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Vertical price transmission and its inflationary implications in South African food chains

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ABSTRACT
Various studies interrogate the issue of food inflation from a commodity level vantage point but fail to relate how commodity prices manifest in retail prices, and ultimately, how it impacts food inflation. This study uses vertical price transmission analysis, with time series econometric techniques, to determine how underlying commodity prices manifest in final retail prices and the associated reasons for it. Implications for food inflation are also reflected on. Two value chains, namely wheat-to-bread and maize-to-maize meal are considered due to their importance as staples in low(er) income consumer diets in South Africa. Results indicate full price transmission in the wheat-to-bread chain but incomplete price transmission in the maize-to-maize meal chain. In addition, prices in the wheat-to-bread chain are determined at producer and consumer level and bi-directional transmission takes place, whereas maize prices are determined at retail level and transmitted through the chain, to commodity level. Symmetry in price adjustment was not rejected in both chains. Implications of the findings for staple food inflation is that it does not seem that the price determination and price transmission processes in these chains are contributing factors to the inflationary pressures that these chains have experienced over the past decade. Symmetric price transmission in both chains seems to suggest no opportunistic behaviour on the part of firms to exploit situations where commodity prices decrease.

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1. Introduction

There is a vast amount of empirical literature on price transmission for food products, which can broadly be classified as either vertical analysis or spatial analysis. In terms of vertical price transmission analysis, studies are mostly conducted in developed countries for relatively sophisticated supply chains. The focus of the majority of these studies is on the (asymmetric) price adjustment process with the ultimate objective to relate findings to market or organisational structure[1], significant mark-up adjustment costs[2] or a substantial effect of inventory levels on the price adjustment process.[3] Meyer and von Cramon-Taubadel (2004) provide a valuable and concise review of the causes of asymmetry in price transmission with associated studies.

In terms of spatial price transmission analysis, a new wave of studies was sparked by the commodity super cycle, experienced in the preceding decade. It encouraged research into the effect of commodity price spikes on food prices. Davidson *et al*. (2012), however, highlight that these research studies typically focused on price movements (global to local) at commodity level and therefore

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made inferences about unprocessed food prices rather than food prices at retail level. A large body of research that falls into this category can be found (see *inter alia* Minot (2011) and Trostle (2008)). Although both of these approaches could be invaluable in understanding certain elements associated with food price dynamics, most studies that applied them failed to inform general food price inflation or even food price inflation associated with disaggregated food groups or food products. In South Africa specifically, there are no studies that consider the ultimate impact of price determination and price transmission processes on food inflation. This study aims to explore this, specifically for staple products, by also taking into account the salient features associated with the value chains under consideration.

2. Background and literature overview

Common claims in popular and scientific literature are that staple food supply chains in South Africa suffer from high levels of concentration, which leads to market power abuse and rent seeking and ultimately contributes to food inflation (see *inter alia*, Stanwix (2015), African Centre for Bio-Safety (2014)). In fact, public perception that cost increases are passed on quicker and more fully than cost decreases, and that this contributes to inflationary pressures associated with food prices, is endemic in South Africa. This study analyses this issue with the aid of basic time series techniques, which account for possible price asymmetry.[4] Basic time series techniques have long been established as popular methods to quantify the long-run relationships and short-run dynamics between prices at two different nodes of a supply chain (see *inter alia* Abdulai, 2002). This study uses similar methods in order to gauge these properties of two key food value chains in South Africa, namely wheat-to-bread and maize-to-maize meal. These value chains are of vital importance, in terms of food security for almost all South African households. This is exasperating for low(er) income households, who spend approximately 34% of their food expenditure on bread and cereal products (StatsSA, 2014). These two chains also provide an interesting case for comparison in that they share certain similarities and differences. These will be elaborated on in the discussion of the features of the chains that follow.

Several studies considered similar issues in the South African context, but they have several short comings. Schimmelpfennig et al. (2003) identified a need to determine the impacts of exogenous changes on local producer and consumer prices for maize in South Africa. They estimated an error correction model (ECM) and found that exogenous factors can create important disequilibria through price stickiness and that price disequilibrium can last for up to six months. In terms of explicitly analysing the vertical relationship between producer (commodity) and consumer (retail) prices, they only mentioned the existence of a strong correlation between the two price levels and did not apply methods to estimate/measure this. In another study initiated in response to high food prices experienced during 2001 to 2003, Cutts and Kirsten (2006) analysed vertical price transmission in the maize, wheat, sunflower and fluid milk chains and found asymmetry in all the chains. In addition, they found that the level of asymmetry decreased with the perishability of the retail products. Funke (2008), in turn, did a similar study on maize, poultry, beef, sugar and dairy and found asymmetry in the price transmission process between the maize mill door and retail price. Both of the aforementioned studies applied a method to test for asymmetry based on Granger and Lee (1989) and von Cramon-Taubadel (1996), in which the error correction term is segmented into positive and negative components.

