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CHAPTER 1

INTRODUCTION

1.1 The importance of research on food inflation

The concern with food inflation is embedded in the importance of managing headline inflation. Numerous marked incidents in political and economic history have been linked to inflation, often strongly supported or driven by food inflation (Ngidi, 2015). Examples of these are hyperinflation in Latin America during the latter part of the 1980's and early 1990's, which sparked a political crisis and the Arab Spring in 2011. Various researchers have noted that the latter incident ignited because of high food prices. Locally, there is also a case to be made that the food price crisis of 2008/09 resulted in a wave of xenophobic attacks and a subsequent shock in 2011/12 lead to the Marikana mining massacre[1]. To this end, Figure 1.1 shows the correlation between rapid food inflation and social unrests in South Africa.

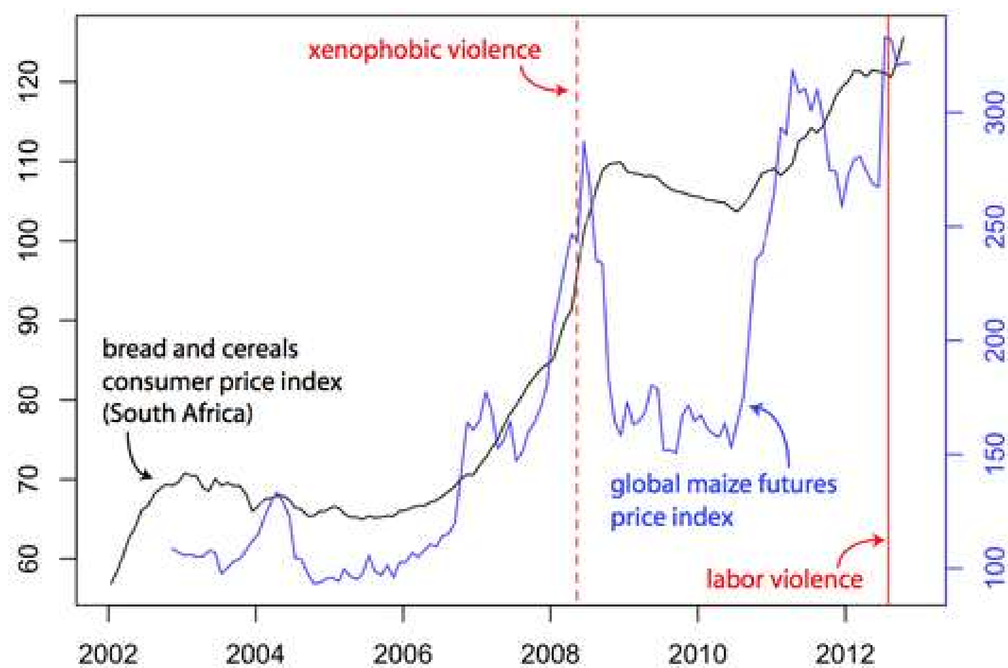

Figure 1.1: Food price increases and social unrest in South Africa

Source: Bar-Yam, Lagi and Bar-Yam, (2014).

[1] In August 2012, the South African police opened fire on a group of protesting mineworkers in the North-West province. For the full article, go to http://www.sahistory.org.za/article/marikana-massacre-16-august-2012.

From a macroeconomic perspective, the key monetary policy objective is price stability. There is however little agreement on how this should be achieved. When inflation literature is reviewed two schools of thought on this emerges. The first is a monetarist school, where money growth is the main factor that drives inflation. This is, in turn, managed by monetary policy. On the other side of the spectrum is a structuralist school which postulates that price increases are determined on the real side of the economy with limited scope for monetary policy intervention. In South Africa, and many other emerging economies, the focus seems to have been on the monetary approach, with a local inflation targeting strategy officially implemented and considered by monetary policy makers since 2000. What is however noteworthy is that food prices have played a significant role in headline inflation over the past two decades (see Rangasmay (2011) and Figure 1.2 below). Food price shocks, to a large extent, falls into the structuralist realm of inflation analysis. This seems to leave scope for structural analysis pertaining to inflation, in this case specifically food inflation. This could ultimately result in policy recommendations that would allow for a broader policy framework, which extends beyond exclusive monetary policy, with regards to (food) inflation.

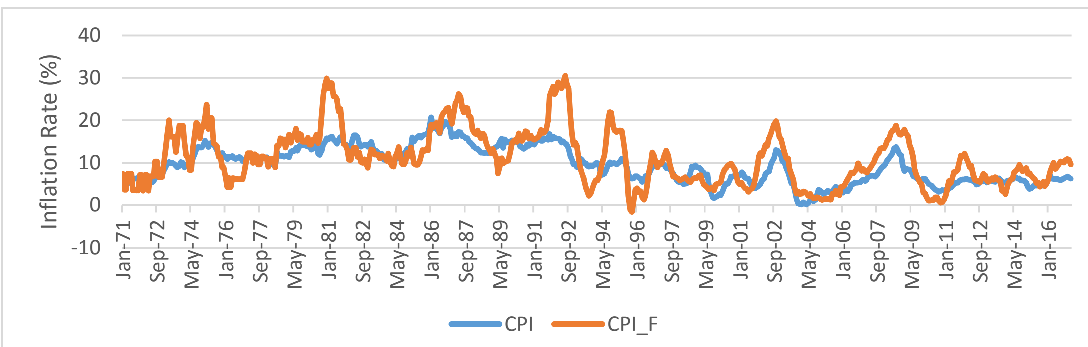

Figure 1.2: Headline and Food Inflation in South Africa (Jan 19710 – March 2017)
Source: Statistics SA

1.2 A critical appraisal of the state of food inflation research

In considering structural/fundamental factors associated with inflation, food inflation is key. This was highlighted, in 2008, by the then chairman of the US Federal Reserve, Ben Bernanke, in the following quote:

"*Rapidly rising prices for globally traded commodities have been a major source of relatively high rates of inflation we have been experiencing in recent years, underscoring the importance for policy of both forecasting price changes and understanding the factors that drive those changes*"

Echoing this, the broad theme of food price and inflation research gained prominence since the commodity super cycle experienced between 2005 and 2008. The most prominent and widely cited initiatives, in terms of food inflation, were the Transparency in Food Pricing (TRANSFOP) research, which focused on price and inflationary issues in the EU, and a wide variety of studies conducted by the International Monetary Fund (IMF). The former included a range of studies, from product-specific analysis (see *inter alia* McCorriston (2013) and Holm, Loy and Steinhagen (2012)) to aggregate analysis (see Davidson *et al*. (2012)). Prominent IMF studies, in turn, were mostly concerned with the role of food prices in headline inflation and how this affected policy (see *inter alia,* Walsh (2012) and Alper, Hobdari and Uppal (2016)).

Evident from the above is that there seem to be two distinctive approaches with regard to food inflation research. The first is a so-called "agricultural economics" approach that considers food prices and inflation in an aggregated or disaggregated form. This is in line with the TRANSFOP examples as given above. Here the disaggregated form should be understood as product-specific analysis aimed at determining the transmission dynamics between two prices either in two locations or at two different nodes of the supply chain. In this type of analysis, the inflationary implications of the transmission process are considered either implicitly or explicitly. In an aggregated form, total food inflation is considered and the objective of these studies are usually to determine what the main fundamental drivers and their associated dynamics are. The second is the "monetarist" approach in that it is typically found in monetary focused literature. This specifically considers the role of food inflation in headline inflation and other macroeconomic variables and are often concerned with the statistical and mathematical properties of inflationary series (as opposed to the underlying fundamental dynamics). Here, the IMF studies cited above serve as good examples. Although inclined to a monetary focus, the latter should not be confused with the monetary school of thought, as compared to the structuralist school, above. Here it is simply dubbed a monetary approach since it is associated with mainstream monetary literature. Conceptually, the two approaches, as highlighted above, allow one to think about food inflation at three different tiers, namely product specific/industry inflation, aggregate food inflation and headline inflation. This conceptualisation is presented graphically in the figure below.

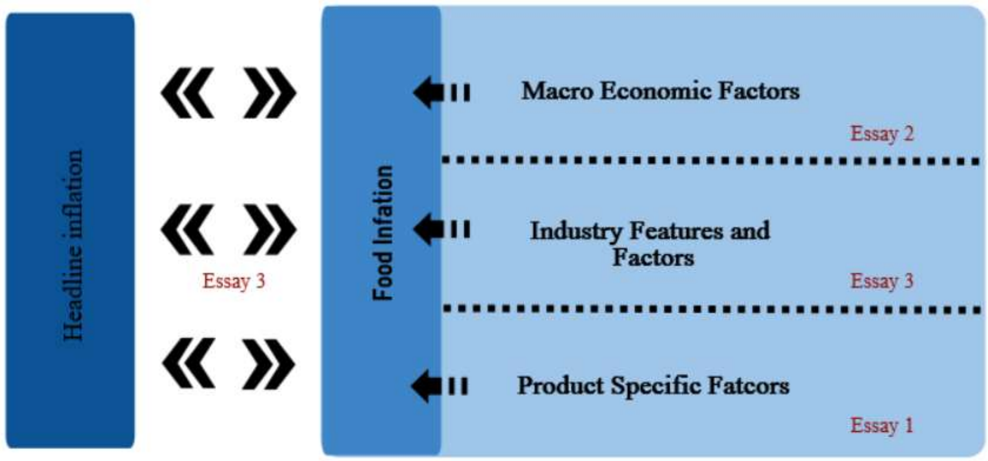

Figure 1.3: A disaggregated conceptualization of inflation

Two issues apparent in the consideration and classification of literature above are that there seems to be a fundamental disconnect between the statistical properties and the fundamental industry dynamics, as highlighted in Figure 1.3. Secondly, and related to this, inflation research seems to occur in either an "agricultural economics" or "monetary economics" silo so that the different tiers, as described above, are not linked to one another. This was practically underscored by the drought experienced in the summer rainfall regions in South Africa in 2015 and 2016. Although there was a general consensus that the drought was the main driver of food inflation, it was unclear to what extent (magnitude) and how long (duration) this shock would affect food and ultimately headline inflation. This study therefore attempts to conceptually link the various tiers associated with inflation, in an attempt to establish a link between fundamental product or industry movements and dynamics of inflation, be it food or headline inflation.

1.3 Research questions, objectives and methods

The broad research question associated with this study is therefore concerned with how to think about food inflation in the context of the broader inflationary milieu, whilst also considering the salient industry and product features and fundamentals. The approach here is to let this question guide the broad theme of the study, as opposed to a literal estimation and establishment of a quantitative link between the different tiers. The identification of the apparent disconnect, therefore, served as a conceptual framework in which more specific research questions, associated with the different tiers, as identified in Figure 1.3, could be analysed. Being cognisant of this, three research questions, tailored to the South African milieu, emerged:

- *What are the effects of value chain structure and price formation features on inflation related to specific products*?

South Africa has staple food chains that are notoriously concentrated and are often accused of opportunistic and rent seeking behaviour. This, in turn, would affect price transmission and price formation in these chains and provide inherent inflationary support for the retail prices of these products. The legitimacy of these claims is explored at the hand of basic time series techniques that account for possible asymmetry.

- *What is the effect of fundamental factors on food inflation dynamics*?

Grounded in basic neo-classical economics, theory dictates that prices are determined where supply and demand equilibrates. Following this line of thought, inflation, which is defined as a general growth in price levels, would, therefore, be the result of strong, growing demand and/or reduced supply. The nature of inflationary drivers, be-they demand or supply driven, could ultimately affect a broader and longer term policy strategy with regard to food inflation. In an attempt to determine this, the magnitude and duration of shocks to key supply and demand factors are determined with time-series econometric techniques.

- *What are the features of industry–specific inflationary dynamics and what does this imply for policy*?

It is often postulated that food price shocks are transitory and, as a result, it should not be considered in the medium to longer-term policy strategy of monetary authorities. This statement is interrogated on an aggregate food inflation and industry level with various statistical and time series properties of the variables in question and a gap analysis, as applied by Checceti and Moesner (2008).

1.4 Outline of the study

Chapter 1, presented here, serves three purposes. The first is to provide the broad(er) context in which this research has been conducted. The second is to give a critical synthesis of research on food inflation. Lastly, the chapter gives an overview of three specific research questions with a brief background, claim to be investigated and a short discussion on method. The rest of the study is organised into four chapters. The first considers product-specific supply chain features and its implications for inflationary dynamics. The second reflects on macroeconomics and their linkages (in terms of time and duration) to food inflation. The third evaluates the link between food and headline inflation and the statistical properties of industry-based inflation indices. The last chapter concludes with a summary of the main policy findings and possible opportunities for future research.

CHAPTER 2

VERTICAL PRICE TRANSMISSION IN STAPLE FOOD CHAINS IN SOUTH AFRICA[2]

Summary

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 essay 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. 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 suggest 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 suggests 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.

***Keywords**: Maize to maize meal, Wheat to bread, price transmission, asymmetry*

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[2] The essay, as presented here, has been accepted for publication in Agrekon, as: Louw, MH., FH Meyer and JF Kirsten. 2017. Vertical price transmission in Food Chains in South Africa. *Agrekon*, Vol 56(3). July 2017.

2.1 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 are on the (asymmetric) price adjustment process with the ultimate objective to relate findings to market or organisational structure[3], significant markup adjustment costs[4] or a substantial effect of inventory levels on the price adjustment process[5]. 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 studies typically focused on price movements (global to local) at commodity level and therefore 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 fail 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 essay aims to explore this, specifically for staple products, by also taking the salient features associated with the value chains under consideration, into account.

[3]See Cutts and Kirsten (2006) for a local example and Serra and Goodwin (2003) for an application to the Spanish Dairy Industry.
[4]See, inter alia, Azzam (1998), where rigidity in retail prices due to repricing costs is explored.
[5]See, *inter alia*, Ben Kaabia and Gil (2005) on the effect of holding stocks on price transmission in the Spanish lamb sector.

2.2 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 is contributing to inflationary pressures associated with food prices, is endemic in South Africa. This essay analyses this issue with the aid of basic time series techniques, which account for possible price asymmetry[6]. 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* Abdullai (2002)). This paper 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 exasperated for low(er) income households, which 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 shortcomings. Schimmelpfennig, Beyers, Meyer and Scheepers (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

[6]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 v. Cramon-Taubadel (2004) 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.

