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Spatial price transmission and trade policies: New evidence for agricultural products from selected sub-Saharan African countries with high frequency data

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by

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Spatial price transmission and trade policies: new evidence for agricultural products from selected sub-Saharan African countries with high frequency data

Lodovico Muratori^{*} and Susanne Fricke[†]

We assess the conjunctural impact of price insulating policies on spatial price transmission of maize, rice and wheat in Cameroon, Kenya and Tanzania in the period 2005-2015. We therefore separately estimate the impact of trade policies within two regimes of behaviour of the domestic price series: the first regime with an increasing trend of domestic prices and the second regime with a decreasing trend. We find a significant impact of trade policies in both price regimes. This is however much larger if prices are increasing. Our results show that trade policies were able to insulate the three analyzed countries from the price shocks on international markets during the food price spike crisis 2007/2008. Although the impact of these policy instruments proved to be relevant as a counter-cyclical measure during the food price spike crisis, these policies cannot be regarded as structural long-term solutions. This paper extends the existing literature on spatial price transmission in agricultural markets by estimating the impact of tariff and non-tariff trade policies using monthly data. Employing monthly data allows for a more precise assessment of short-lived movements in the analysed series, which could disappear due to a time aggregation bias at lower yearly frequencies. While monthly price series are provided in the GIEWS database, we obtain monthly ad-valorem equivalent tariff rates by a time disaggregation of the yearly effectively applied weighted average tariff rate from the WITS/UNCTAD-TRAINS database through the monthly trade policies from the FAO-FADPA. By presenting high frequency analyses and techniques that are able to detect non-linearities in the Data Generating Process (DGP), this study provides results which differ from what is stated in the standard literature (Anderson and Nelgen, 2012a) (Anderson and Nelgen, 2012b) (Anderson and Nelgen, 2012c).

Keywords: spatial price transmission, staple crops, trade barriers, food price spikes

JEL Codes: F14, O24, Q11, Q17

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Introduction

The nature of international price transmission of agricultural commodities and the assessment of its determinants became a key issue in the course of the food crisis in 2007/2008 when food importing countries suffered from a significant increase in poverty due to food price shocks (Yang et al., 2015). As they predominantly feature economies based on agriculture, questions concerning the nature and characteristics of the transmission of prices and price information for agricultural products are especially crucial for sub-Saharan African countries.

Anderson and Nelgen (2012b), Anderson and Nelgen (2012c) and Yang et al. (2015) provide evidence that during the food price spike crisis several countries increased their taxes on agricultural exports, reduced import duties and introduced import subsidies. In case of upward price spikes, the most commonly stated objective of these measures was to safeguard the domestic food security of consumers (Anderson et al., 2014, 311). Governments also expressed the intention to reduce inflationary or balance-of-payments pressures resulting from an upward price spike (Anderson and Nelgen, 2012b) (Anderson and Nelgen, 2012c).

The present study assesses the conjunctural impact of price insulating policies on spatial price transmission of maize, rice and wheat in Cameroon, Kenya and Tanzania in the period 2005-2015. We focus on the question whether price insulating policies were able to insulate the country from shocks on the international markets during the food price spike crisis. The three countries we select are highly dependent on cereal imports, with maize, rice and wheat taking up a considerable share of their overall import of agricultural products. Moreover, since all three countries introduced tariff and non-tariff barriers within the last years and especially in the course of the food crisis 2007/2008, they are especially suitable for our analysis.

This paper improves the approach developed by Anderson and Nelgen (2012b) and Anderson and Nelgen (2012c) by estimating the impact of tariff and non-tariff trade policies on spatial price transmission in the agricultural markets with the help of monthly data. The use of monthly data allows for a more precise assessment of short-lived movements within the analysed series. These could disappear otherwise, when using lower frequency data (i.e. yearly).

Since the Gauss-Markov conditions are not fully met by the time series we are analysing, we use further empirical methodologies which introduce some control factors for these

violations: fractional integration, non-linear regime shifting in the time series as well as country time-invariant effects in the panel analysis. The empirical strategy thus provides a consistent and efficient estimation of the coefficients of the price insulating policies.

Trade policies are defined as a set of tariffs, para-tariff and non-tariff equivalent measures which governments introduce in order to influence the trade volume and relative prices in their respective countries.

We use an indicator of trade policies, the ad-valorem equivalent tariff rate, which covers the same set of trade policies included in the nominal rate of assistance introduced by Anderson and Nelgen (2012a), Anderson and Valenzuela (2008) and Anderson et al. (2008), like specific, ad-valorem, mixed tariffs, non-tariff barriers, standards and behind-the-border measures.

The determination of the tariff rate is based on the tariff schedule and is extended to include the specificities of trade policies of each country, in order to take into account preferential trade agreements, border and behind-the-border trade measures.

Non-tariff barriers comprise technical measures such as sanitary or environmental protection activities as well as other measures traditionally used as instruments of commercial policy, e.g. quotas, price control, exports restrictions or contingent trade protective measures, as well as further behind-the-border measures, such as competition, trade-related investment measures, government procurement or distribution restrictions (UNCTAD, 2015).

Based on the prevalence of such trade policies with regard to agricultural products, Cameroon, Kenya and Tanzania were selected as country samples.

As a reference framework we use the “Law of One Price” and the Enke-Samuelson-Takayama-Judge spatial equilibrium models (Enke, 1951) (Samuelson, 1952) (Takayama and Judge, 1972).

We compare the results based on a time series approach with the ones derived from the panel analysis. ARFIMA models, which do not take into account non-linearities in the DGP and time-invariant country heterogeneity, bias the effect of trade policies on spatial price transmission and their ability to offset the impact coming from the price shocks on the international markets.

Instead, both Markov switching and panel models provide evidence that trade policies play an important role in all market situations, but the presence of non-linearities in the DGP and time-invariant country heterogeneity affects the price transmission mechanism.

Overall, this study separately estimates the impact of trade policies within the two regimes of behaviour of the domestic price series: in the first regime the trend of domestic prices is

increasing, in the second one it decreases. This highlights that trade policies play a role both in case of increasing and decreasing domestic prices. Nevertheless, price insulation policies are more relevant if prices are increasing, as the magnitude and the significance of the coefficients are larger within the regime of increasing trends of domestic prices.

We find that trade policies were indeed able to insulate the country from the price shocks on the international markets during the food price spike crisis, i.e. in times when insulation was needed most. It is noteworthy however, that, although the impact of these instruments could be proven to be relevant as counter-cyclical measures during the food price spike crisis, these policies cannot be regarded as structural solutions.

1. *Literature review*

While the question whether governments are able to effectively insulate the domestic economy from international price shocks has long been a matter of research, the practical relevance of the study of price transmission in agricultural markets again became evident in the course of the food crisis 2007/2008, when several countries introduced policy interventions in order to insulate themselves from price spikes at the international level. In the following, we briefly summarize the literature on price transmission, its specific relevance for agricultural markets and the role of price insulating policies.

1.1. *Price transmission background*

We focus on *spatial price transmission*, which is part of the *horizontal price transmission* and refers to cross-market price transmission which concerns the linkages between international and domestic prices and vice versa³ (Esposti and Listorti, 2013). Being an indicator for the integration of a country into the world market spatial price transmission is based on the theory of spatial arbitrage and relates to the hypotheses of the law of one price (Enke, 1951) (Samuelson, 1952) (Takayama and Judge, 1972). Standard spatial price determination models postulate that price transmission is complete with equilibrium prices of a commodity sold on competitive foreign and domestic markets (differing only by transaction costs). These models predict that changes in supply and demand conditions in one market will affect trade and therefore prices in other markets as equilibrium is restored through spatial arbitrage.

³ Another level of price transmission is *vertical price transmission*, which refers to the transmission of prices from consumers, triggered by demand shocks, to producers and vice versa. It describes price transmissions along a value chain (Swinnen and Vandeplass, 2014). Instead, a second part of horizontal price transmission is cross-commodity price transmission which refers to spillovers between prices of different commodities observed at the same position in the value chain (Esposti and Listorti, 2013).

Since a complete price transmission has important implications for economic welfare - see for example (Rapsomanikis and Conforti, 2006) - the question of price pass-through is of particular relevance for agricultural markets. Since agricultural commodities are considered to possess high poverty leverage, the study of price transmission in the agricultural markets is of significance for the reduction of poverty in developing countries (Mosley and Suleiman, 2007). This underlines the need for the assessment of determinants of price transmission.