This paper builds on the above analysis in several ways. Firstly, the data for this analysis ranges from 2000 to 2016 for wheat-to-bread and 2008 to 2016[5] for maize-to-maize meal. This range includes various occurrences that might have had an impact on the price formation and price transmission processes in these chains. From the supply side these events include the global commodity super cycle between 2005 and 2008, a severe drought in 2015/16 and significant increases in the costs of inputs such as labour and electricity since 2008. In terms of changes in demand, there has been increasing urbanization which affects the substitution between staples in South Africa, rapid income growth followed by a recession in 2009, and recent consumer protest to high food prices in the form of #BreadPricesMustFall in 2015. Secondly and closely related to the above, this study test for a structural break in the long-run relationship, which could have been induced by one/some of the events mentioned above. Thirdly, the study uses more sophisticated methods than applied by Cutts and Kirsten (2006) and Funke (2008). The methods applied here have improved specifications of the underlying data generating process of the long run error term and were developed by Enders and Granger (1998) and popularised by, *inter alia*, Abdulai (2002). According to Frey and Manera (2007) the method proposed by Enders and Granger (1998) is an extension of the model by Granger and Lee (1989) in that asymmetries are accounted for based on whether the deviation from equilibrium is increasing or decreasing, instead of the level of the shift. It also allows one to account for the autoregressive structure of the error term associated with the long run relationship. These models are the threshold autoregressive (TAR) model and the momentum-threshold autoregressive (M-TAR) model and, to the authors' knowledge, these methods have not yet been applied to analyse staple food price transmission in South Africa. Lastly, and as mentioned above, the similarities and differences in these chains allows for an interesting case of comparison which could possibly lead to findings on how value chain structure impact the price transmission process.

The overarching objective of this paper is to determine how commodity price dynamics contribute to staple food inflation. In order to answer this fundamental question, the paper deals with three sub-objectives. The first is to obtain an efficient estimate of price transmission from commodity to retail level. Such an estimate is important when one needs to evaluate how changes in the underlying commodity prices will filter through to final retail prices. The second is to consider possible asymmetry and short run price dynamics in the two food value chains. This could possibly serve as a starting point to inform the notion of market concentration and opportunistic behaviour with respect to changes in the underlying commodity prices and how this could be contributing to food inflation. It would also inform the nature/direction of the price determination process in these chains. The third is to compare the results of the two chains to ultimately infer value chain factors that could affect price determination and transmission. All three of these objectives are considered in order to evaluate how price dynamics within supply chains contribute to staple food inflation in South Africa.

3. Key features of the selected value chains

Staple food supply chains in South Africa are categorised by a high market concentration and vertical integration. In the case of wheat-to-bread there are four major players engaged in the milling and baking process. These companies are Tiger Brands, Premier Foods, Pioneer Foods and Food Corp. These four millers accounted for around 80 per cent of the total wheat milled in South Africa in 2015. In 2016, the South African grain information service (SAGIS) determined that there are 80 wheat processors in South Africa. This decreased from a little over a 100 in 2008. Discussions with industry experts, however, indicate that this reduction is not due to firms going out of business but is rather an indication of increased consolidation since 2008. In terms of baking, plant bakeries of the aforementioned companies bake between 50 and 60 per cent of the total bread sales and in-store retailing bakeries account for roughly 20 per cent of total bread sales in South Africa. Over the past 15 years the average cost share of wheat per loaf of brown bread was around 21 per cent.

With regards to maize, the milling process is somewhat less concentrated with the 20 largest companies producing 80 per cent of the total maize milled in South Africa in 2015. The maize milling sector in South Africa is also dominated by Tiger Brands, Premier Foods and Pioneer Foods. According to SAGIS there were 344 maize processors[6] in South Africa in 2016. Over the past two decades this has varied between 333 and 468 which indicate much more variability than in the case of wheat. This is an indication that it is much easier for maize processors to enter and exit the market based on returns of the final product. Over the past eight years the average cost share of white maize per 2.5 kg packet of maize meal was 57 per cent.

A summary of the similarities and differences between the chains are considered below. Based on the above features certain comparative expectations can be developed:

1. Price transmission will occur more fully in the maize chain than the wheat chain due to the larger cost share and shorter chain associated with maize. According to Gardner (1975) and McCorriston *et al.* (2001) the long run price transmission elasticity will equal the cost share and a longer value chain would therefore implicitly result in a smaller cost share of the underlying commodity which would indicate poorer price transmission.
2. Price formation for wheat will occur at commodity level and mark-up pricing will occur through the chain, consistent with mark-up pricing as described by Heien (1980). This expectation is based on South Africa being a small producer by world standards and that local wheat prices are derived from world prices. In contrast to this, price formation in the maize-to-maize meal value chain will occur at producer and consumer level, since South Africa is a net exporter of maize and the largest white maize producer in the world.
3. The structure of the wheat-to-bread value chain is more conducive to opportunistic behaviour in terms of capturing gains when commodity prices decrease compared to the maize-to-maize meal value chain. This is because of the higher concentration associated with this chain and the high(er) level of vertical integration.