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 essay builds on the above analyses in several ways. Firstly, the data for this analysis ranges from 2000 to 2016 for wheat to bread and 2008 to 2016[7] 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 supercycle 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 urbanisation 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[8] in 2015. Secondly and closely related to the above, this study tests 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 those 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

[7]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.

[8] In October 2015 protests erupted at food retailers in Khayelitsha in the Western Cape. For the full article go to: http://www.news24.com/SouthAfrica/News/Protesters-occupy-Shoprite-demand-lower-bread-price-20151020

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 allow for an interesting case of comparison which could possibly lead to findings on how value chain structures impact the price transmission process.

The overarching objective of this essay 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.

2.3 Key Features of the Selected Value Chains

Staple food supply chains in South Africa are characterised 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% 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 (SAGIS managers) however indicate that this reduction is not due to firms going out of business but rather an indication of increased consolidation since 2008. In terms of baking, plant bakeries of the aforementioned companies bake between 50-60% of the total bread sales, while in-store retailing bakeries account for roughly 20% 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%.

With regard to maize, the milling process is somewhat less concentrated with the 20 largest companies producing 80% 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[9] 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 possibly because it is much easier for maize processors to enter and exit the market based on returns of the final product. Over the past 8 years, the average cost share of white maize per 2.5kg packet of maize meal was 57%.

A summary, of the similarities and differences between the chains, is considered in Table 2.1 below.

Table 2.1: Key feature comparison between Wheat to Brown Bread and Maize to Maize Meal

	Wheat to Bread	**Maize to Maize Meal**
Vertical Integration	Integration of milling and baking and baking and retailing operations is quite common	No vertical integration between milling and retailing
Market Concentration (Concentration Ratio (5))[10]	83%	45%
Number of processing firms 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 our domestic requirements	South Africa is the largest producer of white maize in the world. With the exception of the 2015/16 season, it is a net exporter of white maize[11]

[9]This includes maize processing for human consumption and animal feed.

[10]The concentration ratio (5) indicates what percentage of production is produced by the five largest firms in the sector.

[11]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%.

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 (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 markup pricing will occur through the chain, consistent with markup 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 essay is structured as follows: Section 2.4 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 2.5 tests for asymmetry in price behaviour and considers the short-run dynamics around the long-run equilibrium. Section 2.6 is a comparative section that contrasts the two supply chains. Section 2.7 concludes the paper with some thoughts on how value chain structure could impact price transmission and price determination and how this could ultimately impact staple food inflation.

2.4 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 cointegration test as developed by Engle Granger (1987) and Johansen (1988). A drawback of the above cointegration methods is that they assume linearity and symmetry. In this regard, this essay 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 paper 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 700g loaf, and prices for maize meal are for a 2.5kg 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 810kg of brown bread flour. In the baking process, roughly 420g of flour is used to bake a 700g loaf of bread. Given the information above one ton of wheat can yield 1928 loaves of brown bread. These extraction rates and conversion ratios are 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% is 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 Appendix A2.1 and A2.2. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests in Appendix A2.1 and A2.2 confirm that all the series in question are non-stationary and integrated of order 1.

Cointegration tests of the non-stationary prices are performed using Engle Granger's procedure and the Gregory and Hansen (1996) test. These results are presented in Table 2.2 for wheat to bread and 2.3 for maize to maize meal. Table 2.2 confirms co-integration with the Engle-Granger procedure and the Gregory Hansen procedure (with a shift in the level and a trend)[12]. The latter is a test for cointegration in the presence of a structural break. The full results of the Gregory Hansen procedure are presented in Table A2.3(a) in the appendix and show that a break, in the case of wheat, occurs in March 2008. In the case of maize, cointegration is confirmed with the Engle-Granger test, but no cointegration was found with the Gregory Hansen procedure (see Table A2.3(b) in the appendix). This implies that there is no structural break in the case of maize[13]. 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 1.1). This could, in turn, be explained by substantial increases in prices of key inputs in the production of bread, such as electricity and labour[14] since 2008.

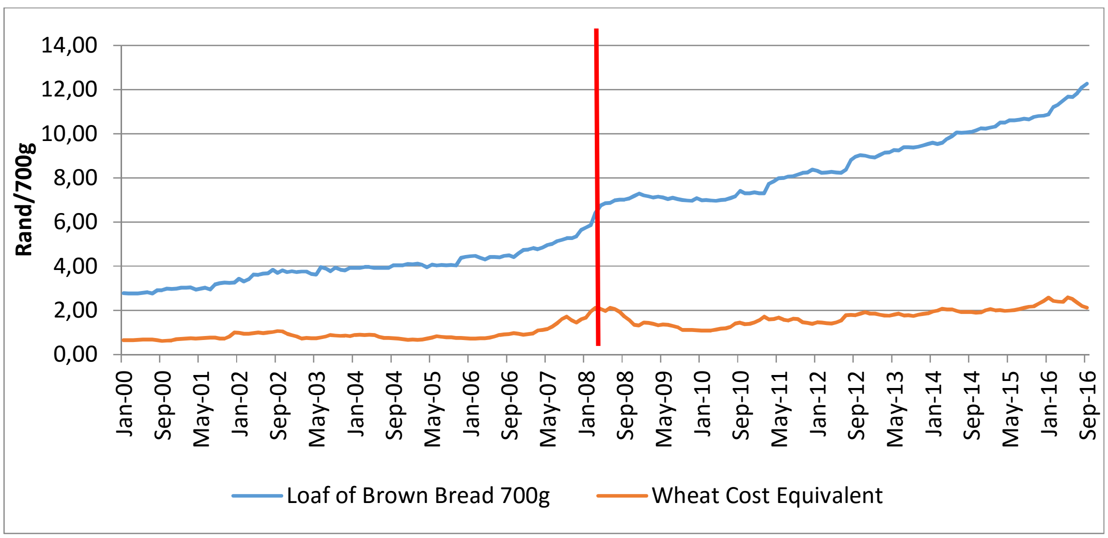


Figure 2.1: Wheat to Bread Margin (Jan 2000 to Sep 2016) with break=March 2008

12 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 cointegrated.

13 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.

14 Between 2008 and 2011, annual real wages increased by 13.45% and electricity costs increased by 27.5% in 2008, 31.3% in 2009, 24.8% in 2010 and 25.8% in 2011.

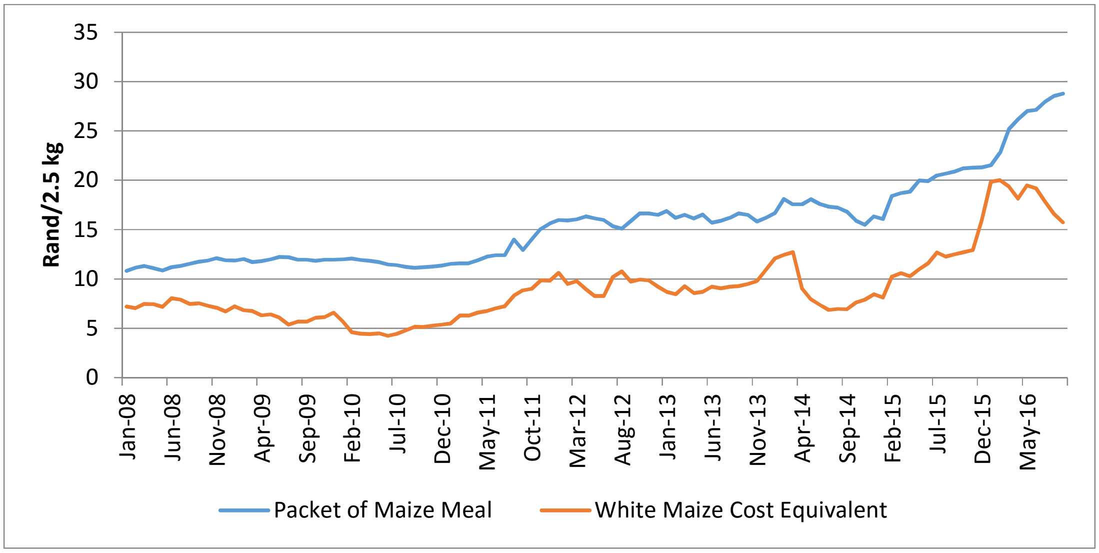


Figure 2.2: White Maize to Maize Meal Margin (Jan 2008 to Sep 2016) Wheat to Bread Co-integration Analysis (test on coefficient of lagged residual)

Based on the confirmed long-run relationship, as depicted in Table 2.2 and Table 2.3, one can proceed to consider the estimation results of the cointegrating regression function as the long-run elasticity with which prices are transmitted through the value chain (from wheat to brown bread or maize to maize meal).

Table 2.2: Wheat to Bread Co-integration Analysis (test on coefficient of lagged residuals)

Cointegration Equation	Johansen ML test (H0: r=0)		Engle & Granger Procedure	Gregory and Hansen Procedure	
	Trace	Max Eigen		With Intercept Shift	With Intercept Shift and Trend
$LBB = f(LWC\ \ )$	30.1***	29.76***	-3.02***	-3.78	-5.54***

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%).
Note: LBB is the log of Brown Bread, and LWC is the log of the wheat cost equivalent

Table 2.3: Maize to Maize Meal Co-integration Analysis (test on coefficient of lagged residuals)

Cointegration Equation	Johansen ML test (H0:r=0)		Engle & Granger Procedure	Gregory and Hansen Procedure	
	Trace	Max Eigen		With Intercept Shift	With Intercept Shift and Trend
$LMM = f(LMC)$	16.2**	15.64**	-2.9***	-3.38	-3.88

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%)
Note: LMM is the log of Maize Meal, and LWC is the log of the maize cost equivalent

Gupcheck (2013) however notes that this interpretation is based on the assumption that the long-run 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[15] is incorporated into the long-run relationship. A Dynamic Ordinary Least Squares (DOLS) according to the Phillips & 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) note that estimations which ignore the dynamics of the data generating process can result in considerable finite sample bias.

Table 2.4 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 by conventional information criteria.

Based on the results in Table 2.4 it can be seen that price transmission is 0.98 and close to perfect throughout the time series (there is no change in the slope parameter, see column 3 of Table 2.4). 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[16]. The intercept for the base period is 1.048. Since the equation is specified in logs the exponentiated value of the intercept parameter can be considered 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 2.4 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. After the shift the intercept value is 1.243 which amounts to a margin of R3.47 when wheat costs are excluded.

---

[15]The structural dummy takes on a value of 0 for the period Jan 2000 to February 2008 and 1 otherwise.

[16] 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 Kinnucan (1988) who 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.

Table 2.4: 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[17]	167.09	1.048	
Dummy for Regime 2	0.195	17.304	1.243	
Trend	0.006	62.524		
Wheat Cost Equivalent:				
Ln(WC)	0.98	116.59	0.98	1.14
Phillips & Loretan Terms:				
ΔLn(WC(-1))	-0.34	-4.88		
ΔLnWC(1)	-0.33	-4.86		
Resid(-1)	0.94	43.63		

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 2.5 below.

[17] 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 2.5: 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:	1.37	41.81		
Constant				
Wheat Cost Equivalent:				
Ln(MC)	0.63	41.75	0.63	0.92
Phillips & Loretan Terms:				
ΔLn(MC(-1))	-0.19	-2.74		
ΔLn(MC(1))	-0.1	-1.5		
Resid(-1)	0.85	17.21		

The elasticity from the above DOLS model shows incomplete price transmission of 0.63 in the maize to maize meal value chain[18]. 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 by the above mentioned authors is uncompetitive behaviour and changes in technology. Discussions with industry experts revealed that the average industry extraction rate of 62.5% could be increased in times when returns are under pressure. This amounts to a change in technology and are therefore the most likely explanation for the imperfect price transmission reflected in Table 2.5. 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.

2.5 Testing for Asymmetry and Determining short-run dynamics

Based on the cointegration 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

[18]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.

estimation of the VECM. These are reported in Table 2.6. 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 2.7, below.

Table 2.6: TAR and MTAR model parameter estimates (Wheat to Bread)

	TAR Model	**M-TAR Model**
Variable	Parameter Estimate	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
$H_0: \gamma_1 = \gamma_2$	0.02	0.025
AIC	-598.108	-586.581

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%) Note: $\gamma_1$andγ_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.

Table 2.7: Vector Error Correction Model (Wheat to Bread)

	ΔBB		ΔWC	
	Coefficient	*t-stat*	*Coefficient*	*t-stat*
Constant	**0.009*** **	**5.07**	-0.003	-0.672
ΔBB_{t-1}	**-0.161*** **	**-2.248**	0.236	1.257
ΔBB_{t-2}	-0.108	-1.49	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}	-0.02	-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**

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%)

The results of the VECM above 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 period to correct for deviations from equilibrium and wheat cost equivalents moving around 7% 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 2.8. 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[19]. The estimation results of this model are presented in Table 2.9.

Table 2.8: 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

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%)

The t-statistics for the ECT_{t-1}coefficient for the column considering maize cost (MC in Table 2.9) 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 explained by a saturated market, with stagnant growth aimed at a low(er) income consumer with little or no capacity to absorb price changes.

[19]In the case of a 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 a TAR model was utilised.

Table 2.9: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*

Asterisks denote the levels of significance (* for 10%, **for 5% and *** for 10%)

In terms of short-run dynamics, the estimates indicate that within a month, retail prices adjust to eliminate roughly 3.8% (refer to the EC term of the ΔMM in Table 2.9) of a shock from the equilibrium margin. If the maize cost column in Table 2.9 is further regarded, a unit change in the margin causes producer prices to adjust by a 15.7% change per period to correct for deviations from the equilibrium margin.

2.6 Comparing the results of the Chains

The essay 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[20], this, in combination with perfect price transmission does

[20]Non-competitive behaviour can take many forms. It can be geographical segmentation, which result in area specific monopolies, predatory pricing strategies to keep new entrants out, cost information sharing between firms ect. 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

seem to indicate the absence of exploitative pricing behaviour with regard 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% 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 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 a purchase again.

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% 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% of a deviation from equilibrium per period. Maize prices, in turn, adjust around 15.7% per period.