1.2. Policy-related trade costs as determinants of price transmission

One major determinant of price transmission are trade costs, functioning as a wedge between domestic and international prices. Trade costs themselves are mainly driven by government policies. Especially border and domestic policies (e.g. export subsidies, non-tariff barriers, quotas and prohibitive tariffs) can have a strong impact on the degree of spatial price transmission. This is of particular relevance for African countries, where very high policy-related trade costs can reduce the long run pass-through of price information and increase the costs for importing and exporting. However, research on the exact nature of the relationship between specific policy measures and price transmission is still very limited and focuses mostly on advanced economies.

The role of domestic policies has been confirmed by Mundlak and Larson (1992) who find that domestic policies indeed affect prices. However, variations in world prices remain the dominant component in the variations of domestic prices. Moreover, Thompson et al. (2002) stress the point that policy-liberalizing reforms contribute to a more rapid convergence of domestic and international prices. Yang et al. (2015) also identify policy-related trade costs as a main determinant of the pass-through of food prices, next to the level of income. For the rice market in Bangladesh, Goletti et al. (1995) conclude that especially trade-related food grain policies had a significant effect on price co-movements and price transmission.

A particular aspect of the impact of domestic policies is the role of monetary policy and the impact of exchange rate movements. The pass-through of exchange rate movements to domestic prices is higher in industries with homogeneous goods, such as raw materials, among which are also agricultural goods (Bouakez and Rebei, 2008) (Ca'Zorzi et al., 2007). Furthermore, the impact of monetary policy on agricultural prices was stressed by Schuh (1974). Importantly, he concludes that the effects are different for small and large exporting countries since small countries face fixed world prices while large countries can influence

their terms-of-trade⁴ (Orden, 2002) (Schuh, 1974, 2-3).

1.3 The role of price-insulating policies

Price insulating policies are domestic trade policies which are employed to insulate the domestic economies from price shocks (Will and Anderson, 2012, 8) (Freund and Özden, 2008). These policies are thought to be able to reduce the conjunctural impact of imported shocks and cannot be regarded as structural trade policies as their focus is on the short term price transmission only.

Anderson and Nelgen (2012b) and Anderson and Nelgen (2012c) provide evidence that during the food crisis 2007/2008 several countries increased agricultural export taxes, reduced import duties and introduced import subsidies with the aim of ensuring domestic food security or to reduce inflationary or balance-of-payments pressures from an upward price spike. Also in this case, the general equilibrium effects are different for large and small countries. While large economies can influence international prices, small economies are not able to do so (Suranovic, 2010).

Empirical evidence on the effect of price insulation policies is mixed. Anderson and Nelgen (2012b) and Anderson and Nelgen (2012c) conclude that such policies were inefficient and ineffective: the larger the numbers of countries insulating their domestic markets, the more other countries perceive a need to do likewise. In turn, if all countries enforce these trade barriers at the same time, public interventions to stabilize agricultural prices remain without any impact (Anderson and Nelgen, 2012b) (Anderson and Nelgen, 2012c). Anderson et al. (2014) also show that price-insulation policies during the 2008 food crisis added to the spike in international prices for rice, wheat maize and oilseeds which actually diminished the benefits of price insulation. While these insulation policies resulted in a smaller increase of domestic prices for these commodities in some developing countries, other countries recorded an even higher increase in domestic prices than in the absence of such political acts.

Cioffi et al. (2011), show that the European price stabilization mechanism was able to insulate the European tomato and lemon markets against low import prices in fifty percent of the cases. Esposti and Listorti (2013) come to the conclusion that the suspension of EU

⁴ For a small exporting country, an overvalued exchange rate reduces the world price in domestic currency proportionately. In turn, lower prices imply an increase in the demand of crops and a reduction in total supply because mobile resources are moving away from the industry. In the case of a large country, on the other hand, domestic and foreign prices diverge by the extent of overvaluation, while the elasticities of demand and supply of both trading partners affect the degree to which domestic prices are going to sink and foreign prices are going to soar (Orden, 2002) (Schuh, 1974, 2-3).

import duties on cereals in 2008 was effective to offset the impact of a bubble of international cereal prices and claim that this relationship can be generalized to several markets and commodities.

In addition, Magrini et al. (2017) conclude that support policies aimed at the agricultural sector are effective and hence increase domestic food security.

In order to measure price distortions, these studies mainly rely on the usage of yearly data on the nominal rate of assistance (NRA), i.e. the percentage by which the policies that were implemented have raised the gross returns for farmers compared to the situation without any political intervention (Anderson, 2009). However, as it employs yearly data to compute the NRA, these studies on price-insulating policies are not able to detect short-lived movements of the price series.

This shortcoming implies that, up to now, the intra-annual impact of trade policies on spatial price transmission is not included in price transmission analysis.. Intra-annual price variability is due to weather conditions, seasonality (e.g. harvesting times) and demand shifts over the year and is thus highly relevant for investment, production and consumption decisions made by the economic agents.

Taking the example of the maize market, Figure 1 in the Annex shows how monthly data hence provides richer information than the corresponding yearly observations⁵.

2. Methodology

2.1. Identification strategy

The rationale of our identification strategy is to compare the results of different methodologies and, within the framework of a robustness analysis, to obtain a consistent and comprehensive interpretation of the relationship between price-insulating policies and prices: we applied the autoregressive fractional integration (ARFIMA), the Markov switching vector error correction (MSVECM) and a set of long panel models⁶.

In our study, domestic prices are taken as given and shocks to them are not modelled in the analytical framework of this study. Macroeconomic factors like exchange rates and all-commodity price inflation enable us to take into account the hypothesis of the non-neutrality of money, i.e. the assumption that monetary policy affects real agriculture prices.

⁵ The situation is similar for both the rice and the wheat market, even though the time series graphs are not reported in the Annex.

⁶ A long panel is a panel database where $T > N$.

We furthermore expect that there could be differences in the results of the analysis of each crop market because policy-makers might adopt different trade policies for each of them. Indeed, domestic consumers and producers have distinct preferences towards each agricultural product and its specific cultivation properties, post-harvest preservation features and international integration of their respective markets determine whether a given trade measure will be effective.

Time series from monthly data allow for a more precise assessment of short-lived movements within the analysed series which could have disappeared when analysing a lower data frequency due to a time aggregation bias. Monthly data provides a richer set of information about the time series than yearly observations (see also Figure 6 in the Annex)⁷. The analysed time series violates the Gauss-Markov conditions as can be seen from the result of the specifications tests, which are reported in the Annex. Such tests identify fractional integration, non-linear regime shifting in the time series as well as country time-invariant effects in the panel analysis.

The empirical methodologies adopted for this study introduce some factors into the estimation which control for these disturbances.

These techniques do not allow for a separate identification of the estimate of these disturbances from the error term. Yet, the coefficient of the price insulating policies, which is the focus of this analysis, is consistent and can be properly identified.

The main strength of the ARFIMA is that this model is able to separate the fractionally-integrated long-run dependence, which cannot be expressed by a stationary ARMA model, from the short-run parameters p and q , which are the focus of interest of this analysis.

The added value of the MSVECM is that this approach allows us to take into account non-linear shifts in the general state of the trading system or of the surrounding economic and political environment.

Finally, the techniques for long panels have the advantage that they are able to control for the presence of time-constant omitted – because of failed measurements or non-existent observations – variables which are correlated with the explanatory variables as such panel databases contain information on both inter-temporal dynamics and individual heterogeneity (Hsiao, 2007, 5) (Hsiao, 2014, 1-10) (Baltagi, 1998)⁸.

⁷ To note that high-frequency analysis reduces the availability of the macroeconomic variables, since, for instance, GDP and trade flows, are not collected on a monthly basis.

⁸ Additionally, if the behaviour of each observation-unit is similar, conditional on certain variables, panel data enables us to obtain a more accurate description of the behaviour of each observation-unit because they supplement observations of one unit with data from other units (Hsiao, 2007, 6) (Hsiao, 2014, 1-10). Panel

2.2. Selection of the Sample

We choose maize, rice and wheat as sample crops for our analysis. They are politically and economically relevant in terms of trade, the generation of welfare and food security. Furthermore, these crops are a significant part of the domestic food supply and income generation. As sample countries we choose Cameroon, Kenya and Tanzania, all of which import a large share of maize, rice and wheat. The overall import shares of the three crops amount to around 40% for Cameroon and Tanzania and around 30% for Kenya in 2013 (FAO, 2016c).

We focus on the analysis of imports only since spatial price transmission analysis for exports is not eligible for these countries since they can be considered small countries in terms of world trade⁹. The “small open country hypothesis”, which states that there is no transmission from domestic to international prices while transmission from international to domestic prices, holds (Suranovic, 2010).