The remainder of the paper is structured as follows: Section 4 will deal with the estimation of the long-run relationship, which can be considered as the price transmission elasticity between producer and retail prices. Section 5 tests for asymmetry in price behaviour and considers the short-run dynamics around the long-run equilibrium. Section 6 is a comparative section that contrasts the two supply chains. Section 7 concludes the study with some thoughts on how value chain structure could impact price transmission and price determination and how this could ultimately impact staple food inflation.

4. Estimating a long-run relationship

Numerous methods to establish price relationships between variables have been applied in empirical studies ranging from basic correlation tests to general co-integration test as developed by Engle and Granger (1987) and Johansen (1988). A drawback of the above co-integration methods is that they assume linearity and symmetry. In this regard, this study utilises threshold models and investigate the possibility of a structural break in the long-run relationships. Boetel and Lui (2010) notes that disregarding structural breaks may result in biased estimates of price relationships.

This study analyses the farm–retail price relationship for the wheat-to-bread and maize-to-maize meal supply chains in South Africa by employing data from January 2000 to September 2016 for wheat-to-bread and January 2008 to September 2016 for maize-to-maize meal. Prices for brown bread are for on a 700 g loaf and prices for maize meal are for a 2.5 kg packet. For the analysis to be relevant we need to understand the milling technology and associated milling costs. With current milling technologies employed in South Africa, one ton of wheat will yield 810 kg of brown bread flower. In the baking process, roughly 420 g of flour is used to bake a 700 g loaf of bread. Given the information above one ton of wheat can yield 1928 loaves of brown bread. These extraction rates and conversion ratios were used to calculate an average monthly wheat cost equivalent for brown bread, based on the average monthly wheat price calculated from daily closing price data reported by the South African Futures Exchange (SAEFX). Similarly, an extraction rate of 62.5 per cent were used to calculate the cost equivalent of white maize, based on white maize prices reported by SAFEX, for a 2.5 kg bag of super maize meal. All variables in question are converted to natural logarithms. The univariate properties of the data are presented in Table A1 of the Appendix. The Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests in Table A2 confirm that all the series in question are non-stationary and integrated of order 1.

Table 1. Key feature comparison between wheat-to-brown bread and maize-to-maize meal.

	Wheat-to-brown bread	Maize-to-maize meal
Vertical integration	Integration of milling and baking and baking and retailing operations are quite common	No vertical integration between milling and retailing
Market concentration (concentration ratio (5))[a]	83%	45%
Number of firms processing in 2016	80	344
Average cost share of commodity in final retail price	21%	57%
Commodity position in world market	Small. South Africa imports roughly 50% of domestic requirements	South Africa is the largest producer of white maize in the world. With the exception of the 2015–2016 season, it is a net exporter of white maize[b]

Notes: [a]The concentration ratio (5) indicates what percentage of production is produced by the five largest firms in the sector. [b]Exports over the past decade have ranged between 9% and 30% of total deliveries per season. The average over the past 10 years was around 17%.

Co-integration tests of the non-stationary prices are performed using Engle and Granger's (1987) procedure and the Gregory and Hansen (1996) test. These results are presented in Table 2(a) for wheat-to-bread and 2(b) for maize-to-maize meal. Table 2(a) confirms co-integration with the Engle and Granger procedure and the Gregory and Hansen procedure (with a shift in the level and a trend).[7] The latter is a test for co-integration in the presence of a structural break. The full results of the Gregory and Hansen procedure are presented in Table A3 in the Appendix and show that a break, in the case of wheat, occurs in March 2008. In the case of maize, co-integration is confirmed with the Engle and Granger test, but no co-integration was found with the Gregory and Hansen procedure. This implies that there is no structural break in the case of maize.[8] Although the objective of this study is to determine the presence of a break and to account for this in estimations in order to obtain unbiased price transmission elasticities, it is worthwhile to note that this break date could possibly be explained by a notable stretch in the margin between wheat and brown bread since 2008 (see Figure 1). This could, in turn, be explained by substantial increases in prices of key inputs in the production of bread, such as electricity and labour[9], since 2008.