Table 2.10: Comparative Summary

<table>
<tr><th></th><th colspan="2">Wheat to Bread</th><th colspan="2">Maize to Maize Meal</th></tr>
<tr><td>Long-run price transmission</td><td colspan="2">0.98</td><td colspan="2">0.63</td></tr>
<tr><td>Price Determination</td><td colspan="2">Bi-directional.
Prices are determined at commodity and retail level and transmitted through the chain.</td><td colspan="2">Uni-directional.
Prices are determined at retail level.</td></tr>
<tr><td>Asymmetry</td><td colspan="2">No</td><td colspan="2">No</td></tr>
<tr><td rowspan="2">Rate of adjustment to equilibrium (per period)</td><td>Brown bread</td><td>4%</td><td>Maize meal</td><td>4%</td></tr>
<tr><td>Wheat Cost</td><td>7%</td><td>Maize cost</td><td>15.7%</td></tr>
</table>

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.

2.7 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 essay, 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 altogether. In fact, in a sub-sample of the considered time series (2000-2007), various companies in this chain have engaged in collusive behaviour[21]. Although this finding is important, it should also be noted that wheat makes up about a fifth of the total cost of a bread and as a result, it might be worthwhile to consider other cost factors such as electricity and distribution cost 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 maize cost adjustment of almost 16% per period. This is in contrast with findings of Cutts and Kirsten (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

[21] See Mncube (2013) for further details.

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 upstream 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 factors for maize meal prices being transmitted to the producer level.

CHAPTER 3

FUNDAMENTAL DRIVERS OF FOOD INFLATION – EVIDENCE FROM SOUTH AFRICA[22]

Summary

Food inflation and its associated drivers is an important issue to consider in a food security and macroeconomic context. Despite this, scientific research on this is sparse. This essay gauges the impact of key fundamental variables on food inflation in terms of magnitude and duration. It employs time series econometric techniques and finds that the exchange rate, world food/commodity prices and local agricultural prices are the main drivers of food inflation in South Africa. In terms of the short-run dynamics, the results suggest that agricultural prices and the exchange rate take up to two months to manifest in food inflation, whereas world commodity prices only affect local food inflation after eight months. The effect of the recent drought and exchange rate depreciation on food inflation is also explored, in terms of scale and persistence. Simulations suggest that the length and effect of the recent drought, as manifested in agricultural prices, will result in double-digit food inflation lasting in excess of 12 months after the commencement of the shock. Simulation results also show that perseverance in exchange rate shocks seems to affect the scale of the final effect on food inflation more than the perseverance, with long-term shocks starting to dissipate within the simulation period of 18 months. These outcomes confirm the results of previous studies that the persistence of shocks in key drivers of food inflation, is an important consideration.

Keywords*: fundamental variables, agricultural prices, exchange rate, food inflation*

[22] This essay will be submitted as an article to an accredited journal.

3.1 Introduction

Rapid food inflation has been on the list of pertinent issues that threaten food security and social stability, and this is not unique to South Africa, but affect a spectrum of emerging economies. In addition to this, Lagi, Bertrand & Bar-Yam (2011) have argued that the events of the Arab Spring in 2011 may have been prompted by spikes in food prices, which in turn lead to protests by vulnerable urban communities. Locally, although consumers are not explicitly protesting against high food prices, a general sense of unhappiness with issues such as service delivery and wages might just need a(nother) rapid food inflation shock to spark and/or intensify such demonstrations. Even if such protests do not occur, food security and implicitly food affordability is central to governments' strategies of poverty alleviation, employment and development. Food affordability is one of the main issues that affect food security in South Africa. This is confirmed by Altman, Hart and Jacobs (2009) who argue that the problem of household food insecurity is intensified by the increasing cost of food. In terms of policy decisions relating to food security, it is therefore of the utmost importance to understand food inflation and the drivers of changes in food prices. Food inflation is also important in a macroeconomic context since it has a non-trivial impact on aggregate inflation in South Africa (see Rangasamy (2011) and Figure 3.1 below). Mohanty and Klau (2001), in turn, identify food inflation as the most common determinant of headline inflation in emerging economies

More specifically, understanding the drivers of food inflation and the impact and duration of shocks of these drivers on food inflation, ultimately determines the policy measures to be implemented in order to curb it. To this end, it is worth noting that food inflation driven primarily by demand factors can be controlled with monetary policy. Contrastingly, supply drivers or dominance in supply drivers might require a combination of policies that address structural issues (economy-wide and industry specific) to control food inflation. This essay, therefore, explores the nature of South African food inflation in terms of key supply and demand (fundamental) drivers.

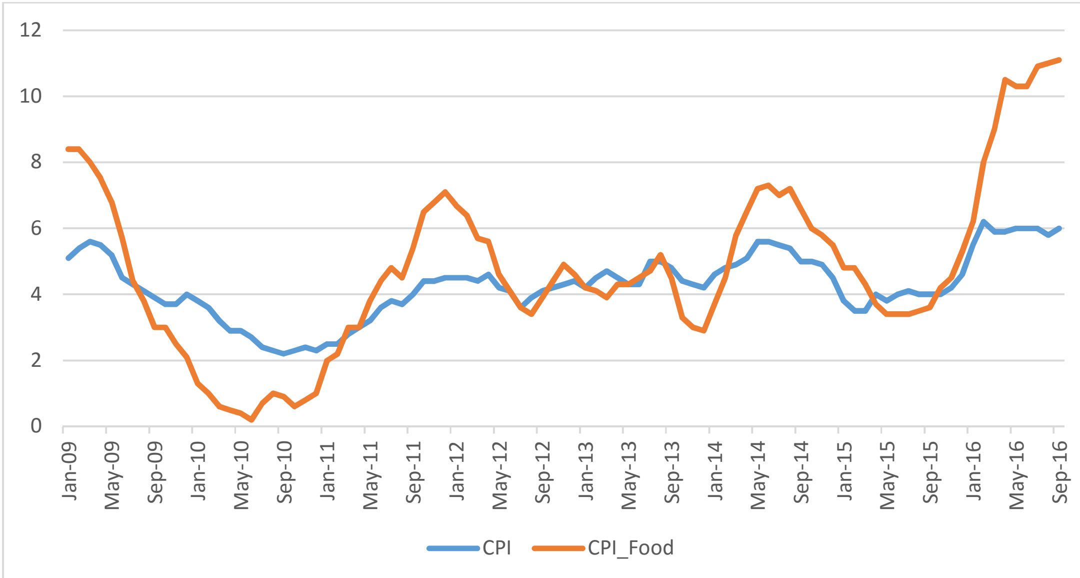


Figure 3.1: CPI and CPI_Food in South Africa (Jan 2009-Sep 2016)
Source: StatsSA, 2016

From 2002 to 2016, there were multiple episodes of rapid food inflation in South Africa. In the last quarter of 2002, year on year food price inflation touched on 20%. This spike in food prices was attributed to a sharp depreciation in the exchange rates, especially the Rand/USD exchange Rate. This was combined with high local prices of grains tending to import parity[23] as a result of a small harvest. Local prices stabilised in 2003 due to a significant appreciation in the exchange rate, only to regain momentum from 2005 to 2008. The latter price surge was predominantly ascribed to increases in global commodity prices. Westhoff (2010) attributes the aforementioned global price increases, from 2005 to 2008, to a metaphorical "perfect storm", where factors such as higher biofuel production, droughts in key grain producing countries and sharp growth in developing countries such as China and India all worked in tandem to push global commodity prices to record levels. Over this relatively short period of time, the demand for grains and oilseeds in the world market increased by more than 100 million tons (approximately 15%). Commodity prices, and consequently food prices, decreased in 2009 and 2010, but not return to pre-2005 levels, indicating a structural change in commodity markets. In 2011, local food inflation again moved towards double digits, with year on year inflation reaching 8.9% in July 2011. This increase was yet again attributed to higher international commodity prices, due to drought conditions in the US, but also due to a substantial rise in local administered prices, such as electricity. This increased

23 For a definition of the various trading regimes consult Meyer, Westhoff, Binfield and Kirsten (2006).

cost throughout the supply chain. Another local food price shock was experienced in the first half of 2014. This shock was widely blamed on high international prices combined with a weaker exchange rate. More recently the severe drought in the 2015/2016 grain production season pushed food inflation to levels in excess of 11%. The effects of the drought were apparent in food prices from October 2015 up until the end of the sample period (September 2016) considered in this essay. The effects of this drought were also amplified by a depreciating exchange rate.

Despite its recurrence, apparent importance and the fact that rapid food inflation is covered extensively in the popular media in South Africa, seemingly very little scientific research has been devoted explicitly to this topic over the past decade. Only two recent studies were identified (see Rangasamy (2011) and Griesel (2015)). The overarching objective of this paper, therefore, is to study the key drivers of food inflation in South Africa. Specifically, this essay aims to identify and quantify the key fundamental factors that impact local food inflation. It also ventures into analysing the dynamics between the associated variables included in the analysis.

This essay therefore aims to contribute to the existing literature on food inflation in the following ways. Firstly, by explicitly quantifying and identifying the factors driving food inflation in South Africa. This will add to the body of literature on drivers of food inflation in emerging economies (see *inter alia* Anand *et al.* (2016) and Nazlioglu *et al.* (2011)). Secondly, this is the first study that looks at magnitude *and* duration of fundamental shocks and how this affects perseverance of South African food inflation. Davidson *et al*. (2016) note that it is often neglected to analyse the effect of the duration of a shock on food inflation and that this is a key component when inflation dynamics are analysed. Lastly, this essay uses an alternative method in co-integration analysis, which hasn't been applied in the South African context before. We adopt a nonlinear autoregressive distributed lag model which facilitates the identification and quantification of a wide range of fundamental factors. This form also allows for differentiation between the effect of upward and downward commodity price shocks on food inflation. The expectation that this distinction is vital is driven by two factors. The first is that numerous studies on specific value chains in South Africa found evidence of asymmetric price behaviour in terms of the underlying commodity[24]. The second is based on the visual inspection of graphs depicting commodity price indices concurrently with food inflation. These are included in Appendix A3.2 and show clear evidence that food inflation does not seem to decrease in times of prominent commodity price decreases (note 2004/11-2005/08 and 2008/07-2012/02 for local agricultural prices and 2008/07-2009/02 and 2014/03-2015/12 for international commodity prices).

3.2 Literature Review

A review of the literature on the key drivers of food inflation shows that analysis of the fundamental factors affecting food inflation can take multiple forms. The first distinction that is apparent from the literature is that some studies consider food inflation in a bivariate context, where inflation is analysed as a function of one specific variable (see *inter alia* Ibrahim (2015) on oil prices and Loening *et al.* (2009) on exchange rates), and others consider it in a multivariate context where multiple drivers, and the dynamics between them, are considered together (see *inter alia* Davidson *et al.* (2016) and locally Rangasamy (2011)). Another distinction is found in the price level considered in the analysis. Some studies consider food inflation at a commodity level such as Abbott (2011) and Nazlioglu *et al*. (2011), whilst others consider food prices at retail level. In response to this, Davidson *et al.* (2016) rightly note that the nature of domestic retail food prices differs significantly from agricultural prices and that this could have important implications on how the interpretation of events on commodity markets are translated into policy recommendations. Despite these differences, a wide array of studies is considered here. This will facilitate the determination of factors that are commonly associated with food inflation and the methods used to analyse it.

Davidson *et al.* (2016), employ a co-integrated VAR methodology to study retail food inflation in the United Kingdom. They conclude that local agricultural prices, international commodity prices, exchange rates and local demand factors impact food inflation significantly over the long and short run. Oil prices are however not found to be a significant driver over the long run, but only affected food inflation through its link with primary

[24]See Cutts and Kirsten (2006) on maize, wheat, milk and sunflower oil supply chains, Uchezuba (2011) and Mkhabela and Nyhodo (2011) on poultry and Funke (2008) on beef, maize, poultry, milk and sugar.

commodity prices. Anand *et al.* (2016) employ a partial equilibrium framework to study the interaction of food demand and supply in determining food prices in India. They find that food demand is the key driver of Indian food inflation. Mueller *et al*. (2012), although not explicitly considering the drivers associated with food inflation, notes that in net exporting emerging economies such as Brazil and Argentina food inflation, to a large extent, originates from global food price spikes. They also argue that the way in which these global spikes manifest in local food inflation is determined by the institutional and political context in a country. In a bivariate setting, Baumeister *et al.* (2014), analyse the effect of oil prices on retail food prices in the United States with a VAR model and also find no evidence that oil price shocks have more than a negligible impact on food prices. In the Euro-area, Ferrucci, *et al.* (2012) applied an unrestricted asymmetric VAR model and found that international commodity prices are a, if not the, key determinant of local producer and consumer prices. Loening *et al.* (2009), in turn, by applying an error correction framework, confirm the expectation that domestic food prices in Ethiopia are mainly driven by the exchange rate and international food commodity prices, since Ethiopia is a net-food importing country.

From a food commodity price perspective, Abbott *et al.* (2011) identify the key forces driving food commodity prices as biofuel demand, which intensifies the link between energy and food prices, exchange rate dynamics, and physical factors relating to supply, such as weather conditions. They do not attempt to quantify the effects of the different factors on food prices but rather focus on describing the nature and interactions between the key drivers. Mitchell (2008) and Trostle (2008) also identify biofuel production and a food-fuel linkage as a key driver of local food commodity prices. If commodity specific studies are considered, Dillon and Barett (2013), with the use of standard time series techniques, highlight that oil prices can influence food prices through three channels. The first is through its use as an input in agricultural production. The second is through manufacturing and distribution cost of food products and the third through the food-energy link established with bio-fuel production. In contrast, by applying the Toda-Yamamoto causality approach, Nazlioglu *et al.* (2011) found that oil prices and exchange rate movements do not affect agricultural prices in Turkey.

Locally, Rangasamy (2011) analysed food inflation in South Africa by identifying inflationary episodes and determining the probability of the episode being caused by rapid food inflation. This study also did a variance decomposition and found that domestic factors, such as local producer prices, play a much larger role in creating inflationary pressures in food prices compared to international factors such oil prices and exchange rates. Griesel (2015), in turn, ventured into the forecasting milieu and forecasted local food inflation with a VAR model. Non-food inflation, oil prices, exchange rates, local supply balance figures, money supply, the producer price index and the repurchase rate was used as variables that could explain changes in food inflation. Analysis of the short-run dynamics revealed that the exchange rate and the rate of non-food inflation were the two variables responsible for the majority of variation in food inflation. This is in contrast to findings of Rangasamy (2011) mentioned above. It is also contrasting to public perception that food inflation fuels general inflation and not the other way around. Studies that have implicitly touched on South African food inflation and its determinants are, *inter alia*, Cutts and Kirsten (2006), Funke (2008), Uchezuba (2012) and Louw *et al.* (2017). These studies all found significant pass-through of commodity price changes to final retail prices of groups of food products or specific food products.