Moreover, the three selected countries are suitable for our analysis since several price insulating policies were implemented during the food price spike. While Kenya’s reduction of import tariffs points towards a trade liberalising policy, the imposition of a number of rules and regulations on food products illustrates the rise in non-tariff barriers (FAO, 2016d). Similarly, Cameroon and Tanzania adjusted the import duties on rice and wheat (FAO, 2016b). Tanzania also reduced import tariffs for food products, but at the same time introduced periodic export bans on staple commodities, such as for example the temporary export ban on maize in 2008 which was later expanded to all cereals (FAO, 2014).

The significance of the analysis of these three countries is also amplified by the fact that these countries are regarded as highly competitive within the Sub-Saharan African region and are relatively well integrated in global trade¹⁰.

datasets are also better able to study complex issues of dynamic behaviour (Baltagi, 1998).

Finally, if the data is non-stationary, long-panel methodologies provide a computational advantage as unit-root tests for long panels have a higher power than the ones for time series. Moreover, unit-root tests for long panels follow a Gaussian asymptotic distribution, while the ADF and the Philips-Perron converge to non-standard limiting distribution) (Lütkepohl, 2005) (Hlouskova and Wagner, 2006) (Hsiao, 2007, 7) (Hsiao, 2014, 1-10).

In addition the increase of efficiency in the estimation of long panels with respect to time series or cross-section samples is possible but not necessary as large datasets might imply a rise of heterogeneity in the sample and should be evaluated case-by-case.

⁹ This implies that they only reveal a very small share in world exports and imports.

¹⁰ This is for example underlined by the Global Competitiveness Index which consists of sub-indices comprising institutions, infrastructure, macroeconomic environment, health and education or financial market development and takes scores from 1 to 7, i.e. from a low degree of global competitiveness to a high degree of global competitiveness. In 2015, Kenya (score: 3.9) and Cameroon (score: 3.7) rank above the Sub-Saharan African average (score: 3.6) and Tanzania (score: 3.6) just within the Sub-Saharan African average (World Economic Forum, 2015).

2.3. *Econometric Model*

In order to assess the impact of trade policies which have been enforced by the governments of Cameroon, Kenya and Tanzania in the period of 2005-2015 we carry out a partial equilibrium analysis. The effect of price insulating policies on other countries or on the international prices is not addressed. Since all African countries are small in terms of world trade¹¹, the general equilibrium effect of price insulating policies is very limited and price transmission occurs just from international to domestic prices.

The main econometric strategy of this study consists in carrying out a robustness analysis by comparing the results of the different econometric approaches.

The econometric model is derived from an extended version of the law of one price, which can be expressed in the following way:

$$P_{dom,j} = (E_{dom/int} P_{int,j})$$

with P_{dom} as the (average) domestic price, $E_{dom/int}$ the exchange rate and P_{int} as the international price.

It is possible to take the logarithmic form of the previous equation:

$$\ln(P_{dom,j}) = \ln(E_{dom/int}) + \ln(P_{int,j})$$

In this approach, the basic law of one price is extended by introducing the logarithm of the all-commodity inflation π . Furthermore, the international price is replaced by the logarithm of the border price $P_{border,j}$:

$$\ln(P_{dom,j}) = \ln(E_{dom/int}) + \ln(P_{border,j}) + \ln(\pi) + \varepsilon$$

The border price $P_{border,j}$ is the actual import price after the application of the ad-valorem equivalent tariff rate to the international price and is computed as $P_{border,j} = [(1 + T_{t-1}) * P_{int,j}]$, where T_{t-1} is the ad-valorem equivalent tariff rate at time $t-1$. This relationship is estimated by crop for each country.

Inflation and border price have an impact on the price transmission process because international markets are not regarded as perfect and some frictions in the price formation of each crop are allowed.

If such variables are not taken into account within the regression, the error term ε has a

¹¹ This implies that they only reveal a very small share in world exports and imports.

structure. Their inclusion in the regression, however, renders the error term stochastic.

In this framework, prices of other food items, materials, etc. included in the all-commodity price inflation index do not transmit completely and quickly to the international price of the crop j and are thus regarded as a separate control variable. Furthermore, the introduction of tariff and non-tariff barriers creates some distortions and reduces the degree of transmission between international and domestic prices. Such distortive effect is explicitly taken into account for the determination of the main explanatory variable, as explained in the section about the database building.

The introduction of exchange rate and all-commodity inflation in the econometric specification allows us to control for the correlation between changes in money supply and variations of real agricultural prices, as assumed by the money non-neutrality hypothesis.

While there is no endogeneity between P_{int} and P_{dom} (small country assumption), ad-valorem the equivalent tariff rate could be endogenous since policy-makers set the rate according to the prevailing domestic price. The ad-valorem equivalent tariff rate T_{t-1} is used to avoid endogeneity. Since the model is log-log, the coefficient can be interpreted as elasticity.

Time series and panel econometrics aim at understanding the structure of the unknown Data Generating Process (DGP) and the price adjustment mechanism. On basis of such information, it is possible to disentangle some relationships among variables. The advantage of comparing several econometric approaches is to gain a complex and more robust and differentiated picture of the underlying price mechanism and transmission processes.

3. Data

For each of the three African countries we consider, about 120 monthly price observations between January 2005 and December 2015 are available¹². The crops analysed are included in the 2017 Harmonized Commodity Description and Coding System under the chapter 10 (Cereals)¹³.

¹² Employment of monthly data reduces the number of available covariates, for instance data on GDP and trade flows are not collected on a monthly basis, but it improves the quality of the assessment of the short-lived movements of the time series, which cannot be detected at lower yearly frequency because of time aggregation bias.

¹³ They are identified with a three 4-digit code, i.e. 10.01. for wheat, 10.05. for maize and 10.06. for rice. Such level of detail in the product classification is enough to answer the research question addressed in this study (Amjadi et al., 2011) (World Bank, 2016b). The 6-digit HS classification could provide more information about the trade flows of these crops than the 4-digit HS codes. Nevertheless, such level of detail is not available for all countries and crops. Moreover, the difference between maize in seed (1005.10) or in other form (1005.90) or between brow rice (1006.20) and broken rice (1006.40) is of minor relevance for the research question addressed in this study

The yearly ad-valorem equivalent tariff rates¹⁴ are provided in the WITS (World Bank Integrated Trade Solutions)/UNCTAD-TRAINS (Trade Analysis Information System) and they consist of tariff, para-tariff and non-tariff measures¹⁵.

Starting from the yearly data provided in the WITS/UNCTAD-TRAINS database, we computed their time disaggregation by exploiting the information entailed in the FADPA database (UNCTAD, 2016) (FAO, 2016b) (World Bank, 2016a).

The FADPA database gives precise information on the monthly policy changes applied by each country. Nevertheless, the FADPA database records just the ad-valorem equivalent tariff rate at the time of adoption and the termination of a given trade policy.

Therefore, the WITS/UNCTAD-TRAINS database is needed to build up a complete time series and to include data concerning the periods when trade policies were not changed.

This operation is accurate as FADPA and WITS databases provide equivalent results. Indeed, they employ a similar approach for the computation of tariff and non-tariff barriers. This time disaggregation is possible as tariffs and non-tariffs barriers as well as trade policies are quite constant over time. The combination of these three datasets allows for the detection of discontinuous change of trade policies on a monthly basis and to build up a database of monthly ad-valorem equivalent tariff rates.

The employment of the average ad-valorem equivalent tariff rate is preferred over the nominal rate of assistance (NRA) because of the lack of information needed for the computation of the latter (Anderson and Nelgen, 2012a) (Anderson and Valenzuela, 2008) (Anderson et al., 2008) (Basu et al., 2010) (UNCTAD, 2005). Indeed, the producer and border prices series are not available for the chosen crops in the analysed countries;

¹⁴ On the one hand, the indicators employed exhibit some disadvantages because their accuracy depends on the quality of the underlying data and the selection of the most appropriate weighting scheme. In addition, the weighted tariff rate does not allow for a differentiation between the dissimilar effect of trade policies on consumers and producers as well as for taking into account different elasticities between different products in the same country or the same product in different countries. This limitation, however, we regarded to be of minor relevance, since it is not the main goal of this study to provide such a differentiated picture with respect to the groups of economic agents, crops and countries. It is important to be aware that unweighted average tariff rates tend to overstate the height of average tariffs because they include very high and prohibitive tariffs whereas weighted average tariff rates tend to be biased downwards because the import levels of high-tariff items tend to be low. On the other hand, weighted tariff rates allow for the inclusion of some trade diversion/creation effects among countries which are due to regional trade agreements or similar areas. A further issue in the computation of the weighted average ad-valorem equivalent tariff rates is that a problem of endogeneity could arise because prohibitive tariffs lead to zero import flows. In this regard, fixed weights and past period trade values are used to avoid such downwards bias of this indicator and soften the endogeneity problem (Fugazza, 2013).