Based on the confirmed long-run relationship, as depicted in Tables 2(a) and (b), one can proceed to consider the estimation results of the co-integrating regression function as the long-run elasticity with which prices are transmitted through the value chain (from wheat to brown bread). Gupcheck (2013), however, notes that this interpretation is based on the assumption that the long-run

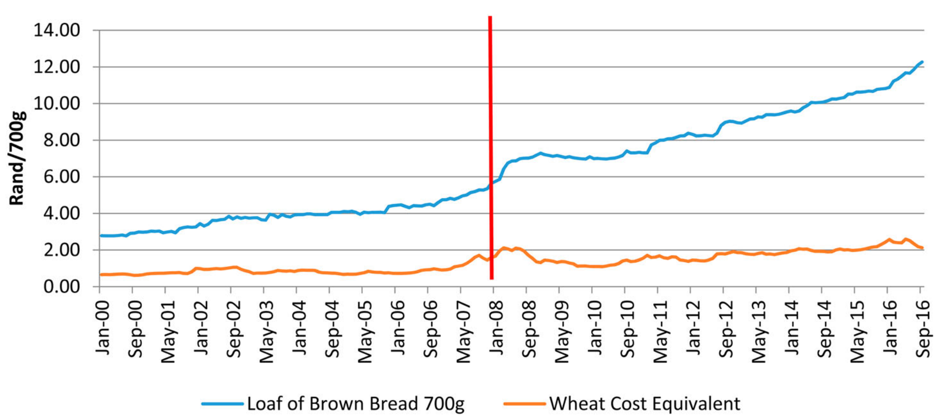

Figure 1. Wheat-to-bread margin (January 2000 to September 2016) with break = March 2008.

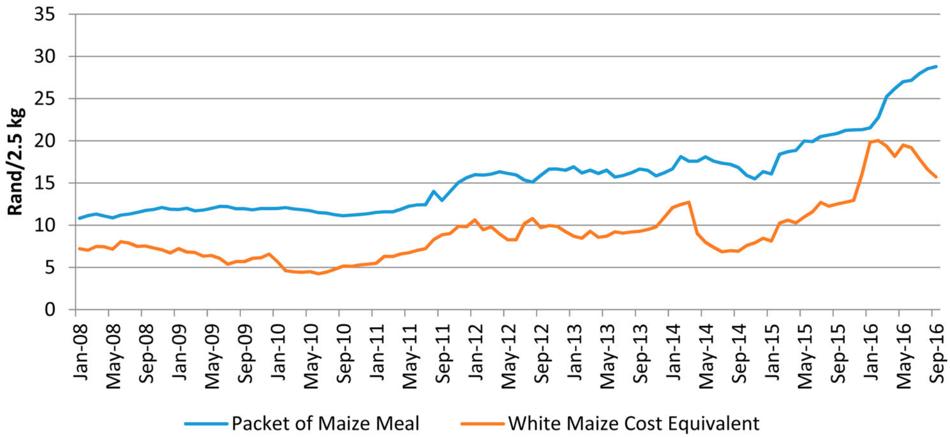

Figure 2. White maize-to-maize meal margin (January 2008 to September 2016).

relationship between the two variables is time invariant, which might not be realistic. Based on the Gregory and Hansen test, this is indeed the case for the wheat-to-bread margin. In order to account for the change in level, a dummy[10] is incorporated into the long-run relationship. A dynamic ordinary least squares (DOLS) procedure according to the Phillips and Loretan (1991) procedure, which includes lagged and leading terms of the regressors in first differences and the errors, is further used to ensure consistent estimates of the price transmission parameter. To this end, Banjeree *et al*. (1993) notes that estimations which ignore the dynamics of the data generating process can result in considerable finite sample bias. Table 3(a) represents the estimation results. The long-run equation for the wheat-to-bread chain is therefore estimated in a two-step procedure with the first step accounting for the static components from which a residual term is estimated. The lagged residual term along with the lagged regressor in first difference are then added in the second step. The lag length is determined with conventional information criteria.

Based on the results above it can be seen that price transmission is 0.98 and close to perfect throughout the time series (no change in the slope parameter, see column 3 of Table 3(a)). Since the equation is specified in terms of wheat cost equivalents we expect the price transmission elasticity to be equal to one in the case of perfect price transmission.[11] The intercept for the base

Table 2(a). Wheat-to-bread co-integration analysis (test statistic on coefficient of lagged residual).

	Johansen ML test (H0: $r = 0$)			Gregory and Hansen procedure	
Co-integration equation	Trace	Max Eigen	Engle and Granger procedure	With intercept shift	With intercept shift and trend
$LBB = f(LWC_?)$	30.1***	29.76***	−3.02***	−3.78	−5.54***

Notes: LBB is the log of brown bread and LWC is the log of the wheat cost equivalent. Asterisks denote the levels of significance (*10%, **5% and ***10%).

Table 2(b). Maize-to-maize meal co-integration analysis (test statistic on coefficient of lagged residual).