What is important to note from the studies reviewed above is that there is little consensus regarding the main drivers of food inflation, be it at commodity or retail level. This is even more pronounced for emerging economies of which specifically India, Turkey, Argentina and Brazil are touched on in the literature study. It seems that the existence and nature of anticipated drivers such as oil prices, exchange rates and international commodity prices are to a large extent affected by the structure and features of the economy under consideration, with factors such as the level of development and net trade status of food for the country in question, expected to play a key role. Based on the studies reviewed above, and the overview of South African food inflation over the last decade, it seems that the key variables that should be considered in this analysis are exchange rates, agricultural prices, international commodity prices, oil prices and demand related variables.

3.3 Methods

In the literature, food inflation and its drivers are usually examined by means of standard time series techniques. While these methods allow for long and short-run analysis, they are based on certain pre-conditions associated with the data. Pesaran and Shin (1999) note that the Johansen test for cointegration pre-supposes that all variables are integrated of order 1.

In a case where this does not hold, an autoregressive distributed lag (ARDL) model could be estimated in a linear or non-linear form. This approach allows for the inclusion of regressors with different orders of integration and, in the case of the non-linear ARDL, it can capture both long and short run asymmetries which conventional error correction techniques cannot do. The general specification for of the ARDL model is specified as follows:

$$\theta(L)y_t = \rho_0 + \rho_1 w_t + B'(L)x_{it} + \mu_t \qquad (1)$$

With $\theta(L) = 1 - \sum_{i-1}^{\infty} \theta_i L^i$ and $\beta(L) = \sum_{j=1}^{\infty} \beta_j L^j$, with *(L)* being the lag operator and w_t being a vector of deterministic variables which include the intercept, trends, dummies and other exogenous variables (with fixed lags). An asymmetric variation of the above model was developed by Shin *et al.* (2011) and is an expansion of the linear model depicted in (1).

To account for possible asymmetries in variables, we can consider the nonlinear asymmetric cointegrating regression:

$$\mathrm{y_t} = \alpha_0 + \beta^+ \mathrm{x_t^+} + \mathrm{B^-} \mathrm{x_t^-} + \mu_t \qquad (2)$$

Where B^+ and β^- are the related long-run parameters and x_t is a k x 1 vector of explanatory variables decomposed as:

$$x_t = x_0 + x_t^+ + x_t^- \qquad (3)$$

Where x_t^+ and x_t^- are the partial sums of positive and negative changes in x_t.

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0) \qquad (4)$$

And

$$x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \qquad (5)$$

The associated short run dynamics can be captured by specifying an unrestricted error correction model[25]:

$$\Delta y_t = \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \varphi y_{t-1} + \sum_{j=1}^{p-1} \gamma \Delta y_{t-j} + \sum_{j=0}^{q} (\tau_j^+ \Delta x_{t-j}^+ + \tau_{t-j}^- \Delta x_{t-j}^-) + \varepsilon_t$$

for $j = 1, \dots, q$ (6)

where $\theta^+ = \varphi\beta^+$ and $\theta^- = \varphi\beta^-$

In order to implement the ARDL empirically one needs to follow three steps. The first is to ensure that no variable included in the analysis is I(2). The presence of an I(2) variable yields the computed F-statistic, for testing for co-integration, as invalid. The second step entails estimating equation (6) using standard Ordinary Least Squares (OLS) estimation methods. Here we follow a general to specific approach to arrive at a final specification by dropping insignificant lags. The third step involves testing for cointegration among variables by applying the bounds test as developed in Pesaran *et al.* (1999) and Shin *et al*. (2011).

25 For a comprehensive derivation of and ARDL(p,q) model with an associated asymmetric error correction model consult Shin *et al*. (2011).

3.4 Data, Model and Empirical Results

As mentioned above, it seems that the key drivers to consider, when regarding food inflation, are local supply and demand factors[26], exchange rates, oil prices[27] and international food/commodity prices. As a result, the variables included in the analysis, with their associated sources, are depicted in Table 3.1. The univariate properties of the data are included in Table A3.1 in the appendix.

Table 3.1: Variables and Data Sources

Variable	Description	Source
CPI_F	Consumer Price Index for food and non-alcoholic beverages	Statistics South Africa
NEER	Trade weighted index of the Rand	South African Reserve Bank
World	World Food Price Index	Primary Commodity Prices – International Monetary Fund
Oil	Brent Crude Light Blend 38 API, FOB UK	Primary Commodity Prices – International Monetary Fund
Retail	Monthly Retail Trade Figures	South African Reserve Bank
Agri[28]	Agricultural Producer Price Index	Statistics South Africa

As mentioned earlier, the data covers the period January 2002 to September 2016, and all the variables are included in logarithmic form.

The investigation is performed on the empirical model below:

$$lnCPIF_t = f(lnAgri_t^+, lnAgri_t^-, lnWorld_t^+, lnWorld_t^-, lnER_t) \quad (8)$$

[26] Retail trade data serves as a proxy for local demand in that it is a coincidental indicator for inflation and reflects the current state of the economy. It is acknowledged that unemployment and per capita GDP figures would've served as more appropriate proxies. These variables are however not available in a monthly frequency for South Africa. This variable was included in the initial specification of the model but found to be statistically insignificant. The flawed nature of the proxy used may also play a significant role in the insignificant parameters estimated in the empirical analysis, but in the absence of improved data it is not possible to make a better inference regarding this variable. Further analysis revealed that there is a strong relationship between the demand proxy and food inflation up until 2009, after which demand seems to dampen and food inflation keeps a relatively steep trajectory (see appendix A3.2).

[27] Oil prices were included in the initial specification of the model but were omitted in the empirical estimation due to insignificant long and short run parameters. This results correspond to findings of Baumeister *et al.* (2014) and Nazlioglu (2011) who also found that oil price did not significantly influence food prices in the US and Turkey. Further reading revealed that oil prices do seem have an impact on food prices in South Africa but that this impact is episodic (see Aye (2014)) when determined with rolling causality tests.

[28] Agricultural PPI serves as a proxy for local supply factors.

If the steps, as laid out in the methods section are followed, Table A3.1 in the appendix reveals that all variables, with the exception of Agricultural PPI, are non-stationary in levels but stationary in first differences, suggesting an integration order of 1. If one, however, considers the KPSS test, this series is stationary in levels. This contradiction seems to suggest an order of integration between 0 and 1. It can however safely be concluded that none of the variables is I(2) and we can, therefore, proceed to test for co-integration in an ARDL framework. We start off by testing for co-integration, using an unrestricted error correction model, derived from the model presented in equation (1). The optimal lag length of the unrestricted error correction model is determined by conventional information criteria. In order to arrive at a final ARDL specification, a general to specific approach is followed. This is done by starting with p =max and q=12 and dropping all insignificant right hand side variables. Co-integration between the significant regressors is confirmed in that the joint significance of the parameter of the lagged variables, in levels, exceeds the upper bound of the critical value available in Pesaran *et al*. (1999) and Shin *et al.* (2011)[29]. This is shown in Table 3.2. The estimates of the model are presented in Table 3.3.

Table 3.2: Bounds test for co-integration

Model	**F-Statistic**	**95% lower bound**	**95% upper bound**	**Conclusion**
Asymmetric ARDL model [a]	5.01	2.87	4.19	Co-integrated

[a] An estimated version of the non-linear ARDL model is presented in Table 3.3

[29] In an NARDL, due to the dependence structure that exists between the partial sum decompositions x_t^+ and x_t^- , the exact number of regressors (k) that one should consider is not clear. We therefore adopt a conservative approach as advised by Shin *et al*. (2011) and select k=5.

Table 3.3: Non-linear ARDL estimation results

Independent Variable	Coefficient	
Constant	0.259***	
$\Delta LCPIF_{t-1}$	0.062	
$\Delta LCPIF_{t-2}$	0.125*	
$\Delta LCPIF_{t-3}$	0.116	
$\Delta LCPIF_{t-4}$	-0.039	
$\Delta LCPIF_{t-5}$	-0.106	
$\Delta LCPIF_{t-6}$	0.027	
$\Delta LCPIF_{t-7}$	-0.055	
$\Delta LCPIF_{t-8}$	-0.134*	
$\Delta Lagriculture^{+}$	0.049*	
$\Delta Lagriculture^{-}$	0.032	
$\Delta Lworld^{+}_{t-8}$	0.039*	
$\Delta Lworld^{-}$	-0.016	
ΔLER	0.033*	
ΔLER_{t-2}	0.051***	
$LCPIF_{t-1}$	-0.078***	
$LAgriculture^{+}_{t-1}$	0.017***	
$LAgriculture^{-}_{t-1}$	0.01	
$LWorld^{+}_{t-1}$	0.024***	
$LWorld^{-}_{t-1}$	0.011	
LER_{t-1}	0.024***	
Model Diagnostics		
Test	**Test statistic**	**p-value**
Jarque –Bera	5.584	0.06
ARCH	0.331	0.57
LM Q(4)	1.651	0.20

Where *** denotes a 1% level of significance, ** a 10% level of significance and * a 10% level of significance.

In order to confirm the suitability of the non-linear model, we applied the Wald test for both long and short run asymmetries. The results are depicted in Table 3.4. According to this, the hypotheses of symmetric adjustment can be rejected in the long and short-run for both local agricultural prices and international food commodity prices. This further substantiates that a linear model for the behaviour of food inflation in South Africa would be misspecified.

Table 3.4: Wald Test for long and short run asymmetries

	Time Frame	Test Statistic	P-value
$LAgriculture$	Long-run	1.35	0.24
	Short-run	3.51	0.06
$LWorld$	Long-run	1.69	0.2
	Short-run	0.13	0.71

The estimated long-run coefficients can be used to determine the long-run relations or the so-called β parameters, as discussed in the methods section. This is done by taking the long-run coefficients (θ_i), that is depicted in Table 3.3, and dividing it by the coefficient of the lagged dependent variable (φ_{t-1}). The estimated relations are shown in Table 3.5. From the results below we can conclude that a positive 10% increase in international commodity prices leads to a 3.1% increase in food inflation. Likewise, a 10% change the exchange rate leads to an 3.1% change in food inflation and a 10% positive shock in local agricultural prices leads to a 2.1% increase in food inflation. Negative shocks are not discussed due to their statistical insignificance.

Table 3.5: Long-run Relations

	Long-run elasticities
$LAgriculture^{+}$	0.21***
$LWorld^{+}$	0.31***
LER	0.31***

Where *** denotes a 1% level of significance, ** a 10% level of significance and * a 10% level of significance.

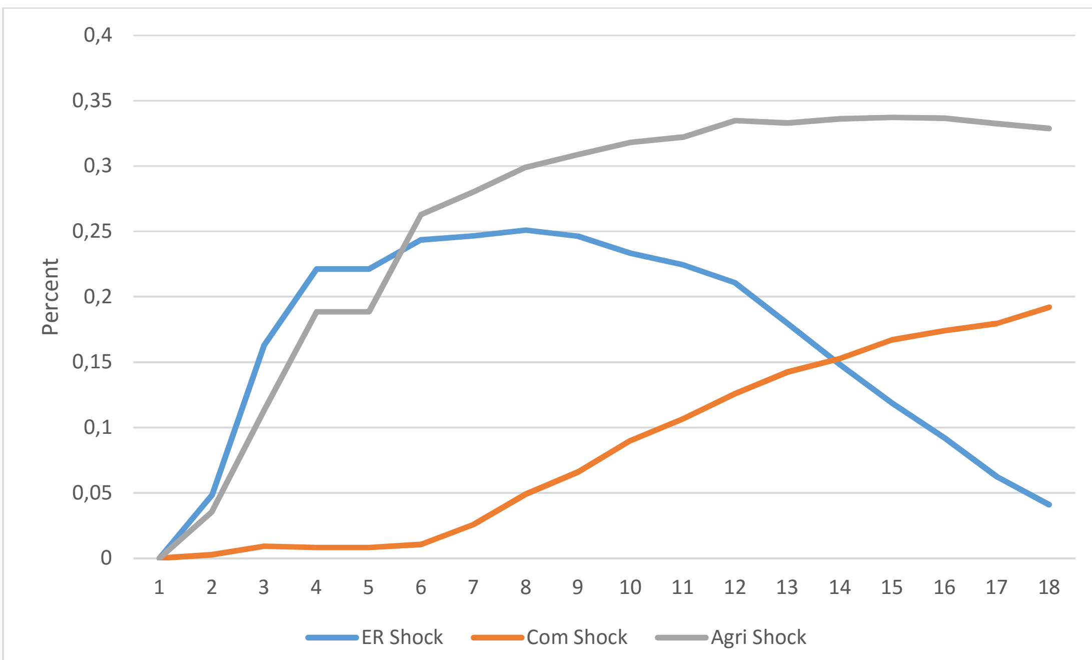
In terms of the short run impact of the identified variables on food inflation in South Africa, it appears, from Table 3.3, that international commodity prices have no contemporaneous effect on food inflation, but that increases in international prices $(\Delta Lworld)$ only manifest in local food inflation after 8 months. This can possibly be explained by the fact that international commodity prices exert upward pressure through its link to local agricultural prices and processed food products imported into South Africa. This effect is expected to take a number of months due to distribution and manufacturing lags. Local agricultural prices have a significant contemporaneous effect on food inflation, whereas exchange rate effects take up to two months to manifest in food inflation figures.

3.4.1 Retail Food Price Dynamics

Although the model provides invaluable information on the long-run relationships between the identified variables, it provides very little insight on the impact of a shock in one of the regressors in terms of magnitude *and* duration. The NARDL could provide some insight on this through dynamic coefficients. It was however opted to analyse the dynamics with a Vector Auto Regressive (VAR) model. This is beneficial in comparison to an ARDL model in that it accounts for the possible interrelatedness between variables.

We carry out impulse response (IR) analysis to determine the dynamic effect of a shock using standard (as opposed to orthogonalised) impulse response functions. The impulse response functions are computed with Monte Carlo simulations, similar to the methods used by Davidson *et al*. (2016). According to Davidson *et al*. (2016), it is important to note that this method of introducing a shock ignores the observed correlation between error terms and differs from the IR analysis where errors are considered orthogonally. The concern with the orthogonal arrangement is that the ordering choice is somewhat arbitrary. The standard approach, as applied here, considers a shock to the respective drivers in isolation and the shocks are only affected by the empirical distribution of the errors[30].