¹⁵ This indicator is the result of a far-reaching sensitivity analysis, which was carried out by the UNCTAD/World Bank team (UNCTAD, 2016) (Basu et al., 2010) (UNCTAD, 2005) (Fugazza, 2013). The sensitivity analysis consists of different approaches in order to give a reliable estimate of the ad-valorem equivalent tariff rate, which is weighted according to the yearly/ monthly import share from partner countries.

therefore it is not possible to compute this indicator from the raw data.

The monthly all-commodity price-index for fuel and not fuel goods as well as the exchange rate (national currency per US dollar, period average) are derived from the IMF database (IMF, 2016).

Monthly data on international and domestic prices of agricultural crops are taken from the FAO-GIEWS (Global Information and early warning system) Database (FAO, 2016a). Domestic prices are measured as the average of the values at different retail markets in several areas of each country.

Price data are collected by the FAO from national statistical authorities and harmonized in order to make possible cross-country comparisons. Although the collection and harmonization procedures carried out by the FAO is rigorous and this database is largely used for empirical analyses, readers should be aware of such a caveat.

A time series and an unbalanced as well as balanced panel databases were built and used for the estimation¹⁶.

4. Results of the analysis

We compare the behaviour of the price series in three sub-Saharan African countries: Cameroon, Kenya and Tanzania. for the three major staple crops maize, rice and wheat.

During the food crisis 2007/2008, these three countries introduced several trade policies.

In the first part of this study, we analyse each country separately by employing time series econometrics methodologies. Later on, we build a panel database from the series of the three countries and in this way time-invariant country effects are controlled for.

Panel databases are only available for rice (Cameroon and Tanzania) and maize (Cameroon, Kenya and Tanzania). Given the limited availability of tests and models for unbalanced long panels, the analysis is carried out on balanced panels only.

In order to properly mimic the Data Generating Process (DGP), the selection of the most appropriate econometric model is data-driven.

Therefore, several preliminary tests are run. The results for the preliminary tests are depicted in the Annex in Tables 1-4. In most of the cases the time series exhibits significant seasonal components. Seasonality in the agricultural sector is mostly supply-led because the availability and perishability of products strongly influence the market and vary across the year according to weather conditions. To get a consistent estimate of the effect of the

¹⁶ In the unbalanced panel database there are some missing values because we did not implement an imputation strategy for the missing values. Indeed, all possible strategies were regarded as not being sound enough and not able to avoid biases in the database-building.

variables of interest, seasonality is removed. We use the X13 algorithm-based methodology¹⁷. All standard preliminary tests are then applied to seasonally adjusted time series.

The specification tests provide evidence that the analysed time series violate the Gauss-Markov conditions. The factors to control for these violations, like fractional integration, non-linear regime shifting in the time series as well as country time-invariant effects in the panel analysis allow for a consistent and efficient estimation of the relationship between price insulating policies and prices within the framework of a robustness analysis¹⁸.

Since most of the time series in the database are fractionally integrated, an Autoregressive Fractionally Integrated Moving Average (ARFIMA) model is computed.

The ARFIMA model allows for the separation of the fractionally-integrated long-run dependence from the short-run response of the time series which are the focus of interest of this analysis.

In all ARFIMA models it is evident that the impact of the international macroeconomic framework is key to the determination of domestic price. In particular, both the coefficients of all-commodity price inflation and exchange rate or at least one of them are significant.

The ARFIMA models are appropriate to describe the DGP, the fractional integration parameter d being large (between 0.33 and 0.5) and highly significant. The analysed countries are highly integrated with the international economic environment. The outcome with regard to the importance of the trade policies is mixed. While the coefficients of trade policies were not significant for the maize market in all three countries as well as for the rice market in Tanzania, such measures played an important role in insulating the Cameroonian rice and wheat market from international price shocks. These results give rise to an ambiguous interpretation and suggest that more advanced tests and methodologies should be applied.

¹⁷ The X13 algorithm-based methodology is an extension of the X12 and X11 ARIMA methods. In this approach, each time series Y_t is assumed to be the multiplicative composition of the three parts of trend-cycle (C_t), seasonal (S_t) and irregular component (I_t): $C_t \times S_t \times I_t$. The trend-cycle component is obtained by applying a trend moving average to the original series Y_t , which is then de-trended: $SI_t = S_t \times I_t = Y_t / \hat{C}_t$. Then, a quarterly or monthly seasonal moving average is applied to the de-trended series SI_t and a seasonally-adjusted time series is obtained: $SA_t = Y_t / \hat{S}_t$. The Henderson symmetric filter are applied to seasonally-adjusted time series SA_t to obtain the trend-cycle component and the process is iterated from the first step. Henderson (1916) minimize the sum of squares of the third difference of the moving average series, by applying symmetric filters in the middle of the time series and asymmetric weights at its end and at its start. This procedure removes all irregular variations shorter than 6 months and preserves cyclical patterns longer than one year (Ladiray and Quenneville, 2001).

¹⁸ Since a logarithmic transformation was applied to all variables, the coefficients of the regression can be interpreted as elasticities.

Since the Zivot-Andrews tests suggest the existence of structural breaks for many time series, a set of Markov Switching Models with a threshold and two regimes was estimated. All models are run without constant.

The results shown in Table 5 and in Table 6 confirm that the DGP behaves differently in the two regimes. While the main divide between the two regimes for wheat market is the absolute value of the domestic prices, the key element for the maize and rice market for the definition of the two regimes is the increasing or decreasing trend of domestic prices.

The variables of interest exhibit different significance and magnitudes, depending if they lie in one or in the other regime.

The relevance of international drivers in spatial price transmission is confirmed: in particular, the coefficients of the exchange rate are positive, very large in magnitude and very stable in significance across all specifications.

Only if the trend of maize domestic prices decreases, the exchange rate in Kenya and Tanzania does not play a role. The opposite situation occurs for the rice market in Tanzania, where the increasing trend of domestic prices renders the exchange rate not significant.

Moreover, the all-commodity-price inflation is important in several specifications, but its coefficient level of significance is much more unstable. In some cases, the coefficient is positive; in some other cases it is negative.

From the estimation of the Markov switching models, which allow for taking into account the existence of non-linearities and the prevalence of different behaviours of DGP in the two regimes, the interpretation of the role of trade policies changes in a significant way.

The prevalence of one or the other regime in the maize market determines the magnitude and significance of the coefficient for trade policies.

In the rice market, the coefficients of trade policies are highly significant for all countries and their magnitude is larger with increasing than decreasing domestic prices.

Moreover, the regimes of the wheat market in Cameroon are not determined by the trend of domestic prices, but by their absolute value. In the DGP of wheat domestic prices, there are two regimes: the former with high average domestic prices, the latter with low domestic prices. In both regimes, the coefficients of trade policies are highly significant.

Furthermore, such coefficients are positive for Cameroon and Tanzania if the DGP lies in the regime with the increasing trend of domestic prices, while they are negative or not significant if a decreasing trend of domestic prices is prevailing. In contrast to that, in Kenya the coefficient for trade policies is positive if the decreasing trend of domestic prices prevails, while it is negative if the trend of domestic prices increases.

If the sign of the coefficient is the same as for the trend of domestic prices and smaller than one, domestic prices grow less than international prices: trade policies are able to insulate the country from price shocks on the international markets during the food price spike crisis. The price insulation effect of trade policies is stronger if the coefficient has the opposite sign of the direction of the trend because the trade policies are able not just to speed down the trend of domestic prices, but also to offset it.

Such offsetting effect takes place on the maize market in Tanzania and on the rice market of Cameroon and Tanzania if the trend of domestic price decreases.

Across all markets, countries and specifications, the states are very persistent: transition probabilities to be in a given state in the next period conditional on being in the same state in the current period are very high, ranging from 85% to 99%. Both the states with increasing or decreasing trend of domestic prices as well as with high or low domestic prices exhibit similar persistence. This matrix of transition probabilities means that the DGP is very unlikely to switch from one state to the other. The impact of trade policies on spatial price transmission in the maize and wheat markets is much larger if the DGP lies in the regime with increasing trend of domestic prices than in the case where the regime of decreasing trend of domestic prices prevails.

Important insights can be also obtained from the panel analysis. Results are depicted on the Annex in Tables 7-13. In particular, the markets of maize and rice look very different here. While the panels concerning the rice market are stationary, the database for maize is non-stationary and non-cointegrated. This implies the application of different estimation techniques for the two panels.