	Johansen ML test (H0: $r = 0$)			Gregory and Hansen procedure	
Co-integration equation	Trace	Max Eigen	Engle and Granger procedure	With intercept shift	With intercept shift and trend
$LMM = f(LMC)$	16.2**	15.64**	−2.9***	−3.38	−3.88

Notes: LMM is the log of maize meal and LWC is the log of the maize cost equivalent. Asterisks denote the levels of significance (*10%, **5% and ***10%).

period is 1.048. Since the equation is specified in logs the exponentiated value of the intercept parameter needs to be taken to get the geometric mean associated with brown bread prices. This yields a value of 2.85, which shows that the average margin is R2.85 if wheat cost equivalents are equal to zero. The regime coefficient for the intercept term of regime two is calculated as the intercept in the base period plus the estimated parameter for the intercept in regime 2 (see Table 3(a) dummy for regime 2 column 3). The importance of allowing for an intercept shift is supported by the significance of the *t*-statistics of the estimated parameters.

In the case of maize, the Gregory and Hansen test suggests that there is no need to account for a structural break. The estimation results are depicted in Table 3(b) below.

The elasticity from the DOLS model shows incomplete price transmission of 0.63 in the maize-to-maize meal value chain.[12] Incomplete transmission in value chains can be ascribed to, *inter alia,* the inefficient flow of information, the nature of the returns to scale associated with the cost function in an industry (see McCorriston *et al*. 2001) or other factors in the chain that result in inefficiencies. Other possible explanations for the incomplete price transmission are the nature of the product in the consumer basket or the shelf life of the product. Since maize meal is a staple, it could potentially serve as a key value item for retailers. As a result, retailers might be inclined to absorb some of the price changes in order to attract customers to their stores. This, however, needs to be proven empirically. Another factor to consider is that maize meal has a relatively long shelf life and, as a result, retailers can make use of inventory management strategies to absorb some of the price changes of the underlying commodity.

Table 3(a). Results of the dynamic OLS model with a dummy and trend (wheat-to-bread).

Dependent variable: LBB

Description	Estimated parameter (1)	*t*-statistic (2)	Intercept/price transmission elasticity (3)	Johansen price transmission elasticity (4)
Intercept:				
Constant	1.048[a]	167.09	1.048	
Dummy for regime 2	0.195	17.304	1.243	
Trend	0.006	62.524		
Wheat cost equivalent:				
Ln(WC)	0.980	116.590	0.980	1.140
Phillips and Loretan terms:				
ΔLn(WC(−1))	−0.340	−4.880		
ΔLnWC(1)	−0.330	−4.860		
Resid(−1)	0.940	43.630		

Notes: [a]In the absence of a structural break the constant assumed a value of 1.33 and the coefficient associated with the natural log of wheat cost equivalent assumed a value of 0.58. This shows the importance of accounting for the structural break.

Table 3(b). Results of the dynamic OLS model (maize-to-maize meal).

Dependent variable: LMM

Description	Estimated parameter	*t*-statistic	Intercept/price transmission elasticity	Johansen price transmission elasticity
Intercept:				
Constant	1.37	41.81		
Wheat cost equivalent:				
Ln(MC)	0.63	41.75	0.63	0.92
Phillips and Loretan terms:				
ΔLn(MC(−1))	−0.19	−2.74		
ΔLn(MC(1))	−0.10	−1.50		
Resid(−1)	0.85	17.21		

5. Testing for asymmetry and determining short-run dynamics

Based on the co-integration tests results for wheat-to-bread in the previous section, one can now turn to the estimation of a vector error correction model (VECM) to determine how deviations from the long-run equilibrium are corrected in the short run. To analyse the possible asymmetry in error adjustment, a test for asymmetry is conducted before the estimation of the VECM. These are reported in Table 4(a). In both the threshold autoregressive (TAR) model and the momentum threshold autoregressive (M-TAR) model there is no indication of asymmetry (see $H_0:\gamma_1 = \gamma_2$ that is not rejected). We therefore proceed to estimate a symmetric VECM which is presented in Table 5(a).

The results suggest that both brown bread prices (BB) and wheat cost equivalents (WC) move to correct for deviations from the long-run equilibrium (based on the significance of the ECT_{t-1} coefficients). This contradicts *a priori* expectations that price formation occurs at commodity level and mark-up pricing occurs through the value chain. The magnitude of the error correction terms is very small, albeit statistically significant. This is an indication that shocks to the system are corrected at a very slow rate, with bread prices moving almost 4 per cent per period to correct for deviations from equilibrium and wheat cost equivalents moving around 7 per cent to correct for deviations from equilibrium.

In terms of maize-to-maize meal, TAR and M-TAR models were again employed to establish the existence of asymmetric price behaviour. These are presented in Table 4(b). The null hypothesis of symmetric price determination could not be rejected in the case of the TAR model. It was, however, rejected for the M-TAR model. In addition to this the M-TAR model is preferable to the TAR model based on the AIC. Despite this the authors, however, opted to proceed with the TAR estimation that found symmetry. This is because the short-run dynamics of this model is more intuitive and can be clearly related to observed price dynamics.[13] The estimation results xof this model are presented in Table 4(b).