As mentioned above, if the approach as explained in Davidson *et al.* (2016) is followed, the dynamic effect of a 10% one-period shock in each driver on food inflation in South Africa can be determined. The effects of shocks in the respective drivers are depicted in Figure 3.2, below.



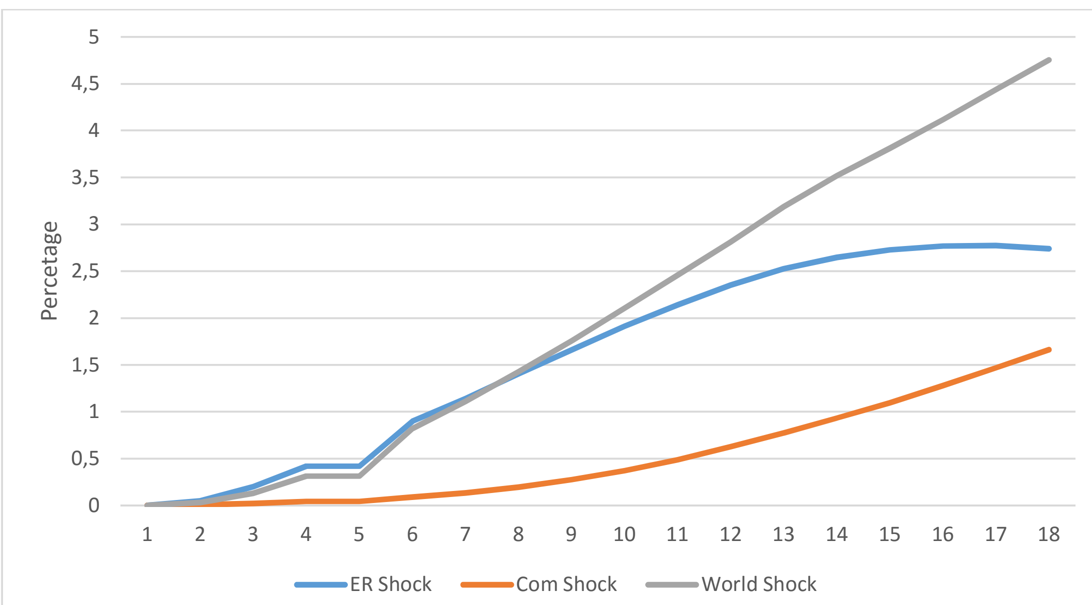
Where ER Shock represents an Exchange Rate Shock, Com Shock a world price shock and Agri Shock a local agricultural price shock

Figure 3.2: The Percentage Change in Food Prices following a one period 10% shock

30 It is acknowledged that since the shocks are not orthogonalised, a structural interpretation derived from the simulation is not possible. The model does however show what would happen in the case of a shock to an individual equation.

Figure 3.2 shows that, over an 18-month simulation period, shocks to exchange rate and local agricultural prices have the largest effect on food inflation in South Africa. Specifically, a 10% shock in the exchange rate, applied to one period, is estimated to increase food inflation by 0.04% in the month directly following the disturbance. This impact increases to around 0,25% in the seventh month after the shock and diminishes to below 0,05% over the rest of the simulation period. In the case of local agricultural prices, the month immediately following the shock also yields a 0.04% shock but increases over the simulation horizon to reach a high of 0.34% after a year. Towards the end of the 18-month period, this effect starts to subside. International food commodity prices have an almost negligible effect in the months directly following a shock. In the seventh month, we do however see that food inflation starts to react to such a shock. Food inflation then starts increasing to levels of around 0.2%. This seems to correspond to the basic dynamic factors analysed with the ARDL above where it showed that international commodity prices take 8 months to affect food inflation significantly.

We also repeat the simulations above, by applying a 10% permanent shock to each of the drivers to determine the effect on food inflation. The result is that the shock lasts longer and that the subsequent effects are much larger. The results are presented in Figure 3.3.



Where ER Shock represents an Exchange Rate Shock, Com Shock a world price shock and Agri Shock a local agricultural price shock

Figure 3.3: The Percentage Change in Food Inflation following a 10% permanent shock

From the above, it should be apparent that a permanent shock in the exchange rate results in food inflation increasing by around 2,7% over the forecasting period, whereas international commodity shocks result in a less than 1,5% increase and local commodity prices reaching around 3,6% towards the end of the simulation period.

The two scenarios above represent two poles of how shocks to drivers of food inflation could possibly play out. In reality, it is safe to assume that shocks would vary in length and it is, therefore, worthwhile to explore shock durations that are more relevant empirically. Figure 3.4 and Figure 3.5 shows how the duration of a shock, specifically in agricultural prices and exchange rates, impacts on the magnitude of food inflation that is ultimately experienced.

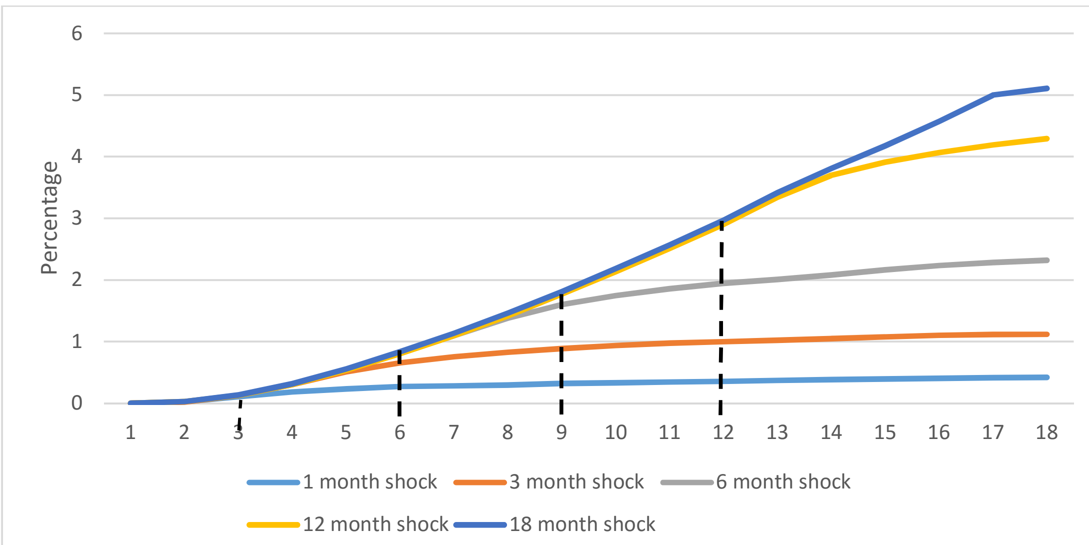


Figure 3.4: Percentage Effect on South African Food Inflation of a 10% shock to agricultural prices by duration of the shock

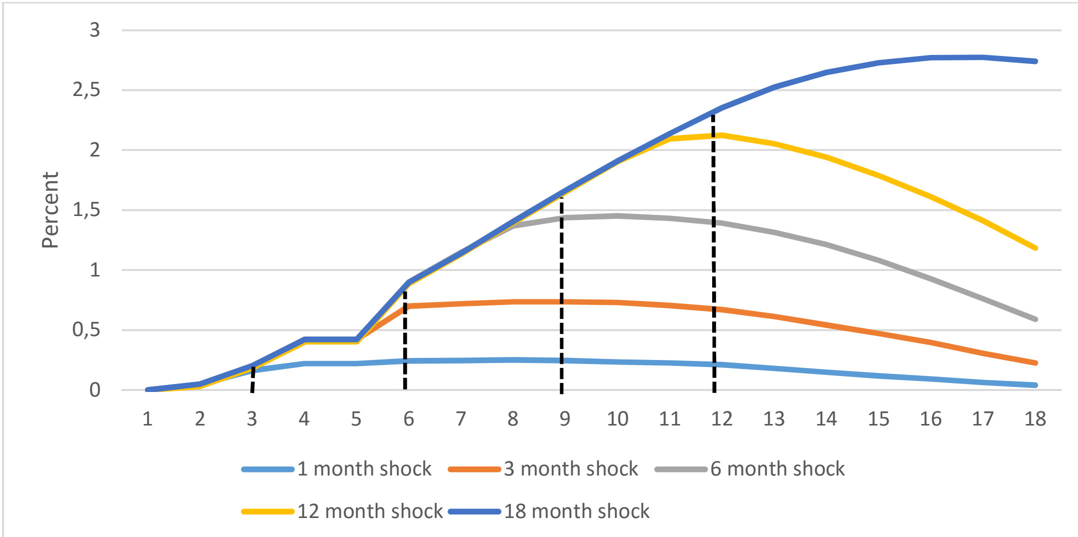


Figure 3.5: Percentage Effect on South African Food Inflation of a 10% shock to exchange rate by duration of the shock

The focus on agricultural prices and exchange rates can be motivated by its current relevance. The severe drought experienced in the 2015/16 production season had significant impacts for local food inflation, but there was no tool that could be used make the impact of the drought quantifiable. The estimated VAR model with the associated shocks as depicted in Figure 3.4, shows how the effect of an increase in agricultural prices (that could be as a result of a drought), related to different shock lengths, ultimately affects food inflation. From Figure 3.4 it is apparent that a three-month price shock of 10%, in agricultural prices, will lead to an increase in food inflation of around 0.5% over a period of 18 months. A six-month agricultural prices shock, in turn, will lead to an increase in food inflation of a little more than 1%. A 10% shock over 12 months would result in food inflation increasing in excess of 4% over the simulation period. If one considers the inflation associated with agricultural prices during the time of the discussed drought[31] it is clear that persistent shocks of the magnitude experienced, will induce double-digit inflation and that the size and persistence of the effect on food inflation increases with the duration of the shock. This shows that the maximum effect on food prices does not start to dissipate at a fixed period after the shock has occurred but are very much dependent on the length of the shock. Although Figure 3.4 shows that the rate of growth in inflation starts to decrease to the end of the simulation period, following a persistent 10% agricultural price shock, it does seem to suggest that the

[31] At the end of the estimation range (September 2016), monthly agricultural price inflation for the preceding year varied between 5.6% and 26.5%. with only two months recording inflation less than 10%.

effect of the 2015/2016 drought will take well in excess of 12 months to dissipate from local food inflation.

In terms of exchange rates, Figure 3.5 shows that a 10% shock lasting 3 months, will reach a maximum of around 0.75% and start to dissipate after a year from the initial shock. Similarly, a 6-month shock will reach a maximum of around 1.5% and also start to dissipate after roughly 12 months after the initial shock. It seems that the length of an exchange rate shock has a greater effect on the magnitude than the persistence of food inflation. This could possibly be attributed to the fact that exchange rate shocks are usually short lived. It is however acknowledged that there has been a general depreciating trend associated with the South African currency since 2012 and permanent shock of 10% over the simulation period therefore also seems plausible. This will result in a 2.75% increase over an 18-month simulation period. From Figure 3.5 it seems that the effect of a permanent exchange rate shock will stabilise toward the end of the simulation period.

It is also worthwhile to consider the differences between the long-run elasticities and the estimates generated with the permanent shock. Davidson *et al*. (2016) note that the extent to which estimates of the permanent shock vary from the long-run elasticity depends on the importance and nature of the interactions among variables in the system. These interactions are incorporated into simulations generated with the VAR but omitted from the corresponding long-run elasticities. The results suggest that incorporating the interaction between variables seems to amplify the effect of the drivers on food inflation. This differs from findings of Davidson *et al.* (2016), who found that allowing for the interaction between variables dampens the effect of a shock on food inflation. The reason could possibly be found in the salient differences between the UK (for which Davidson *et al.* (2016) did their analysis) and South Africa[32].

Vector Auto-Regressive models can further be analysed by doing a variance composition. This provides a useful summary of the comparative significance of each variable to the evolution of all other variables included in the system. Table 3.6 provides the effect of each variable to domestic food inflation at various points over the forecasting horizon. The values

[32] The apparent differences include the significance of demand as a driver of food inflation in the UK and the strength of the Pound Sterling. Both these factors could have a dampening effect on local and global supply shocks, this however needs to be proven empirically.

report the relative prominence of a shock from each source so that each row sums to 100. The columns, therefore, trace how the contribution of each of the drivers changes over time.

Table 3.6: Forecast Error Variance Decomposition of South African Food Inflation

Month	*South African Food Inflation*	*World food commodity prices*	*South African Agricultural Prices*	*Exchange Rate*
1	100	0	0	0
6	81.019	0.319	9.004	9.657
12	72.901	2.626	14.266	10.207
24	65.098	8.931	19.608	6.363
36	59.548	13.102	23.613	3.737

Assuming that 1, 12 and 36 months represents short, medium and long term, respectively, the decomposition suggests that in the short-run idiosyncratic shocks to food inflation tends to overshadow shocks associated with the drivers. This indicates that shocks in the identified drivers take time to reflect in inflation figures. Exchange rate and local agricultural prices are the first to register in food inflation figures, with the exchange rate amounting to 10% of the variation in the medium term and agricultural prices amounting to 14% for the same period. World food commodity prices only amount to 2.6% if a 12-month period is considered. Over the long term, however, agricultural prices account for roughly a quarter of the variation. World commodity prices account for around 13% of the variation in the long-run. In contrast with the two price variables, the effect of the exchange rate diminishes over the long-run to account for roughly 4% of the variation in food inflation.

3.5 Conclusion

The objective of this essay was to identify and quantify the key fundamental factors that impact food inflation in South Africa. This is done by means of an ARDL analysis, to gauge the impact of various factors. Subsequent to this, the dynamics between food inflation and the various variables, as identified in the ARDL analysis, are considered. This is done with a standard Vector Autoregression model, in order to analyse the durational effect of the shock.

The ARDL analysis reveals that the key drivers of food inflation in South Africa are local and global commodity prices and the exchange rate. This is to some extent to be expected since South Africa is a net importer of food[33]. It is however surprising that the demand proxy does not have a significant impact on food inflation. Further analysis revealed that there is a strong relationship between the demand proxy and food inflation up until 2009[34], after which demand seems to dampen, and food inflation keeps a relatively steep trajectory. This could be an indication that demand could be treated as "episodic" and models should account for this with thresholds and regimes. As a result, this is recommended for future research. The results further indicate that asymmetries in local and international commodity prices need to be accounted for and if these are treated in a linear form there is evidence that the model could be misspecified. Another apparent finding from the ARDL analysis is that world food commodity prices take a relatively long time (8 months) to manifest in food inflation figures. The other two variables are quick to manifest in inflation and this is what one would expect.