In this framework the significance of international macroeconomic factors is confirmed: either the all-commodity inflation or the exchange rate or both are highly significant. Nevertheless, the ability of governments to insulate the country from international shocks through trade policies is not similar between the two markets.

On the one hand, countries were able to insulate domestic economies from rice price shocks on the international markets in the analysed period, since the coefficient for trade policies in the rice market is highly significant, positive and smaller than one. . On the other hand, the non-significance of the coefficient for trade policies in the maize market provides evidence that such instruments had no price insulation effect in this case.

At the same time, tests for dependence across countries in the database were computed. The CD test shows that there is no cross-sectional dependence between countries. The significance of the coefficients of the international macroeconomic variables and the output

of the CD tests are a hint at the fact that the countries are strongly dependent on the development of the macroeconomic framework, but are not linked by contagion processes. In particular, the domestic variables of interest are not directly influenced by their value in the other countries of analysis but by the international environment.

The insulation effect of the trade policies analysed is quite relevant in terms of welfare of an average consumer. If the case of the Kenyan maize market is taken into account, such instruments are able to insulate the domestic markets from shocks on the international markets by allowing that less than 20% of the increase of the international price of maize is transmitted to the domestic market if a decreasing trend of domestic prices prevails.

On the other hand, if on the Kenyan maize market prices increase, trade policies allow that less than 25% of the international price of maize is transmitted to the domestic market.

A positive shock of 25% on the international maize price, if fully transmitted to the domestic market, implies an increase of the Kenyan domestic price by 77 USD each tonne since the Kenyan average domestic price for maize was 308 USD each tonne between January 2006 and February 2016. The enforcement of price insulation policies makes it possible that the domestic price increases less than the international price and, in particular, just by 15.50 and 14.50 USD each tonne if the trend of domestic prices is decreasing or increasing, respectively.

5. Conclusions

We develop an empirical model of spatial price transmission and address the questions how price shocks are transmitted and how trade policies affect the pass-through of price information. The selection of the different econometric methodologies is data-driven and based on the output of specification tests.

The analysis deals with the maize, rice and wheat markets in Cameroon, Kenya and Tanzania in the period 2005-2015.

These countries are chosen because they enforced several trade policies in order to influence the trade volume and relative prices and mitigate the adverse effects of the food crisis 2007/2009.

In this paper, the value added with respect to previous literature like Anderson and Nelgen (2012b) and Anderson and Nelgen (2012c) comes from the use of high-frequency monthly data, which allows for the detection of short-lived movements which could have disappeared because of a time aggregation bias at a lower yearly frequency. Monthly data provides more

information than yearly data. In addition, the policy coverage of the ad-valorem equivalent tariff rate employed in this study is at least as good as the nominal rate of assistance introduced by Anderson and Nelgen (2012a), Anderson and Valenzuela (2008) and Anderson et al. (2008).

Although there are several distortions in the agricultural markets which determine the violation of the Gauss-Markov conditions in the Data Generating Process (DGP) of the price series, the adopted empirical methodologies provide a consistent and efficient estimation of the coefficients of the price insulating policies because they are able to control for such disturbances.

The results of the analysis show that the price transmission process exhibits non-linearities and regime shifts in the markets of all three countries. Country heterogeneity is highly correlated with the set of international factors which determine the price transmission and induces a non-linear behaviour of price transmission mechanism. The introduction of country heterogeneity in the estimation of the panel model results in a better estimation for the rice market, but not for the maize market.

The comparison between the results of the Markov switching models and the panel analysis enables us to draw the conclusion about the characteristics of the non-linearities in the DGP. The coefficients of the price insulation policies in the rice market keep their significance level both in the Markov switching estimation and in the panel analysis because the non-linearities of the DGP are due to time-invariant country specific effects which are controlled for in the panel models.

Whereas, coefficients of the price insulation policies in the maize market are significant in the Markov switching estimation but become non-significant in the panel models. This is due to the fact that time-invariant country specific effects are not relevant in the maize market. Very likely some other unknown factors play an important role in the DGP.

The application of such sophisticated econometric methodologies, which are chosen on basis of the results of several specification tests, is key to determine the mechanism of spatial price transmission in the maize, rice and wheat markets in Cameroon, Kenya and Tanzania in the period 2005-2015.

ARFIMA models, which do not take into account non-linearities in the DGP and time-invariant country heterogeneity, underestimate the effect of trade policies on spatial price transmission and their ability to reduce the negative impact coming from the price shocks on the international markets.

In contrast to that, both Markov switching and panel models provide evidence that trade

policies play an important role in all market situations, while the presence of non-linearities in the DGP and time-invariant country heterogeneity affects the price transmission mechanism.

Overall, in this study it was possible to separately estimate the impact of trade policies within the two regimes of behaviour of the domestic price series: in the first regime the trend of domestic prices increases, in the second one the trend decreases. This highlights that trade policies play a role both in case of increasing and decreasing domestic prices, their relevance being much larger, however, if prices increase. This implies that trade policies are able to insulate the country from price shocks on the international markets during the food price spike crisis, when it was mostly needed.

It is noteworthy, however, that, although the impact of these instruments has been proven to be relevant as counter-cyclical measures during the food price spike crisis, these policies cannot be regarded as structural solutions as this study does not provide any analysis of structural trade policies.

A discussion of the specific measures for the long term development of agricultural markets is beyond the scope of this paper but provides an interesting subject for further analysis.

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Annex I: Results

Time series Analysis

Figure 1: Comparison among graphs of monthly and yearly time series (Maize: Tanzania, Cameroon, Kenya)





Source: own illustration, based on FAO GIEWS database

Table 1: Results for stationarity tests for all variables (general, country- and crop-specific variables) ¹¹ The time series are seasonally adjusted. This means, if seasonality was detected, the series were deseasonalized.

a) Results for the general variable ‘All Commodity Price Index’ and the country-specific variable ‘Exchange Rate’

Variables	Augmented Dickey-Fuller Test ^a			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
General variable (same for all crops and countries) All Commodity Price Index	-1.862	-3.446	0.674	-1.321	-3.446	0.883	Yes

Country-specific variables	Augmented Dickey-Fuller Test ^b			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
Cameroon Exchange Rate	-1.538	-3.446	0.816	-1.629	-3.446	0.781	Yes
Kenya Exchange Rate	-3.039	-3.449	0.122	-2.791	-3.449	0.200	Yes
Tanzania Exchange Rate	-0.849	-3.448	0.961	-0.686	-3.447	0.974	Yes

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10

^a lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : All Commodity Price Index (2)^b lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Exchange Rate (2)

b) Results for Rice: ‘Average International Price’, ‘Domestic Price’ and ‘Interaction between International Price and Tariff Rate’ for Cameroon and Tanzania

Results Stationarity Tests for Rice							
Crop-specific variable (same for all countries) Average International Price	Augmented Dickey-Fuller Test ^a			Phillips-Perron Test			Non-stationarity
	-1.998	-3.446	0.602	-1.848	-3.446	0.681	Yes
	Cameroon						
	Augmented Dickey-Fuller Test ^b			Phillips-Perron Test			
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	Non-stationarity
Country-specific variables							
Domestic Price	-1.722	-3.447	0.741	-1.593	-3.447	0.795	Yes
Interaction International Price and Tariff Rate	-3.909**	-3.446	0.012	-3.700**	-3.446	0.022	No
	Tanzania						
	Augmented Dickey-Fuller Test ^c			Phillips-Perron Test			
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	Non-stationarity
Country-specific variables							
Domestic Price	-2.601	-3.447	0.280	-2.754	-3.447	0.214	Yes
Interaction International Price and Tariff Rate	-3.129*	-3.448	0.100	-4.244***	-3.447	0.004	No

Note: While the variable ‘All Commodity Price’ is the same for all countries and crops and the variable ‘Average International Price’ for all countries, the respective length of the time series varies depending on the remaining variables for the analysis. We depict here the results for the time series covering most of the months (January 2005-December 2015).

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10

^a lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Average International Price (3)^b lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (2), Interaction International Price and Tariff Rate (3)^c lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (1), Interaction International Price and Tariff Rate (1)

c) Results for Wheat: ‘Average International Price’, ‘Domestic Price’ and ‘Interaction between International Price and Tariff Rate’ for Cameroon

Results Stationarity Tests for Wheat							
Variables	Augmented Dickey-Fuller Test ^a			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Crop-specific variable (same for all countries)</i>							
Average International Price	-2.151	-3.446	0.517	-1.957	-3.446	0.625	Yes
Cameroon							
	Augmented Dickey-Fuller Test ^b			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Country-specific variables</i>							
Domestic Price	-2.028	-3.447	0.586	-1.913	-3.447	0.648	Yes
Interaction International Price and Tariff Rate	-3.018	-3.446	0.127	-2.642	-3.446	0.261	Yes

Note: While the variable ‘All Commodity Price’ is the same for all countries and crops and the variable ‘Average International Price’ for all countries, the respective length of the time series varies depending on the remaining variables for the analysis. We depict here the results for the time series covering most of the months (January 2005-December 2015).