The *t*-statistics for the ECT_{t-1} coefficient for the column considering maize cost (MC) indicate that producer prices are the so-called slave and retail prices are the master, in that producer prices move to correct deviations from the equilibrium, whereas retail prices do not. It can therefore be deduced that prices are formed at retail level and transmitted up-stream to producer level. This does not conform to earlier expectations of bi-directionality in this chain. This finding could possibly be

Table 4(a). TAR and MTAR model parameter estimates (wheat-to-bread).

Variable	TAR model Parameter estimate	M-TAR model Parameter estimate
γ_1	−0.066	−0.049
γ_2	−0.068	−0.057
$H_0:\gamma_1 = \gamma_2 = 0$	4.294**	2.591
$H_0:\gamma_1 = \gamma_2$	0.020	0.025
AIC	−598.108	−586.581

Notes: γ_1 and γ_2 are the AR(1) coefficient of the wheat to bread long-run disturbances, in first differences, separated into positive and negative components with a Heaviside indicator. Asterisks denote the levels of significance (* 10%, ** 5% and *** 10%).

Table 4(b). TAR and MTAR model parameter estimates (maize-to-maize meal).

	TAR model	M-TAR model
Variable	Parameter estimate	Parameter estimate
γ_1	−0.102*	−0.017
γ_2	−0.17***	−0.287***
$H_0:\gamma_1 = \gamma_2 = 0$	4.46**	9.219***
$H_0:\gamma_1 = \gamma_2$	0.542	9.327***
AIC	−302.16	−310.789

Note: Asterisks denote the levels of significance (*10%, **5% and ***10%).

Table 5(a). Vector error correction model (wheat to bread).

	ΔBB		ΔWC	
	Coefficient	*t*-stat	Coefficient	*t*-stat
Constant	**0.009*** **	**5.070**	−0.003	−0.672
ΔBB_{t-1}	**−0.161*** **	**−2.248**	0.236	1.257
ΔBB_{t-2}	−0.108	−1.490	0.373	1.966
ΔBB_{t-3}	0.062	0.848	0.187	0.974
ΔBB_{t-4}	−0.059	−0.823	0.081	0.432
ΔWC_{t-1}	**0.046***	**1.664**	**0.418*** **	**5.722**
ΔWC_{t-2}	−0.020	−0.665	−0.074	−0.933
ΔWC_{t-3}	0.035	1.154	0.028	0.354
ΔWC_{t-4}	−0.004	−0.129	0.022	0.295
ECT_{t-1}	**−0.037*** **	**−3.663**	**0.071*** **	**2.712**

Note: Asterisks denote the levels of significance (* 10%, ** 5% and *** 10%).

Table 5(b). Vector error correction model (maize-to-maize meal).

	ΔMM		ΔMC	
	Coefficient	*t*-stat	Coefficient	*t*-stat
Constant	0.009***	2.639	0.011	1.177
ΔMM_{t-1}	−0.225**	−2.168	−0.312	−1.040
ΔMM_{t-2}	0.01	0.1	−0.385	−1.358
ΔMM_{t-3}	0.062	0.705	0.047	0.186
ΔMM_{t-4}	0.007	0.076	−0.348	−1.372
ΔMC_{t-1}	−0.027	−0.724	0.289	1.789***
ΔMC_{t-2}	0.132***	3.394	0.089	2.66
ΔMC_{t-3}	0.117***	2.861	0.042	0.79
ΔMC_{t-4}	0.069	1.625	0.155	0.357
ECT_{t-1}	−0.038	−1.263	0.157	1.789*

Note: Asterisks denote the levels of significance (*10%, **5% and ***10%).

explained by a saturated market, with stagnant growth aimed at a low(er) income consumer with little or no capacity to absorb price changes.

In terms of short run dynamics, the estimates indicate that within a month, retail prices adjust to eliminate roughly 3.8 per cent of a shock from the equilibrium margin. If the maize cost column is regarded, a unit change in the margin causes producer prices to adjust by a 15.7 per cent change per period to correct for deviations from the equilibrium margin.

6. Comparing the results of the chains

The study firstly aimed to determine if there were any structural breaks in the margin of wheat-to-bread and maize-to-maize meal in order to ensure a consistent price transmission elasticity estimate. In the case of wheat, a structural break was identified in March 2008, which could possibly be explained by rising electricity and labour costs. This break was incorporated into the estimation of the long-run relationship to ensure that the price elasticity obtained with the estimation of this relationship is efficient. It was found that there is complete price transmission from wheat cost equivalents to brown bread with the estimated elasticity amounting to 0.98. In the case of the short run properties no asymmetry was detected in the wheat-to-bread chain. Although this is not conclusive evidence of the absence of non-competitive behaviour[14], this, in combination with perfect price transmission, does seem to indicate the absence of exploitative pricing behaviour with regards to the underlying wheat costs. Short run dynamics also indicate that adjustment back to equilibrium, after a shock has occurred, is slow in the wheat-to-bread chain with roughly 4 per cent of a deviation from equilibrium corrected per month. This slow response could be as a result of the small share (± 20%) that wheat comprises of the final value of a bread. Another possible explanation is that large millers do not purchase wheat continuously. Instead, they are likely to

Table 6. Comparative summary.