The VAR analysis shows that exchange rate and local agricultural prices have the largest impact on food inflation in South Africa. This analysis confirms that world prices are slow to manifest in food inflation. The VAR decomposition further reveals that exchange rates have a substantial effect over the medium term but that the largest factors that influence food inflation over the long term are local commodity prices. The associated VAR simulations show that the high agricultural prices, as a result of the severe drought, are expected to affect food inflation in excess of 12 months after the initial effect of the shock. In contrast, exchange rate shocks are relatively short-lived but shock persistence does have a meaningful effect on the magnitude of the shock experienced over the simulation period.

The above results indicate that food inflation in South Africa is predominantly driven by supply shocks (local, global and those related to exchange rate). Although the methods used to determine this are not directly comparable to studies on other emerging economies included in the literature study, it seems to correspond to the findings of Loening *et al.* (2009) for Ethiopia and Mueller (2012) for Brazil and Argentina. These countries and South Africa share the fact that are heavily engaged in international food and food commodity trade and reliant on local agricultural sectors. It however, differs from results that demand

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33 Rahmanian(2015) break South African Food imports down into the respective food categories. This shows that all cereal products, with the exception of maize, and meats are net importing industries. These two product categories also constitute roughly 50% of the product weighting in the food consumption basket.
34 2009 marks the start of an economic recession in South Africa, with growth contracting by 2 percent in the first half of the year.

is the largest driver of food inflation in India, as shown by Anand *et al*. (2016). This difference could possibly be attributed to the sheer size of the Indian population and income distribution within the two countries[35]. Although the effect of inflation on income distribution is well researched the effect of income inequality on inflationary dynamics are uncertain. This could pose a specific avenue for future research in the broader context of food inflation drivers in emerging economies.

The implication of the findings of this study, from a macroeconomic policy perspective, is that if increasing food inflation is driven by exogenous factors (such as world prices, droughts and exchange rate shocks) the ability to manage shocks in these drivers, using monetary policy, will be limited. It is therefore recommended that other measures, such as policies related to drought disaster management, be put in place to help curb the effects of rapid food inflation, at least as far as local agricultural prices are concerned. In terms of food affordability, which forms a key component of household food security, policies that support the competitiveness of South African food production could go a long way to serve as a buffer for inflationary pressures associated with world food prices and the exchange rate.

[35] In 2011, South Africa had an gini-coeficient of 0.63 in comparison to India with 0.35.

CHAPTER 4

MILK, BREAD AND MONEY – POLICY IMPLICATIONS FOR SECTOR SPECIFIC INFLATIONARY DYNAMICS[36]

Summary

Monetary policy makers often consider core inflation, with food and energy components excluded, in order to gauge "true" movements in inflation. This paper adds to the growing body of literature that proves that food inflation should be included and regarded in its own right when monetary policy is devised. The essay proves that second round effects associated with food inflation are significant and that food inflation in general, and for all it sub-components, is persistent. The findings support advice for a more holistic policy approach to managing food inflation. This could include industry-specific policies, aimed at curbing price increases that result in first round food inflation, combined with monetary policy geared towards minimising the effect of second round food inflation.

Keywords: *Second round effects, core inflation, food inflation*

[36] This essay will be submitted for publication to an accredited journal.

4.1 Introduction

Historically there has been a movement by central banks to consider core inflation[37], with food and energy components removed, as a measure to inform monetary policy decisions (Bryan and Checcetti (1994)). The reasoning behind this is that food and energy prices are prone to supply shocks which could be considered transitory and, as a result, these components should be excluded in order to get a "true" representation of general inflationary trends. Recently, however, a large body of literature has developed which advocate the importance of including food inflation, and even considering it in its own right, in monetary policy decision making, especially in emerging economies (see, *inter alia*, Apler (2016) and Walsh (2011)). These studies note that in emerging economies food inflation plays an important role in the inflationary process for two main and ultimately sequential reasons. The first is that food forms a substantial part of the expenditure basket of consumers in these countries (as compared to the relatively small proportion in developed nations). The second is that this often leads to significant second round effects of food inflation in the form of demand for higher wages. According to Ruch and du Plessis (2015), this, in turn, increases the price of goods through their cost structure and/or through higher demand associated with higher wages. Despite the relatively low share of food in the South African expenditure basket associated with the CPI, (17.24% according to StatsSA (2017)), Rangasamy(2011)[38] and Gupta, Jooste and Ranjbar (2015) have eluded that food and energy prices can affect headline inflation significantly.

In addition to the above, Andrle (2013) notes the following: "*…there has been an acknowledgement among policy makers that existing (monetary) regimes – with their almost exclusive emphasis on monetary targets – have not provided a useful framework for thinking about (structural) shocks*." Altissimo, Ehrman and Smets (2006) in turn states that: "*Although it is the properties of aggregate inflation that are eventually of interest for policy-making, it is crucial to understand the main features and determinants of the …underlying (industries), as these are important factors in the way prices and inflation behave over tim*e.

[37] Here, core inflation should be understood as a measure of inflation that excludes temporary shocks or volatility. This is typically associated with industries such as the food or energy sector. Core inflation therefore reflects the long-run inflationary trend in an economy.

[38] Although this study did explicitly estimate the second round effects of food inflation, this was done for the period 1971-2008. Our study considers the time frame of January 2009 to February, which include multiple structural shocks to food prices after the introduction of the inflation targeting framework in South Africa in February 2000. See Louw *et al*. (2017)) for a full discussion of food inflation for this timeframe.

This is also the case for South Africa, in that it is unclear how industry-specific dynamics[39], such as the 2015/2016 drought, translate to aggregate food inflation and whether these sector-specific shocks result in inflationary persistence or only temporary produce noise in food inflation data. It is further unclear how a change in food inflation ultimately affect headline inflation.

To this end, the objective of this essay is twofold. The first aims to document the contribution of various sector level structural price movements to food inflation over the past two decades. This could possibly serve to inform policy measures at industry level geared towards mitigating the first round effects of food supply shocks on inflation. The second considers the presence of second-round inflationary effects associated with food prices in South Africa. This will be indicative of how effectively monetary policy can manage the impacts of food inflation. As touched on above, second round effects should be understood as the reaction of market participants to first round effects. If one relates it specifically to food inflation, it is the response of consumers and producers in reaction to higher food prices. Consumers react by demanding higher wages and producers respond to higher input cost (in the case of food production), either by producing less or passing on the cost of production, depending on the prevailing market structure. All of these responses add to inflationary pressures created by the initial shock to the underlying food product(s).

In order to form expectations on the presence of second-round effects in South Africa, literature on various other countries, with regards to the link between food and headline inflation is considered. Evidence on the existence and magnitude of second round effects of food inflation varies among countries. Zhang (2010) found no evidence of significant second round effects in China by applying a gap-analysis regression technique as proposed by Cecchetti and Moesner (2008). They noted that these findings could largely be attributed to the nature of the labour force and wage negotiation practices in China. This study informs the current study in two ways. It provides an empirical application of Cechetti and Moesner (2008) and shows the importance of organised labour unions on the inflationary process. Anand (2014), in turn, found evidence of large second round effects in India. This study applied a reduced form general equilibrium model of the Indian economy to determine the

[39] Here industry specific occurrences should be understood as incidents such as drought or a disease outbreak, that causes a significant supply shock in an industry.

presence of second-round effects. In line with this, Walsh and Yu (2012) found that rural wages, in India, respond elastically to food inflation. This implies the presence of second round food price effects in India. Mueller *et al*. (2012) found that second round effects of food inflation in Brazil were limited. Similarly, an implicit finding of Andrle (2013), in developing a forecast and policy analysis system for Kenya, is also that food inflation mainly influenced headline inflation through first round effects. In contrast to this, Misati and Munene (2015) found significant evidence of second-round effects associated with food in Kenya, by applying a gap and Phillips curve analysis. In South Africa, Rangasamy (2011) found evidence of second-round effects for the period 1971 to 2008, by also considering a variation of the Cecchetti and Moessner method. Ruch and Du Plessis (2015), in turn, also found significant evidence of second-round effects associated with food and energy prices by applying a Structural Bayesian Vector Auto Regression (SBVAR) model for the period 1994 to 2014. Less formally, without the application of quantitative models and estimations, food prices are identified as a driver of headline inflationary pressures by, *inter alia*, Kaarestvirtra *et al*. (2008) in China, Cheung (2008) for 8 Asian economies and Woertz, Pardhan, Biberovic and Koch (2008) for the Gulf Cooperation Council (GCC) countries. This array of literature shows that there is no conclusive evidence on the presence and degree of second round effects of food inflation and that the incidence of this is ultimately impacted by the salient features of a specific economy.

In terms of analysing sector specific structural price movements, and exploring its effect on food inflation, literature is limited. In order to document the role of this one can, however, draw on literature that analyses key features associated with inflation in general. In considering the features associated with food inflation and how it affects headline inflation, Walsh (2011) considered inflationary trends. He notes the importance of analysing inflationary patterns and determinants, in that patterns have implications for the conduct and timeliness of policy. In order to gauge inflationary trends/persistence, Pivetta and Reis (2007) posit three methods. These are the Sum of Autoregressive Coefficients (SARC) approach, the Largest Autoregressive Root (LAR) and Impulse Half Life (HL). These methods will be elaborated on in the sections that follow. Another key feature that can be analysed to improve our understanding of an inflationary process is the underlying elements associated with an inflation series. To this end, and as highlighted above, Altisimo *et al*. (2006) note that it is important to identify and understand underlying forces that affect an inflationary process. Rangasamy (2011) employ two methods to do this[40].The first is to consider the relative contribution of the sub-components of an inflation index, with respect to expenditure weight. The second is to estimate the probability of an inflationary episode in food when there are strong inflationary pressures in one of the sub-components of the associated series. The research overview presented above serves three purposes. The first is to highlight the limited research with regards to inflationary indices and their associated sub-components. The second notes the possible methods that can be utilised in order to conduct an inflationary analysis, in a disaggregated form. Lastly, this section indicates that the presence and magnitude of second round effects are to a large extent determined by the salient features of a specific economy.

This paper contributes to existing literature on food inflation in several ways. First, it measures the second round effects of South African food price inflation for the time range January 2009 to February 2017. Although this was done before, in Rangasamy(2011), the more recent time frame, considered in this study was riddled with numerous periods of rapid food inflation, which could ultimately lead to different findings. Secondly, this study considers the inflationary features of the industry indices that serves as sub-components to aggregate food inflation. As mentioned earlier, this provides a first step for industry focused policies to help mitigate the first round effects of food inflation. Lastly, and related to the above, these findings help to establish a link between aggregate food inflation and industry specific price dynamics.

4.2 Sector Level Inflationary Features

In order to analyse the inflationary features associated with the sub-categories of food inflation, four features are considered. The first is the contribution of each sub-group to overall food inflation. This is compared to the weight assigned to each group in the food consumption basket associated with the Consumer Price Index (CPI). The relative contribution is indicative of how rapid price increases in the sub-categories could have contributed to food inflation, in excess of the weight assigned to it. The second is the coefficient of variation. This is a common measure of variability associated with a series,

[40] Rangasamy (2011) employ these methods to analyse the underlying factors that affect headline inflation of which food inflation can be considered a sub-component.

relative to the mean, and is an indication of volatility in this case regarding prices or inflation. The third relates to the probability of an inflationary episode with regards to food, as a result of price dynamics in a specific sub-sector. This serves as a good indication of an industry's role in general food inflationary trends. Lastly, and as an extension of the above, inflationary trends, with a specific focus on persistence, are regarded for food inflation and its various sub-categories. This will serve to inform the hypothesis that shocks in food prices can be treated as temporary disturbances.

4.2.1 Contribution

Below is a depiction of the weight assigned to different food groups in the food consumption basket. From Figure 4.1 it is apparent that meat contributes the largest share to food inflation (at 35.3%). Other large contributing categories are Bread and Cereals, at 20.7% and Vegetables, at 8.4%.

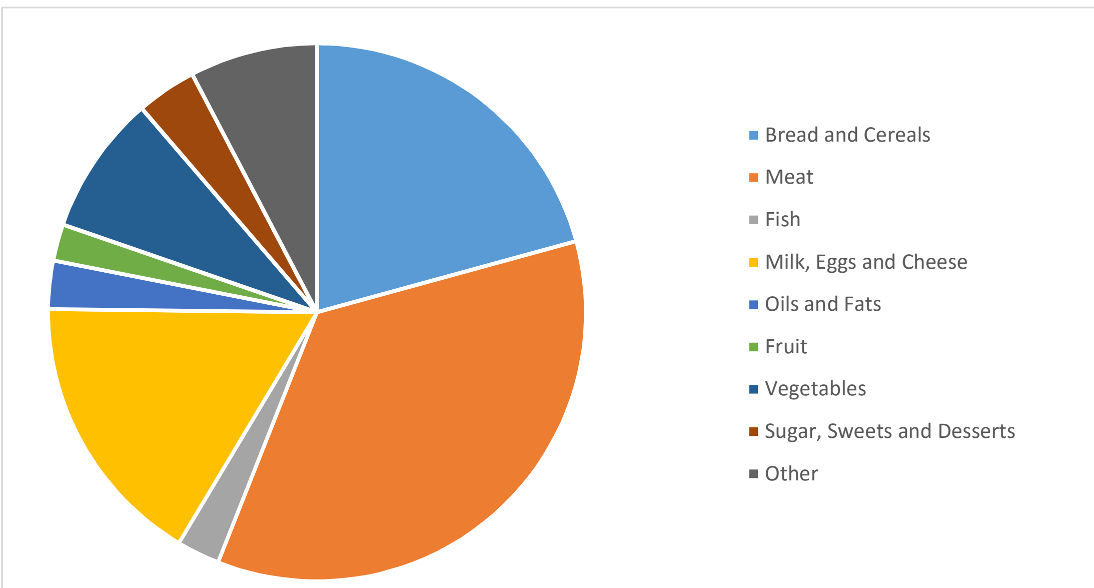

Figure 4.1: CPI food basket compilation

Source: Based on calculations from STATSSA, 2016

It is, however, the weight and the price of a product, in the consumption basket, that effect the impact of a product on aggregate food inflation. As a result, it is useful to consider whether the contribution of each sub-category of food inflation is proportional to its weight. If the influence is disproportional to its weight, it signifies that price dynamics in the respective sectors are either contributing to or "taking away" from the aggregate inflationary process. The table below is a representation of the contribution of the various sub-sectors associated with food inflation.