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10

^a lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Average International Price (2)

^b lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (1), Interaction International Price and Tariff Rate (2)

d) Results for Maize: ‘Average International Price’, ‘Domestic Price’ and ‘Interaction between International Price and Tariff Rate’ for Cameroon, Kenya and Tanzania

Results Stationarity Tests for Maize							
Variables	Augmented Dickey-Fuller Test ^a			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Crop-specific variable (same for all countries)</i>							
Average International Price	-1.707	-3.446	0.748	-1.556	-3.446	0.809	Yes
Cameroon							
	Augmented Dickey-Fuller Test ^b			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Country-specific variables</i>							
Domestic Price	-2.967	-3.447	0.142	-2.350	-3.447	0.407	Yes
Interaction International Price and Tariff Rate	-3.018	-3.446	0.127	-3.064	-3.446	0.115	Yes
Kenya							
	Augmented Dickey-Fuller Test ^c			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Country-specific variables</i>							
Domestic Price	-2.256	-3.447	0.459	-2.168	-3.447	0.508	Yes
Interaction International Price and Tariff Rate	-2.250	-3.448	0.462	-2.071	-3.447	0.563	Yes
Tanzania							
	Augmented Dickey-Fuller Test ^d			Phillips-Perron Test			Non-stationarity
	Test Statistic	5% Critical Value	P-value	Test Statistic	5% Critical Value	P-value	
<i>Country-specific variables</i>							
Domestic Price	-3.229	-3.448	0.079	-2.765	-3.447	0.210	Yes
Interaction International Price and Tariff Rate	-1.74	-3.448	0.733	-1.679	-3.447	0.760	Yes

Note: While the variable ‘All Commodity Price’ is the same for all countries and crops and the variable ‘Average International Price’ for all countries, the respective length of the time series varies depending on the remaining variables for the analysis. We depict here the results for the time series covering most of the months (January 2005-December 2015).

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10

^a lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Average International Price (2)

^b lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (4), Interaction International Price and Tariff Rate (3)

^c lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (2), Interaction International Price and Tariff Rate (1)

^d lag length specification (based on tests for lag-order selection statistics for VARs and VECMs) : Domestic Price (4), Interaction International Price and Tariff Rate (2)

Table 2: Results for structural break tests for all variables (general, country- and crop-specific variables)¹¹ The time series are seasonally adjusted. This means, if seasonality was detected, the series were deseasonalized.

Variables	Minimum t-statistic	5% Critical Value	Time of structural break
Results Structural Break Test Rice, Zivot Andrews Test			
<i>General variable (same for all crops and countries)</i>			
All Commodity Price Index	-3.764	-5.08	December 2013
Results Structural Break Test Wheat, Zivot Andrews Test			
<i>Crop-specific variable (same for all countries)</i>			
Average International Price	-5.980	-5.080	no break
Results Structural Break Test Maize, Zivot Andrews Test			
Cameroon			
	Minimum t-statistic	5% Critical Value	Time of structural break
<i>Country-specific variables</i>			
Domestic Price	-4.995	-5.08	January 2008
Exchange Rate	-3.418	-5.08	September 2007
Interaction International Price and Tariff Rate	-5.619	-5.08	no break
Results Structural Break Test Maize, Zivot Andrews Test			
Kenya			
	Minimum t-statistic	5% Critical Value	Time of structural break
<i>Country-specific variables</i>			
Domestic Price	-3.838	-5.08	September 2008
Exchange Rate	-3.418	-5.08	September 2007
Interaction International Price and Tariff Rate	-4.691	-5.08	May 2008
Results Structural Break Test Maize, Zivot Andrews Test			
Tanzania			
	Minimum t-statistic	5% Critical Value	Time of structural break
<i>Country-specific variables</i>			
Domestic Price	-5.695	-5.08	no break
Exchange Rate	-3.115	-5.08	April 2014
Interaction International Price and Tariff Rate	-3.958	-5.08	January 2012

Note: While All Commodity Price is the same for all countries and crops and Average International Price for all countries, the respective length of the time series varies depending on the remaining variables for the analysis. We depict here the results for the time series covering most of the months (January 2005-December 2015).

Table 3: Results for fractional integration tests for all variables (general, country- and crop-specific variables)¹¹ The time series are seasonally adjusted. This means, if seasonality was detected, the series were deseasonalized.

a) Results for the general variable 'All Commodity Price Index'

Variables	Powers	Geweke/Porter-Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression	Fractional integration
		P-values	P-values	P-values	
<i>General variable (same for all crops and countries)</i>					
All Commodity Price Index	0.4	0.010	0.041	0.001	YES
	0.5	0.000	0.001	0.000	
	0.6	0.000	0.001	0.000	
	0.7	0.000	0.000	0.000	
	0.75	0.000	0.000	0.000	

b) Results for Rice: ‘Average International Price’, ‘Domestic Price’ and ‘Interaction between International Price and Tariff Rate’ for Cameroon and Tanzania

Results Fractional Integration Test Rice								
Variables	Powers	Geweke/Porter-Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression	Fractional integration			
		P-values	P-values	P-values				
<i>Crop-specific variable (same for all countries)</i>								
Average International Price	0,4	0,016	0,104	0,005	YES			
	0,5	0,001	0,004	0,000				
	0,6	0,000	0,000	0,000				
	0,7	0,000	0,000	0,000				
	0,75	0,000	0,000	0,000				
Country-specific variables	Powers	Cameroon			Fractional integration	Tanzania		
		Geweke/Porter-Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression		Geweke/Porter-Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression
		P-values	P-values	P-values		P-values	P-values	P-values
Domestic Price	0,4	0,093	0,101	0,049	YES	0,046	0,004	0,005
	0,5	0,001	0,005	0,001		0,001	0,000	0,001
	0,6	0,000	0,000	0,000		0,000	0,000	0,000
	0,7	0,000	0,000	0,000		0,000	0,000	0,000
	0,75	0,000	0,000	0,000		0,000	0,000	0,000
Exchange Rate	0,4	0,226	0,811	0,205	YES	0,009	0,000	0,000
	0,5	0,022	0,153	0,017		0,000	0,000	0,000
	0,6	0,001	0,010	0,000		0,000	0,000	0,000
	0,7	0,000	0,000	0,000		0,000	0,000	0,000
	0,75	0,000	0,000	0,000		0,000	0,000	0,000
Interaction International Price and Tariff Rate	0,4	0,136	0,022	0,113	YES	0,832	0,073	0,483
	0,5	0,020	0,000	0,016		0,078	0,003	0,070
	0,6	0,001	0,000	0,000		0,059	0,004	0,057
	0,7	0,000	0,000	0,000		0,001	0,000	0,001
	0,75	0,000	0,000	0,000		0,000	0,000	0,000

c) Results for Wheat: 'Average International Price', 'Domestic Price' and 'Interaction between International Price and Tariff Rate' for Cameroon

Variables	Powers	Geweke/Porter- Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression	Fractional integration
		P-values	P-values	P-values	
<i>Crop-specific variable (same for all countries)</i>					
Average International Price	0,4	0,038	0,040	0,023	YES
	0,5	0,002	0,001	0,001	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
<i>Country-specific variables</i>		Cameroon			
	Powers	Geweke/Porter- Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression	Fractional integration
		P-values	P-values	P-values	
	Domestic Price	0,4	0,071	0,111	0,027
0,5		0,001	0,001	0,000	
0,6		0,000	0,000	0,000	
0,7		0,000	0,000	0,000	
0,75		0,000	0,000	0,000	
Exchange Rate	0,4	0,226	0,811	0,205	YES
	0,5	0,022	0,153	0,017	
	0,6	0,001	0,010	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Interaction International Price and Tarif Rate	0,4	0,164	0,613	0,142	YES
	0,5	0,007	0,029	0,004	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	

d) Results for Maize: 'Average International Price', 'Domestic Price' and 'Interaction between International Price and Tariff Rate' for Cameroon, Kenya and Tanzania