	Wheat-to-bread		Maize-to-maize meal	
Long-run price transmission	0.98		0.63	
Price determination	Bi-directional. Prices are determined at commodity and retail level and transmitted through the chain.		Uni-directional. Prices are determined at retail level.	
Asymmetry	No		No	
Rate of adjustment to equilibrium (per period)	Brown bread	4%	Maize meal	4%
	Wheat cost	7%	Maize cost	15.7%

purchase large, homogenous lots that they store and process in the ensuing months. For a large miller who has a silo full of grain, price movements are not relevant. The price will only become relevant once he has made another purchase.

In the case of maize-to-maize meal, no structural breaks were identified. The estimated long-run price elasticity amounted to 0.63 which indicates incomplete price transmission. This implies that only 63 per cent of the changes in the underlying commodity price are passed through the chain to the final retail price. Possible reasons for this are the nature of maize meal in the consumer basket. Agents in the chain (especially retailers) might be inclined to absorb some of the cost increases because maize serves as a "key value item" to attract customers to the store. This, however, needs to be proven empirically. Symmetry in the short-run dynamics was not rejected with a TAR model. It was found that maize cost equivalents adjust to equilibrium which suggests that price formation takes place at the retail level. Maize meal prices move to correct roughly 4 per cent of a deviation from equilibrium per period. Maize prices, in turn, adjust around 15.7 per cent per period.

7. Conclusion

The fundamental question investigated in this paper was how commodity price dynamics impact staple food inflation and to explore the associated reasons for it. The study therefore aimed to address this with three objectives. The first was to obtain an efficient estimate of price transmission from commodity to retail level. The second was to consider possible asymmetry and short run price dynamics in the two food value chains and the third was to compare the results of the two chains to ultimately infer value chain factors that could impact on price determination and transmission. All three of these objectives were considered in order to regard how value chain dynamics and price transmission processes contribute to staple food inflation in South Africa.

In the case of wheat-to-bread, the results indicate full price transmission, no asymmetry and slow adjustment back to equilibrium once a shock has occurred. This is in contrast with earlier findings of Cutts and Kirsten (2006) and seems to suggest that there are no exploitive pricing strategies in the sector with respect to the underlying wheat cost. It is however acknowledged that this does not rule out uncompetitive behaviour all together. In fact, in a sub-sample of the considered time series (2000–2007), various companies in this chain have engaged in collusive behaviour.[15] Although this finding is important, it should also be noted that wheat makes up about a fifth of the total cost of bread and as a result it might be worthwhile considering other cost factors, such as electricity and distribution, to ensure that asymmetry is absent from these cost components as well. This is recommended for future research.

In the case of maize, results indicate imperfect price transmission, no asymmetry and a maize cost adjustment of almost 16 per cent per period. This is in contrast with findings of Cutts *et al.* (2006) and Funke (2008). Again, it seems fair to infer that these results do not make a supportive case for uncompetitive behaviour with respect to the underlying commodity price.

In terms of comparative results, the outcomes are less enlightening than expected with the only notable difference between the two chains the rate of adjustment back to equilibrium and the supply chain level at which price determination occurs. Slower adjustment in the wheat-to-bread value chain confirms *a priori* expectations since it is longer (more steps in the manufacturing process) and since South Africa is a small producer of wheat by world standards. Price determination that occurs at both commodity level and retail level for wheat is, however, unexpected considering that local wheat prices are almost fully driven by world prices and the exchange rate. Local factors that could impact on movement that does not coincide with import parity prices (driven by exchange rate and world prices) are typically supply related in that prices do not perfectly coincide with import parity price movements in times when producers harvest and the quantity of local supply is known. This could explain why there seems to be price determination at both ends of the supply chain. It might therefore seem that producer prices adjust to changes in bread prices but that it is rather a case of producer prices responding to supply related factors in the associated commodity market. Maize prices, in turn, are determined at retail level and transmitted up-stream in the supply chain. This also does not conform to earlier expectations of bi-directionality in this chain. This finding could, however, be explained by the saturated nature of the market and the capacity of the final consumer to absorb price changes.

Implications of the findings for staple food inflation is that it does not seem that the price determination and price transmission processes in these chains are contributing factors to the inflationary pressures that these chains have experienced in the past decade. Symmetric price transmission in both chains seems to suggest no opportunistic behaviour on the part of firms to exploit situations where commodity prices decrease. The level of price determination (commodity level vs. retail level) also seems to suggest that inflationary pressures in the wheat-to-bread value chain are as a result of cost-push inflation and demand pull inflation due to the bi-directionality of the price causality in this chain. In contrast to this, inflation in the maize-to-maize meal chain can be attributed to demand pull factors for maize meal prices being transmitted to the producer level.