Table 4.1: Relative Contribution[41] of various food sub-sectors to aggregate food inflation

	Bread and cereals	Meat	Fish	Milk, eggs and cheese	Oils and fats	Fruit	Vege-tables	Sugar, sweets and deserts	Other food
2008	0.98	1.04	0.98	1.02	1.14	1.11	0.97	0.78	0.93
2009	0.96	1.02	1.02	1.05	1.00	1.00	1.04	0.80	0.98
2010	0.94	1.01	1.04	1.06	0.93	1.04	1.03	0.85	1.01
2011	0.94	1.05	1.00	1.00	1.06	1.01	1.00	0.87	0.99
2012	0.95	1.05	1.01	0.99	1.06	0.98	0.97	0.89	0.99
2013	0.95	1.03	1.02	1.01	1.05	0.97	1.02	0.90	1.00
2014	0.94	1.03	1.01	1.03	0.98	0.94	1.03	0.89	0.99
2015	0.93	1.04	1.03	1.04	0.96	0.91	0.99	0.91	1.00
2016	0.99	1.00	1.01	1.01	1.03	0.98	1.05	0.96	0.99
Mean	**0.95**	**1.03**	**1.01**	**1.02**	**1.02**	**0.99**	**1.01**	**0.87**	**0.99**

Table 4.1 shows that the contributions of the different sub-sectors are proportional to the allocated weights. This is to some extent to be expected since the weights of the respective categories were updated in December 2016, which coincides with the writing of this paper. What is, however, noteworthy is that bread and cereals and sugar related products are consistently contributing less than their allocated weight to total food inflation. Meat, in turn, and on average, contributes 3% more to inflation than its allocated weight of 35.3%. This implies that, on average, meat contributed 36.4%, to food inflation, over the period considered in Table 4.1.

[41] This reflects the relative contribution of the different sub-components relative to their weight, as depicted in Figure 4.1.

4.2.2 Volatility of Food Inflation and its sub-categories

As mentioned above, a common measure associated with volatility is the coefficient of variation. This measure can be represented as follows:

$$CV = \frac{\sigma}{\mu} \qquad (1)$$

Where σ symbolizes the standard deviation associated with the series and μ represents the mean. The CV's of the different sub-sectors associated with food inflation are depicted in Table 4.2.

Table 4.2: Coefficient of Variation of Food Inflation an its Sub-components (2008-2016)

	Food	Bread and cereals	Meat	Fish	Milk, eggs and cheese	Oils and fats	Fruit	Vege-tables	Sugar, sweets and deserts	Other food
CV	58.6	94.9	57.1	47.7	64.4	179.9	130.6	95.7	57.6	45.4

From the table above it is clear that "Oils and Fats", "Fruit", "Vegetables" and "Bread and Cereal" show the highest level of volatility. The volatility in fruits and vegetables can most probably be ascribed to seasonal factors. Bread, cereal, oils and fats are, in turn, volatile as a result of the features of their underlying commodity markets.

4.2.3 The role of sub-sector price movements during inflationary episodes of food in South Africa

In order to identify periods that can be considered as food inflationary episodes, we rely on a method similar to those of Domac and Yucel (2004) in identifying inflationary episodes in emerging economies. To this end, we have constructed a trend inflation series by calculating a nine-month moving average of the monthly food inflation rate. The next step is to identify troughs and peaks. A trough is where the trend inflation rate is lower than in the preceding and succeeding 4 months. A food inflation episode is then identified as a period of time in which trend inflation rises by at least 1%, from trough to peak, and which is preceded by stable or declining inflation. The food inflationary episodes are depicted in Figure 4.2 below.

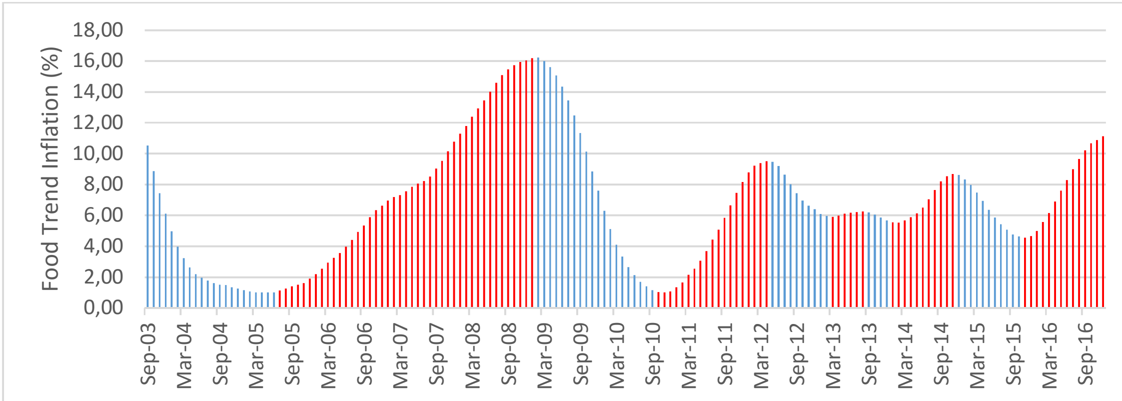

Figure 4.2: Food Trend Inflation in South Africa (Sep 2003 -Feb 2017)[42]

A probit model is used to estimate the conditional probability of a food inflationary episode as a result of price movements a specific food product group. Results associated with this could be useful in terms of devising industry specific policies geared towards curbing price growth. The following equation is estimated:

$$P(FOODINF = 1|x) = \theta(\alpha_1 + \beta_1 BC + \beta_2 M + \beta_3 Fi + \beta_4 D + \beta_5 OF + \beta_6 Fr + \beta_7 Veg + \beta_7 S + \beta_8 Oth) \qquad (2)$$

Food inflationary (*FOODINF*) episode is the binary dependent variable and assume a value of 1 during an inflationary episode and zero otherwise. For an explanation of the explanatory variables included in equation 2, refer to Table 4.3, below.

Table 4.3: Estimated Probit Model - Food Inflationary Episodes

Variable	Abbreviation in Eq. 3	Coefficient/Marginal Effect	P-value
Constant		-1.191*	0.08
Bread and Cereals	*BC*	0.133	0.235
Meat	*M*	**0.411*** **	0.000
Fish	*Fi*	-0.136	0.126
Dairy	*D*	-0.044	0.639
Oils and Fats	*OF*	**0.101***	0.058
Fruit	*Fr*	0.112**	0.021
Vegetables	*Veg*	**0.207*** **	0.000
Sugar and Sugar related products	*S*	-0.162*	0.03
Other	*Oth*	0.349*	0.01

Where *** denotes a 1% level of significance, ** a 10% level of significance and * a 10% level of significance

42 The time range presented in this figure only starts in September 2003 due to a nine month moving average calculation used to calculate trend inflation as based on Domac and Yucel(2004).

The model in Table 4.3 is estimated with Iteratively Reweighted Least Squares (IRLS) and observations from September 2003 to February 2017. Table 4.3 shows the marginal effects associated with the explanatory variables of the model.

The results depicted above, show that there is a significant positive relationship between Meat inflation, inflation in Oils and Fats and inflation in Fruit and Vegetables and food inflation episodes in South Africa. It further shows that a 1% increase in meat inflation increases the probability of food inflation episode by 41%, where a 1% increase in inflation in oils and fats increases the probability of a food inflation episode by 10%, and a 1% increase in the vegetable inflation increases the probability of a food inflation episode by 21%. A 1% increase in inflation related to fruits increases the probability of an inflationary episode by 11%. Although there are other variables with adequate levels of statistical significance (see Sugar and Other) the signs of these variables do not conform to *a priori* expectations, and actually, show that the probability of an inflationary episode will decrease if inflation in these variables increases. This might be attributed to how the products are positioned in the consumer basket. In times of high inflation, consumers are under pressure and move away from luxury products such as confectionary and carbonated drinks (which fall into the sugar category), and therefore there is not demand support for the prices of these products. This could be evaluated empirically in future research. Further unexpected results are that "Bread and Cereals" play a statistically insignificant role in the probability of generating an inflationary episode although the magnitude of the marginal effect is still rather high (13%). Two possible explanations for this comes to mind. The first is that the moving average for food inflation, created to identify periods which technically satisfy the definition of an inflationary episode, could have been smoothed. Short and small shocks associated with bread and cereals would therefore not coincide with "food inflation episodes". The second is that "bread and cereals" are staple/inferior products that might not capture inflation as a result of strong demand growth. "Meat" based on the luxury status afforded to it, in contrast, might. As a result, the insignificance of "bread and cereals" could possibly be explained by demand driven inflation[43].

[43] Although earlier results in the thesis seem to suggest that food inflation is predominantly driven by supply factors the limitations of these results, in terms of the proxy variables used, should be acknowledged. As a result, the possibility of demand driven food inflation should not be discounted. This also underscores the importance of adequate record keeping, with regards to demand factors, on a monthly basis.

4.2.4 Persistence

This section considers the persistence associated with food inflation and its various sub-categories. Walsh (2012) notes that it is important to regard the level of persistence associated with an inflationary series for two reasons. The first is that longer-lived shocks will result in inflation remaining at high levels for longer periods of time. The second is that there is a general perception that food prices are temporary and therefore it has a transitory effect on headline inflation.

There are numerous methods that one can consider in measuring inflationary persistence. The first basic test that can be done to gauge the level of persistence is to regard the univariate properties of the series in question since persistence is a univariate phenomenon. This is done in order to establish the presence of a unit root. The existence of a unit root would be indicative of a high level of shock persistence in the series in question. The univariate properties of the series analysed here are included in Appendix A4.1, and shows that "Bread and Cereals", "Fish", "Dairy and Eggs", "Sugar" and "Other Products" have unit roots. It should, however, be noted that various sources on inflationary persistence warn against the non-rejection of H_0 = Unit Root, due to the presence of a structural break (see *inter alia* Benati and Kapetanios (2002)). As a result, the Zivot and Andrews (1992) test for a unit root with a structural break, was also conducted. This is included in Appendix A4.2 This indicates that the H_0 = Unit Root with a structural break, can be rejected in the case of "Dairy and Eggs" which implies that the series does not have a unit root. For all the other series mentioned above, the unit root cannot be rejected and, as a result, high degrees of inflationary persistence can be expected.

The test for the presence of a unit root analysis, as described above, only provides an indication of the level of persistence, as it does not regard the specific value associated with different roots. In order to address this, Pivetta and Reis (2007) recommend three methods that consider the specific roots and degree of shock decay associated with the series in question. The first is the SARC which considers a k^{th} order autoregressive process and then takes the sum of the estimated coefficients (which are the roots of the series) of this process.

This can more formally be defined by the following equation:

$\tau = \sum_{i=1}^{k} \theta_i$ (4)

Where τ is the SARC and θ_i is the coefficient or root associated with the i^{th} lag.

According to Pivetta and Reis (2007), the logic for using this measure comes from realising that $\tau \epsilon (-1,1)$ and that the cumulative result of a shock on the inflationary process is given by $1/(1-\tau)$. τ therefore serves as an intuitive measure of persistence in that values of τ approaching 1 will lead to permanent shock to the inflationary process whereas low values of τ would imply reversion to levels experienced prior to the shock. This approach might, however, present misleading results in the case where the AR process exhibits oscillating dynamics. In this case, the sum would reveal a low-level of persistence, and could be misleading.

The second measure of persistence is also based on a k^{th} order autoregressive process which is used to determine the largest autoregressive root (LAR). In the case where the largest root is equal to one, a shock is infinitely persistent and, where it is zero, shocks dissipate immediately. This test is similar to the test for a unit root. The main issue with this test is that it ignores the sizes of other roots, which if large, also contribute to the inflationary process.

The third measure of persistence is the calculation of the half-life[44] associated with a k^{th} order autoregressive process. According to Pivetta and Reis (2007), this is the number of periods it takes for the inflationary process to reach 0.5, following a unit shock. Stated differently, it is the number of periods it takes for half of a shock to dissipate from the series. For the purposes of this paper, it is assumed that half-lives greater than 40 periods indicate the presence of a series with a unit root[45]. As such these half-lives are assumed to have infinite persistence.

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44 The commonly employed practice in economics literature is to approximate a half- life based on the formula: $HL = \frac{-log2}{\log(1+\beta)}$ with β being the convergence speed obtained from the error correction representation of the associated AR process (Seong, Morshen and Ahn (2006)).

45 Fourty periods represents 40% of the sample.

In accordance to Walsh (2012), a 9th order AR process is used to calculate the different measures as explained above. The results are depicted in Table 4.4 below.

Table 4.4: Summary of disaggregated inflationary persistence measures

	SARC	LAR	Half-life
Aggregate Food	1.006	0.93	17
Bread and Cereals	1.006	0.97	∞
Meat	0.99	0.91	∞
Fish	1.00	0.94	∞
Milk, eggs and cheese	1.00	0.91	∞
Oils and Fats	0.99	0.98	13.5
Fruit	0.97	0.91	11.2
Vegetables	0.96	0.9	22.8
Sugar and Confectionary	1.02	1.00	∞
Other	1.00	0.94	∞

From the table above it is apparent that all the measures indicate a high level of persistence for all series. The SARC and LAR indicate that most of the series have large roots approaching 1, with 6 of the sub-sectors having an infinite half-life which shows evidence that shocks to the specific food sectors can be regarded as permanent.

The evidence presented above, therefore, shows clearly that food inflationary shocks (at aggregate and sector level) cannot be regarded as temporary and supports recommendations by *inter alia*, Alper (2016) and Walsh (2011) that food inflation should be a central component of monetarists in emerging economies.