Variables	Powers	Geweke/Porter-Hudak Test	Phillips' Modified Log Periodogram Regression	Robinson's Log Periodogram Regression	Fractional integration
		P-values	P-values	P-values	
<i>Crop-specific variable (same for all countries)</i>					
Average International Price	0,4	0,043	0,034	0,027	YES
	0,5	0,006	0,003	0,004	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
<i>Country-specific variables</i>		Cameroon			
Domestic Price	0,4	0,143	0,116	0,033	YES
	0,5	0,003	0,005	0,002	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Exchange Rate	0,4	0,226	0,022	0,205	YES
	0,5	0,022	0,000	0,017	
	0,6	0,001	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Interaction International Price and Tarif Rate	0,4	0,159	0,256	0,137	YES
	0,5	0,019	0,026	0,014	
	0,6	0,001	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
<i>Country-specific variables</i>		Kenya			
Domestic Price	0,4	0,030	0,032	0,014	YES
	0,5	0,001	0,006	0,000	
	0,6	0,000	0,002	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Exchange Rate	0,4	0,009	0,000	0,000	YES
	0,5	0,000	0,000	0,000	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Interaction International Price and Tarif Rate	0,4	0,071	0,102	0,116	YES
	0,5	0,019	0,018	0,006	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
<i>Country-specific variables</i>		Tanzania			
Domestic Price	0,4	0,047	0,912	0,013	YES
	0,5	0,002	0,053	0,001	
	0,6	0,000	0,001	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Exchange Rate	0,4	0,009	0,000	0,000	YES
	0,5	0,000	0,000	0,000	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	
Interaction International Price and Tarif Rate	0,4	0,002	0,001	0,005	YES
	0,5	0,005	0,001	0,001	
	0,6	0,000	0,000	0,000	
	0,7	0,000	0,000	0,000	
	0,75	0,000	0,000	0,000	

Estimated Models

Table 4: Results for autoregressive fractionally integrated moving average (ARFIMA) models

Autoregressive fractionally integrated moving average											
Maize											
	Cameroon		Kenya				Tanzania				
Dependent variable	ln(Domestic Price)		ln(Domestic Price)				ln(Domestic Price)				
Model	containing a constant	containing no constant	containing a constant		containing no constant		containing a constant		containing no constant		
	Coefficient	p-value ^a		Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a		
Constant	9073***	0.000	no convergence of the Broyden–Fletcher–Goldfarb–Shanno algorithm	1.275	0.452			1.716	0.515		
ln(Interaction International Price and Tariff Rate)	0.0004	0.983		0.084	0.370	0.0804	0.393	-0.232	0.441	-0.267	0.369
ln(lnAll Commodity Price Index)	0.1117	0.190		0.269**	0.042	0.318***	0.006	0.27*	0.055	0.317***	0.009
ln(Exchange Rate)	-0.556***	0.005		0.59*	0.055	0.789***	0.000	0.352	0.244	0.531***	0.000

Rice

Dependent variable	Cameroon ln(Domestic Price)		Tanzania ln(Domestic Price)	
Model	containing a constant	containing no constant	containing a constant	containing no constant
	Coefficient	p-value ^a	Coefficient	p-value ^a
Constant	11.418***	0.000	-0.215	0.981
ln(Interaction International Price and Tariff Rate)	0.054***	0.000	-0.0144	0.875
ln(lnAll Commodity Price Index)	0.076*	0.069	-0.385	0.487
ln(Exchange Rate)	-0.864***	0.000	0.828	0.446

Wheat

Dependent variable	Cameroon ln(Domestic Price)	
Model	containing a constant	containing no constant
	Coefficient	p-value ^a
Constant	14.205***	0.000
ln(Interaction International Price and Tariff Rate)	0.026**	0.024
ln(lnAll Commodity Price Index)	0.007	0.883
ln(Exchange Rate)	-1.231***	0.000

^a ***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Table 5: Results for Markov-switching regression models (Maize)

Markov-switching regression model (estimation without a constant)												
Maize												
Dependent varia	Cameroon ln(Domestic Price)				Kenya ln(Domestic Price)				Tanzania ln(Domestic Price)			
Regime	Regime 1		Regime 2		Regime 1		Regime 2		Regime 1		Regime 2	
	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a
ln(Interaction International Price and Tarif Rate)	0.582*	0,06	-0.245***	0,000	0.195***	0,002	-0.247***	0,005	0.603***	0.000	0,227	0,409
ln(lnAll Commodity Price Index)	-0.432	0,123	1.066***	0,000	0.132*	0,057	0,752	0,000	-0.281***	0.002	0,459	0,259
ln(Exchange Rate)	0.838***	0,000	0.351***	0,000	0.931***	0,000	0,685	0,000	0.526***	0.000	0,233	0,074
Transition probabilities												
	Regime 1		Regime 2		Regime 1		Regime 2		Regime 1		Regime 2	
Regime 1	0,967		0,013		0,972		0,027		0,959		0,065	
Regime 2	0,033		0,987		0,028		0,973		0,041		0,935	
Regime determination	Regime 1: increasing trend of domestic prices is prevailing				Regime 1: decreasing trend of the domestic prices is prevailing				Regime 1 increasing trend of domestic trends is prevailing			
	Regime 2: decreasing trend of domestic prices is prevailing				Regime 2: increasing trend of the domestic prices is prevailing				Regime 2 decreasing trend of domestic prices is prevailing			

^a ***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Table 6: Results for Markov-switching regression models (Rice, Wheat)

Markov-switching regression model (estimation without a constant)												
	Rice								Wheat			
	Cameroon				Tanzania				Cameroon			
Dependent variable	ln(Domestic Price)				ln(Domestic Price)				ln(Domestic Price)			
Regime	Regime 1		Regime 2		Regime 1		Regime 2		Regime 1		Regime 2	
	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a	Coefficient	p-value ^a
ln(Interaction International Price and Tarif Rate)	0.522***	0,000	0.673***	0,000	0.482***	0,000	0.175**	0,031	0.151**	0,016	0.213***	0,000
ln(lnAll Commodity Price Index)	0.177**	0,03	0,043	0,21	-0.187***	0,000	-0.151	0,877	0.207***	0,005	0.333***	0,000
ln(Exchange Rate)	0.39***	0,000	0.03***	0,000	0,600	0,000	0.777***	0,000	0.77***	0,000	0.662***	0,000
Transition probabilities												
	Regime 1		Regime 2		Regime 1		Regime 2		Regime 1		Regime 2	
Regime 1	0,898		0,093		0,918		0,113		0,989		0,034	
Regime 2	0,102		0,907		0,082		0,887		0,011		0,967	
Regime determination	Regime 1: decreasing trend of domestic prices is prevailing				Regime 1: increasing trend of domestic prices is prevailing				Regime 1: very high domestic prices are prevailing			
	Regime 2: increasing of domestic prices is prevailing				Regime 2: decreasing trend of domestic prices is prevailing				Regime 2: low or average domestic prices are prevailing			

^a ***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Panel Data Analysis*Preliminary tests and graphs***Table 7: Results for Wooldridge test for autocorrelation for balanced panel data for Maize and Rice**

Balanced Panel Maize (Cameroon, Kenya and Tanzania)			
Wooldridge test for autocorrelation in panel data¹			
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.			
<i>H₀ = no first-order autocorrelation</i>			
	F statistics	p-value	Is there first-order autocorrelation?
Test joint significance of:			
Domestic Price	F(1,2)= 142.551	0,0069	YES
Interaction International Price and Tarif Rate			
All Commodity Price Index			
Exchange Rate			

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Balanced Panel Rice (Cameroon and Tanzania)			
Wooldridge test for autocorrelation in panel data¹			
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.			
<i>H₀ = no first-order autocorrelation</i>			
	F statistics	p-value	Is there first-order autocorrelation?
Test joint significance of:			
Domestic Price	F(1,1)= 4.663	0,2761	NO
Interaction International Price and Tarif Rate			
All Commodity Price Index			
Exchange Rate			

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Table 8: Results for panel unit root tests for balanced panel data for Maize

