implementation of export bans reduced current prices at the Sumbawanga market by 0.0144, with a 5% statistical significance. Seasonality impacts of negative 0.0019 and positive 0.0078 were found for sine and cosine coefficients of the trigonometric function, with 0.3475 coefficient of determination; meaning that about 34.745% variation in monthly price at Sumbawanga was explained by the model. These values are scarcely distinguishable from those of previous studies, including Nikolic and Zaroja (2016), Davids et al. (2017), Pierre et al. (2018), Van Campenhout (2007), and Baffes et al. (2017).

The Mtwara-Sumbawanga and Tabora-Sumbawanga market pairs had negative insignificant impacts. The first lagged monthly price from Sumbawanga in pair with Mtwara and Tabora scored negative impacts, both of which were statistically significant at 10% level. The lagged monthly price from Mtwara had a negative significant impact at 10%, while that of Tabora was negative and insignificantly important in influencing current monthly prices at the Sumbawanga market. Both market pairs indicated negative significant effects with current monthly prices at the Sumbawanga market. Besides, the coefficients of determination were 0.4337 and 0.3943 for Mtwara-Sumbawanga and Tabora-Sumbawanga market pairs, respectively. These results were expected, and resembled those of many of other studies: including Zakari et al. (2014), Pierre et al. (2018), and Amikuzuno and von Cramon-Taubadel (2012).

Moreover, Table 4 shows that a negative insignificant impact was recoded on the Shinyanga-Sumbawanga market pair, whereas a negative and significant speed of long-run adjustment was found for the Bukoba-Sumbawanga market pair. About 64.24% monthly price adjustment between the Bukoba-Sumbawanga markets restore to long-run equilibrium was adjusted in a month. A short-run relationship between lagged monthly price in the Sumbawanga market and its current prices had negative impacts at 10% level of significance. Conversely, the relationship between lagged price at Shinyanga and Bukoba markets indicated insignificant negative impacts with the current monthly prices in the Sumbawanga market. The export ban coefficient scored a negative value for the Shinyanga-Sumbawanga market pair; and a positive impact of the same for the Bukoba-Sumbawanga market pair. The impacts of seasonality was noted with a negative sine coefficient and a positive sign cosine coefficient at the Shinyanga-Sumbawanga market pair; and a positive sine coefficient associated with negative cosine coefficient in the Bukoba-Sumbawanga market pair. The alternating negative and positive impacts on current prices at the Sumbawanga market were statistically significant at 5% level of significance. Additionally, the degree of fit of the model was 0.3985 and 0.4626 for the Shinyanga-Sumbawanga and Bukoba-Sumbawanga market pairs, respectively. This means that, when the Sumbawanga market was the dependent variable, 39.85% and 46.26% of their price variations were explained by own lagged prices, lagged prices of Shinyanga and Bukoba, export ban policy, and seasonality in each market pair. This was a moderate and near average model fit results.

The bivariate VECM results for the Mwanza-Sumbawanga and Musoma-Sumbawanga market pairs show a negative significant impact error correction term at 10% of significance. The monthly maize price adjustment speed of 56.28% and 64.54% towards long-run equilibrium after short-term deviations was found for the Mwanza-Sumbawanga and Musoma–Sumbawanga market pairs, respectively. The short-run dynamic relationship between lagged prices at the Sumbawanga market transmitted negative impacts in all market pairs to its own current monthly maize prices with a 10% level of statistical significance. The price lag in Mwanza produced negative significant impacts with current monthly prices at the Sumbawanga market at 10%, while the price lag in Musoma shows a negative insignificant impact on current monthly maize prices in Sumbawanga. The export ban coefficient registered negative values for both the Mwanza-Sumbawanga and Musoma-Sumbawanga market pairs. Seasonality was noted with positive sine coefficient and negative sign cosine coefficient in the Mwanza-Sumbawanga market pair; and a negative sine associated with a positive cosine coefficient in the Musoma-Sumbawanga market pair.

Apart from having alternating negative and positive impacts on current prices at the Sumbawanga market, the impacts were nearly symmetrically and statistically significant at 5% level of significance. Additionally, the degree of the model fit was 0.4396 and 0.4570; meaning that when the Sumbawanga market was the dependent variable, 43.96% and 45.7% of its price variations were explained by own lagged prices, lagged prices of Mwanza and Musoma, export ban policy, and seasonality in each market pair. This is a moderate and near average model fit results. Basically, our results discussed in the above section agree with several other empirical studies that have closely assessed Tanzania's and several other foreign maize markets. Baffes et al. (2017) find that two-thirds of domestic maize price variations were accounted for by such internal factor as seasonality (harvest cycle), weather shocks, and trade policies. They specifically noted negative significant impacts of export ban policy and seasonality on domestic maize price transmission between selected domestic and regional markets. Dillon and Barret (2016) find that world price variations had lesser impact on domestic maize price than were domestic factors.

4. Conclusions and Policy Implications

This study has empirically highlighted the impacts of export bans and seasonality on spatial maize price transmission between the Sumbawanga and selected deficit markets in Tanzania. The finding shows that 45% of domestic deficit markets that paired with the Sumbawanga market dynamically converged to long-run equilibrium with negative significant ECT at 10% level of significance. Moreover, 64% of the market pairs agreed that export bans had negative impacts on the extent of domestic spatial price transmission between markets; and seasonality had impacts on domestic spatial maize price transmission between surplus and deficit markets, and was statistically significant at 5%. This was revealed by alternating negative and positive cosine and sine coefficients for each price pairs in relation to spatial price transmission between surplus and deficit maize markets in Tanzania.

Moreover, the use of export bans to do away with food insecurity is not optimal for long-run solution to food insecurity and sustainable domestic food price insulation. Policy attention needs to shift efforts towards increased food production rather than imposing ad hoc export bans. The government needs to increase maize availability, reduce consumer prices, and ensure continued maize profitability among farmers and traders through a market resource allocation mechanism. This can be efficiently effected through spending more on inputs and extension services on maize production for sustainable food security attainment, rather than depending on export bans to guarantee domestic food security. Moreover, policies should be in place for the government and other stakeholders to increase and improve transport infrastructures and household level storage facilities; and to device methods to mitigate climate change to insulate elements of seasonality that will smoothen spatial price transmission between surplus and deficit markets.

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