Notes

1. See Cutts and Kirsten (2006) for a local example and Serra and Goodwin (2003) for an application to the Spanish Dairy Industry
2. See, *inter alia*, Azzam (1998), where rigidity in retail prices due to re-pricing costs are explored.
3. See, *inter alia*, Ben Kaabia and Gil (2005) on the effect of holding stocks on price transmission in the Spanish lamb sector
4. It is acknowledged that the presence of asymmetric price transmission between two nodes of a supply chain does not allow for strong inference about competitive behaviour in an industry (see Meyer and von Cramon-Taubadel 2004 and Tapatta 2009 for other possible explanations of asymmetric price transmission). The price determination and price transmission process could, however, serve as a starting point on whether or not a sector is behaving exploitatively in terms of changes in prices of key inputs in the production process, and how it relates to prices of final retail products.
5. Statistics South Africa only started to collect prices for super maize meal in January 2008, which therefore necessitates a shorter time series compared to bread.
6. This includes maize processing for human consumption and animal feed.
7. Gregory Hansen tests for a regime shift where there is a change in level and slope parameters did not find the wheat cost equivalents and brown bread retail prices to be co-integrated.
8. It is acknowledged that the test might have missed a structural break in early 2008. Due to the short(er) length of the time series for maize, 2008 have been trimmed so that a structural break would not be detected here. The trimming parameter has been set at 0.2.
9. Between 2008 and 2011 annual real wages increased by 13.45 per cent and electricity costs increased by 27.5 per cent in 2008, 31.3 per cent in 2009, 24.8 per cent in 2010 and 25.8 per cent in 2011.
10. The structural dummy takes on a value of 0 for the period from January 2000 to February 2008 and 1 otherwise.
11. It is more common in literature to work with prices that are not transformed and look for results that confirms findings established by Gardner (1975) and Kinnuken (1988) that found that the long-run elasticity should be equal to the cost share. Here it is important to take note that prices have been transformed into cost equivalents and therefore one would expect the long-run price elasticity of one.

12. It is acknowledged that there is a relatively large discrepancy between the price elasticity determined with the Johansen procedure and the DOLS elasticity. This could possibly be attributed to a small sample (n = 105). For the sake of consistency we interpret the estimator determined with DOLS but acknowledge the more complete price transmission could have been established with a longer time series.
13. In the case of the M-TAR model residuals are differenced and tested for asymmetry. Findings of asymmetry, therefore, rather indicate asymmetry in the momentum of adjustment as opposed to asymmetry in the actual speed of adjustment. Since this study is concerned with the latter and TAR model was utilised.
14. Non-competitive behaviour can take many forms. It can be geographical segmentation, which results in area specific monopolies, predatory pricing strategies to keep new entrants out, cost information sharing between firms etc. Another form is the explicit or tacit agreement to certain price levels or to adjust prices upward when the underlying cost increases but not do the same when prices decrease. Price transmission analysis speaks to the latter and the results here suggest that this is not an issue in the wheat-to-bread chain. It is, however, acknowledged that all of the former issues were prevalent in the wheat-to-bread chain before 2007.
15. See Mncube (2013) for further details.

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Appendix

Table A1. Univariate properties of the Brown bread and wheat prices (January 2000–September 2016).

Series	Model	Lags	ADF	PP
LBB	Trend and intercept	0	−2.2	−2.29
D(LBB)	No trend, no intercept	0	−5.48***	−14.12***
LWC	Trend and intercept	1	−3.06	−2.61
D(LWC)	No trend, no Intercept	1	−9.33***	−9.21***

Table A2. Univariate properties of the maize meal and white maize prices (January 2008–September 2016).

Series	Model	Lags	ADF	PP
LMC	Trend and intercept	1	−2.37	−2.25
D(LMC)	No trend, no intercept	1	−7.99***	−7.99**
LMM	Trend and intercept	0	−0.92	−1.11
D(LMM)	No trend, no intercept	1	−5.59***	−9.78***

Table A3(a). Gregory and Hansen (1996) co-integration tests with level and trend shift (wheat-to-bread).

	Test statistic	Break point	1% critical value	5% critical value	10% critical value
ADF	−5.54	March 2008	−5.45	−4.99	−4.72
Zt	−5.34	March 2008	−5.45	−4.99	−4.72
Za	−52.40	March 2008	−47.96	−47.96	−43.22

Table A3(b). Gregory and Hansen (1996) co-integration tests with level and trend shift (maize-to-maize meal).

	Test statistic	Break point	1% critical value	5% critical value	10% critical value
ADF	−3.88	NA	−5.45	−4.99	−4.72
Zt	−4.18	NA	−5.45	−4.99	−4.72
Za	−29.17	NA	−47.96	−47.96	−43.22