Balanced Panel Maize (Cameroon, Kenya and Tanzania)														
Results Panel Unit Root Tests ^{1,2}														
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.														
² The tests include non-zero constants and time trend, if they were detected from the graphs or the tests.														
				Domestic Price			Interaction International Price and Tariff Rate			All Commodity Price Index			Exchange Rate	
Test ^a	Null hypothesis	Alternative Hypothesis	Asymptotics	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b Outcome
Fisher ADF (Inverse Chi-squared)	All panels contain unit roots	At least one panel is stationary	T → Infinity	6,594	0,3601	All panels contain unit roots	3,8176	0,7014	All panels contain unit roots	7,0985	0,3118	All panels contain unit roots	11.0625*	0,0865 All panels contain unit roots
Fisher Philips-Perron (Inverse Chi-squared)	All panels contain unit roots	At least one panel is stationary	T → Infinity	3,993	0,6776	All panels contain unit roots	1,6677	0,9476	All panels contain unit roots	1,1271	0,9803	All panels contain unit roots	5,8583	0,4393 All panels contain unit roots
IPS	All panels contain unit roots	Some panels are stationary	T, N → Infinity, sequentially	-0,5338	0,2968	All panels contain unit roots	0,1196	0,5476	All panels contain unit roots	-0,8127	0,2082	All panels contain unit roots	-1.4172*	0,0782 All panels contain unit roots
LLC	Panels contain unit roots	Panels are stationary	N/T → 0	0,4312	0,668	Panels contain unit roots	-0,9198	0,1788	Panels contain unit roots	-0,231	0,4087	Panels contain unit roots	-1.7799**	0,0375 Panels are stationary
Breitung	Panels contain unit roots	Panels are stationary	T, N → Infinity, sequentially	0,0135	0,5054	Panels contain unit roots	0,5787	0,7186	Panels contain unit roots	2,8747	0,998	Panels contain unit roots	-0,6418	0,2605 Panels contain unit roots
Hadri LM	All panels are stationary	Some panels cointains unit root	T, N → Infinity, sequentially	13.0787***	0,000	Some panels cointains unit root	39.341***	0,000	Some panels cointains unit root	14.4595***	0,000	Some panels cointains unit root	28.12***	0,000 Some panels cointains unit root

^a lag length specification (based on Moment and Model selection Aikake Information Criterion for Panel VARs and Panel VECMs) : 1 lag

^b ***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Table 9: Results for panel unit root tests for balanced panel data for Rice

Balanced Panel Rice (Cameroon and Tanzania)															
Results Panel Unit Root Tests ^{1,2}															
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.															
² The tests include non-zero constants and time trend, if they were detected from the graphs or the tests.															
				Domestic Price			Interaction International Price and Tarif			All Commodity Price Index			Exchange Rate		
Test ^a	Null hypothesis	Alternative Hypothesis	Asymptotics	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b	Outcome	Test Statistic	p-value ^b	Outcome
Fisher ADF (Inverse Chi-squared)	All panels contain unit roots	At least one panel is stationary	T→ Infinity	112.288***	0,000	At least one panel is stationary	141.652***	0,000	At least one panel is stationary	89.9196***	0,000	At least one panel is stationary	82.0179***	0,000	At least one panel is stationary
Fisher Philips-Perron (Inverse Chi-squared)	All panels contain unit roots	At least one panel is stationary	T→ Infinity	95.303***	0,000	At least one panel is stationary	114.601***	0,000	At least one panel is stationary	113.5888***	0,000	At least one panel is stationary	93.914***	0,000	At least one panel is stationary
IPS	All panels contain unit roots	Some panels are stationary	T, N → Infinity, sequentially	-12.261***	0,000	Some panels are stationary	15.523***	0,000	Some panels are stationary	10.2823***	0,000	Some panels are stationary	-9.5565***	0,000	Some panels are stationary
LLC	Panels contain unit roots	Panels are stationary	N/T→ 0	-12.163***	0,000	Panels are stationary	15.353***	0,000	Panels are stationary	10.0244***	0,000	Panels are stationary	-8.2628***	0,000	Panels are stationary
Breitung	Panels contain unit roots	Panels are stationary	T, N → Infinity, sequentially	-6.553***	0,000	Panels are stationary	-6.772***	0,000	Panels are stationary	-7.9532***	0,000	Panels are stationary	-5.6295***	0,000	Panels are stationary
Hadri LM	All panels are stationary	Some panels contains unit root	T, N → Infinity, sequentially	-1,662	0,952	All panels are stationary	-1,789	0,963	All panels are stationary	1,378	0,916	All panels are stationary	-0,961	0,832	All panels are stationary

^a lag length specification (based on Moment and Model selection Akaike Information Criterion for Panel VARs and Panel VECMs) : 1 lag

Table 10: Results for Westerlund test for co-integration for balanced panel data for Maize and Rice

Balanced Panel Maize (Cameroon, Kenya and Tanzania)				
Westerlund test for co-integration in panel data ¹				
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.				
<i>H₀ = no co-integration</i>				
Statistics	Value	Z-value	p-value (robust)	Is there co-integration?
Group Mean Statistics				NO
G _a	-2.603	0.202	0.49	
G _t	-12.596	0.632	0.59	
Panel Statistics				
P _t	-4.546	-0.297	0.38	
P _a	-12.664	-0.113	0.39	

Table 11: Results for cross-sectional dependence (CD) test for balanced panel data for Maize and Rice

Balanced Panel Maize (Cameroon, Kenya and Tanzania)			
Cross-Sectional Dependence Test	Statistics	p-value	Is there weak cross-sectional dependence?
H_0 = errors are weakly cross-sectional dependent	-7.244***	≈ 0	NO

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Balanced Panel Rice (Cameroon and Tanzania)			
Cross-Sectional Dependence Test	Statistics	p-value	Is there weak cross-sectional dependence?
H_0 = errors are weakly cross-sectional dependent	-10.39** *	0,000	NO

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Estimated Models

Table 12: : Results for non-stationary non-cointegrated panel model for maize

Non-stationary non-cointegrated panels (FGLS/GLS vs. Prais Winsten with PCSE) ¹									
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.									
Balanced Panel Maize (Cameroon, Kenya and Tanzania)									
AR(1) term	Common to all panels					Panel-specific			
Panel structure	Hetersoschedastic with cross-sectional correlation					Hetersoschedastic with cross-sectional correlation			
Generalized Hausman test	H ₀ = FGLS/GLS and Prais-Winsten with Panel Corrected Standard Errors (PCSE) estimator both consistent, but GLS/FGLS more efficient								
Prais-Winsten w. PCSE vs. GLS	Chi square	p-value	Outcome	Chi square	p-value	Outcome	Chi square	p-value	Outcome
Prais-Winsten w. PCSE vs. GLS	0,39	0,9413	GLS more efficient	1,69	0,639	GLS more efficient	1,96	0,5801	FGLS more efficient
Model	GLS on panel data					GLS on panel data			
Dependent variable	ln(Domestic Price)					ln(Domestic Price)			
Constant	5.939***		0,000	5,485***		0,000			
ln(Interaction International Price and Tariff Rate)	0,0084		0,88	0,011		0,837			
ln(lnAll Commodity Price Index)	0.2**		0,015	0.1988**		0,015			
ln(Exchange Rate)	-0.1633*		0,053	-0.1683**		0,028			
Model	FGLS on panel data					FGLS on panel data			
Dependent variable	ln(Domestic Price)					ln(Domestic Price)			
Constant	6.06***		0,000	5.5***		0,000			
ln(Interaction International Price and Tariff Rate)	0.006		0,914	0,011		0,845			
ln(lnAll Commodity Price Index)	0.199**		0,014	0.198**		0,015			
ln(Exchange Rate)	-0.175**		0,037	-0.17**		0,027			

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10: critical value for hypothesis testing is 0.05

Table 13: Results for stationary panel model for rice

Stationary panels (FGLS/GLS vs. OLS with PCSE) ¹						
¹ if seasonality was detected in the time series, the series were de-seasonalized. Therefore, all series are seasonally adjusted.						
Balanced Panel Rice (Cameroon and Tanzania)						
AR(1) term	Common to all panels			Panel-specific		
Panel structure	Hetersoschedastic with cross-sectional correlation			Hetersoschedastic with cross-sectional correlation		
Generalized Hausman test	H ₀ = FGLS/GLS and OLS with Panel Corrected Standard Errors (PCSE) estimator both consistent, but GLS/FGLS more efficient					
OLS w. PCSE vs. GLS	Chi square	p-value	Outcome	Chi square	p-value	Outcome
	59.95***	0,000	GLS inconsistent, OLS with PCSE consistent	59.14***	0,000	GLS inconsistent, OLS with PCSE consistent
Model	OLS with PCSE			OLS with PCSE		
Dependent variable	ln(Domestic Price)			ln(Domestic Price)		
	Coefficient		p-value	Coefficient		p-value
Constant	4.4***		0,000	4.4***		0,000
ln(Interaction International Price and Tarif Rate)	0.41***		0,000	0.41***		0,000
ln(lnAll Commodity Price Index)	0.09		0,096	0.09		0,113
ln(Exchange Rate)	-0.13***		0,000	-0.13***		0,000

***p-value < 0.01; **p-value < 0.05; *p-value < 0.10; critical value for hypothesis testing is 0.05