4.3 Second round effects of food inflation in South Africa

In order to gauge the dynamics between food and headline inflation in South Africa a gap analysis, as applied by Cecchetti and Moessner (2008) is followed[46]. The approach essentially answers two questions: "*To what extent does core inflation[47] (non-food) manifest in food prices*?" and "*Does food prices cause second round inflationary effects in headline inflation?"* More formally the approach estimates the following:

$$\pi_t^{food} - \pi_{t-12}^{food} = \alpha_i + \delta_i\left(\pi_{t-1}^{headline} - \pi_{t-12}^{food}\right) + \varepsilon_t \qquad (3)$$

and

$$\pi_t^{core} - \pi_{t-12}^{core} = \varphi_i + \beta_i\left(\pi_{t-1}^{headline} - \pi_{t-12}^{core}\right) + \varepsilon_t \qquad (4)$$

Equation (3) reflects the impact of non-food inflation, on food inflation in the parameter estimate of δ. It is expected that δ would be positive in magnitude and level of significance indicating to what degree non-food prices affect food price behaviour.

The basic premise tested in equation (4) is that if CPI inflation excluding food prices, is inclined to revert to headline inflation and determines if there are significant second round effects associated with food inflation in the economy. The hypothesis that $\beta = 0$ is then tested against the alternative that $\beta = 1$. If $\beta = 0$, this would suggest that core inflation is not reverting to headline inflation and the second round of effects of food prices are negligible. If the hypothesis however is rejected, this would serve as evidence that second round effects of food inflation are present and need to be managed with monetary policy. It

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46 It is acknowledged that there are more advanced methods to evaluate second round effects, such as those applied by Ruch and du Plessis (2015). It is however not the objective of this paper to estimate the magnitude of second round effects, but rather to update results on its significance so that it includes significant supply shocks such as the 2015/16 drought and the significant depreciation of the exchange rate on the account of political shocks. It should also be noted that this study regards the exclusive effect of food, as opposed to studies such as Ruch and Du Plessis (2015), which considered second round effects associated with food and energy.

47 Core inflation was calculated with the exclusionary method as discussed in du Plessis, Rand and Kotze (2015). For the purposes of this study only food prices were excluded to determine the "core" component.

is also important to note that in the equations above a 12-month lag, as presented in the equation (3) and (4), signifies a year on year change.

Table 4.5: Impacts of non-food inflation on food inflation (South Africa, Jan 2009 – Feb 2017)

δ	p-value H_0: $\delta = 0$
0.38	0.01

The results in Table 4.5 suggest that there is a significant impact of non-food prices on food prices. This is in line with the results of Rangasamy(2011), who found that the pass-through effect from non-food prices to food prices are much larger than is the case vice versa, for the period 1971-2008. The above estimation was conducted for the period Jan 2009 to February 2017[48], which is a period associated with multiple structural food price shocks. The time series of the different studies, as mentioned above, are depicted in Figure 4.3, below. Here the red line shows where the time series for this paper have started.

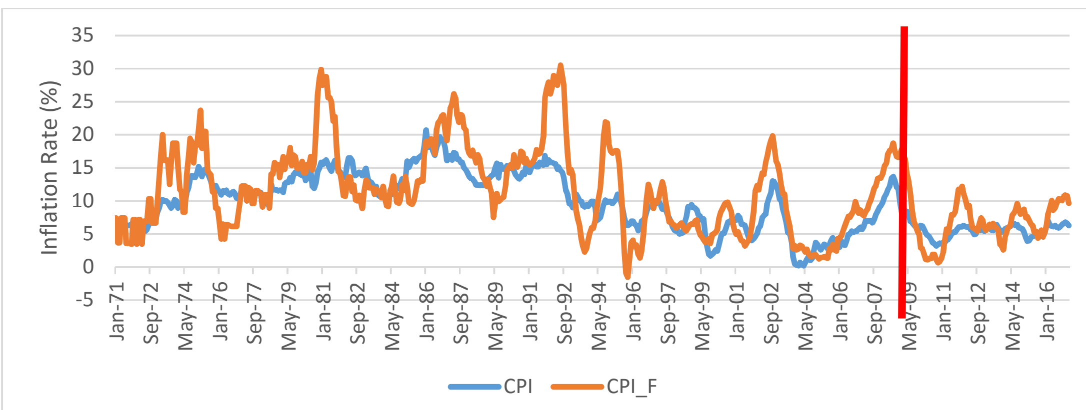

Figure 4.3: Headline and Food Inflation in South Africa (1971-2017)[49]
Source: Statistics SA

48 The focus on the period Jan 2009 to February 2017 is motivated by the fact that the food inflation index was reclassified in 2008, which makes index figures between 2008 and 2009 not directly comparable.
49 From 1971 to 2008, both headline and food inflation rates are based on the CPI indices compiled for primary urban areas. From January 2009 onwards the figures are based on the indices compiled for all urban areas. The series were linked to provide a continuous representation.

Table 4.6: Second round effects of food inflation (South Africa, Jan 2009 – Feb 2017)

$\boldsymbol{\beta}$	p-value H_0: $\boldsymbol{\beta = 0}$
0.94	0.00

With regards to the presence of second-round effects, the estimates in Table 4.6 are positive and significant. This indicates the prevalence of non-trivial second round effects of food prices in headline inflation. The presence of second round food price pass-through corresponds to those determined by Rangasamy (2011), which estimated β equal to 0.46. The estimation results for the period Jan 2009 to Feb 2017 could possibly be somewhat higher due to the high incidence of food price shocks, both locally and globally. If Figure 4.3, presented above, is regarded, there is a clear increase in the co-movement between food and headline inflation since the mid-nineties. The period considered in this study, will therefore reflect this co-movement, as compared to Rangasamy(2011) which included a time frame where there were clear deviations between CPI and CPI food.

4.4 Conclusion

This paper considered the second round effects associated with food inflation in South Africa and the dynamics of sector-specific inflation in food sub-sectors. Descriptive results on the magnitude and volatility of the various sub-groups reveal that meat, oils and fats and vegetables are the greatest contributors to food inflation. This is corroborated by the probit model which finds that inflation in these sectors results in the highest probabilities of generating episodes of food inflation. In terms of persistence, all the sub-categories exhibit a high degree of persistence, which is a general indication that the hypothesis of South African food inflation being temporary, can be rejected. This, combined with the significant second round effects associated with food inflation, as established in Section 4.3, calls for a more pragmatic approach to food inflation management. Second round effects should be managed with sound monetary policy, but industry specific policies aimed at reducing significant price shocks in the various sub-sectors could go a long way in curbing food inflation, and ultimately headline inflation, more successfully. A more holistic approach to food inflation management, which include policy input wider than exclusive monetary policy, is therefore advocated. Sector specific policies could typically include more comprehensive disaster management[50] in order to mitigate the effects of supply shocks associated with climatic conditions. Policies aimed at achieving/supporting a level of self-sufficiency[51], could, in turn, serve as a buffer for global and exchange rate shocks. These policies should specifically be targeted to sectors that have a large inflationary impact as identified in the sections above. It is however acknowledged that industry-specific policies would not address the inherent persistence associated with the various sub-sectors of food inflation since inflation is intrinsically subject to persistence due to inertia in prices. It is further acknowledged that certain industry-specific policies, aimed at stabilising prices can do more harm than good. Examples of these include export bans and the establishment of strategic reserves. The former, evaluated by, *inter alia,* Welton (2010), Trostle (2008) and Mitchell(2008) all find that export bans contribute to price volatility. Establishing and running a strategic reserve program, in turn, are often unsustainable due to the high cost associated these initiatives and also distorts markets (Murphy, 2009). As a result, the full spectrum of a policy impact aimed at mitigating inflationary effects should be analysed.

To this end, this paper also attempted to establish a conceptual link between different tiers of inflation analysis related to food, through the examination of industry specific inflationary dynamics and subsequent industry specific policy recommendations. It is however acknowledged that this is elementary and only serves as first step in linking fundamental factors within different sub-sectors to the aggregate food inflation. For this reason, it is recommended that future research explores methods that link industry-specific fundamentals with food inflation in a structured and measurable manner.

[50] The national disaster management centre was created in terms of the National Disaster Management Act of 2002, with the objective of providing a co-ordinated system of disaster management. The 2015/16 drought however highlighted that processes driven by this centre was not functioning optimally. Improved implementation of these policies could therefore also contribute to mitigating sector specific inflationary effects.

[51] Clapp (2017) provides a useful contextualisation of self-sufficiency and the complexities associated with it. The study advocates that a self-sufficiency agenda should be driven by a country's domestic production capacity as opposed to the rejection of trade in order to insulate markets from shocks. The use of the term here is therefore used in terms of South Africa's production capacity.

CHAPTER 5
CONCLUSION

5.1 Broader Findings in Context

The importance of a sound understanding of food inflation cannot be disputed. This is stressed by policy makers (see comments by Ben Bernanke on p. 2) and researchers alike (*inter alia*, see Altman *et al*. 2009 and Rangasamy (2011)). In light of this, a substantial body of literature on this topic has developed, specifically since the commodity super cycle that occurred between 2005 and 2009. A critical synthesis of this literature, conducted in Chapter 1, however, shows two distinct approaches. The first, dubbed here as the "agricultural economics approach", is concerned with fundamental features and factors that affect product specific prices or aggregated food price levels. The second, "monetarist approach", is concerned with the link between food and headline inflation and the statistical (time series) properties associated with these variables. The organisation of the literature in this manner points to a vital disconnect between fundamental industry-level dynamics and aggregate food inflation trends. This was further amplified by the severe drought of the 2015/16 grain production season in South Africa. Although there was a general consensus that the drought was the key driver of food inflation, there were no robust, quantitative estimates that informed policymakers on how long the price effect of the drought would last and what the magnitude of the shock would amount to.

Being cognisant of this, (food) inflation was disaggregated into different tiers or levels, and three specific research questions were developed for each tier. It is acknowledged that this does not explicitly address the disconnect eluded to above. It does, however, allow for a conceptual/ideological framework in which inflation research and policy analysis could be conducted. Although a resulting future research recommendation is that this framework should be quantified and estimated explicitly, the reasons why it would probably not be done, also became abundantly clear during the research process and can easily be explained by the 80:20[52] principle. Since inflation is a process characterised by inertia, in 80% of the instances idiosyncratic dynamics would be sufficient to explain inflationary movements. In

[52] This is also known as the Pareto principle and states that 80% of the effects come from 20% of the causes.

20% of the cases, however, exogenous shocks, such as the effect of a drought or a severe exchange rate depreciation make the extrapolation of the idiosyncrasies ineffective.

5.2 Findings per tier

The product-specific analysis, as conducted in Chapter 2, interrogated the popular assumption that staple food chains in South Africa employ exploitative pricing strategies with regards to price movements in the underlying commodity market. For the case of brown bread and super maize meal, this was found not to be the case. In terms of the level or node of the supply chain where prices are formed, the analysis revealed that brown bread prices are formed at producer and retail level, which would suggest a combination of demand and supply (cost) related inflationary drivers. Maize meal prices, in turn, are formed at retail level, which could suggest a dominance in demand related inflationary factors.

The macroeconomic analysis, as presented in Chapter 3, considered different fundamental or macroeconomic factors that could impact food inflation. The key variables to consider were identified through a literature study and comprise of demand focused variables such as unemployment, and per capita income and supply (cost) focused variables such as the exchange rate, agricultural prices, world food commodity prices and the price of oil. Despite key theoretical underpinnings supporting the case for the inclusion of a demand variable, the only demand proxy (retail sales) in a monthly frequency, was found to be statistically insignificant. Co-integration analysis showed that exchange rates and world prices have the largest (long-term) effect on food inflation. This is to a large extent expected since South Africa is a net importer of food. Short-term dynamics show that over the medium term local agricultural prices and the exchange rate have the largest impact on food inflation.

The consideration of the link between headline inflation, food inflation and its associated sub-indices interrogated the common premise that shocks in food prices are temporary. This was refuted with the univariate properties of inflation in the respective industries and aggregate food inflation. The confirmation of significant second round effects corroborated this.

5.3 Implications and recommendations for future research

Each of the essays, as summarised in section 5.2, can be considered as a study in its own right. Chapter 2 suggests that there are little or no grounds for the recurring populist rhetoric that staple food producers are not passing on commodity decreases to the final consumer. Chapter 3, in turn, seems to suggest that food inflation in South Africa is dominated by supply-related factors (keeping in mind the shortcomings associated with the demand proxies). If this is indeed the case, food inflation in the future, will to a large extent be affected by productivity and efficiency in the agricultural sector and South Africa at large. Erosion of infrastructure, skill levels of the labour force and poor investor confidence are but a few structural issues that will increase South Africa's reliance on imports and exposure to world markets. This will, in turn, provide a conducive environment for large(r) prolonged shocks associated with food inflation. Chapter 4, show that food inflation plays a key role in headline inflation and that shocks on aggregated, and disaggregated level are persistent. This provides a case for policies with a wider research than just monetary policy.

The global message from the essays presented here is that food inflation is important and in the South African context there is room for a broader and more holistic approach to long-term inflation management. This approach should be concerned with productivity and efficiency in all the tiers identified in the conceptual framework. This, in combination with sound monetary policy, could go a long way in curbing the magnitude and length of fundamental shocks on local food inflation.

Future research can branch out in three apparent ways. The first is to refine the current relatively simplistic models with more sophisticated models that account for the episodic nature of some variables, as identified in Chapter 3. This would be data intensive and a longer time series, than what was used here, would however be needed. The second is to consider product value chains other than those in Chapter 2. Products that are also important from a development and poverty alleviation perspective are, tea, sugar and milk (see Steyn and Labadarios, 1999). The broiler industry, with its high level of vertical and horizontal, combined with its consumption importance as the most affordable meat protein, could be worth investigating. A wider scope of results on products analysed in a similar manner to bread and maize meal, in Chapter 2, could ultimately be combined to inform nutritional analysis of low-income consumers with regards to food affordability. Lastly, the work in Chapter 4 can be used to consider how second round effects of food inflation have changed over time and to establish a link between this and specific economic factors and occurrences. This would, in turn, again inform a broader policy agenda. It is expected that this would closely be related to issues such as the labour organisation of a country and therefore fell outside the scope of this study.

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Appendix

Table A2.1: Univariate properties of the Brown bread and wheat prices (Jan 2000 – Sep 2016)

Series	Model	Lags	ADF	PP
LBrown Bread	Trend and Intercept	0	-2.2	-2.29
D(LBrown Bread)	No trend, no intercept	0	-5.48***	-14.12***
LWheat Cost	Trend and Intercept	1	-3.06	-2.61
D(LWheat Cost)	No Trend, No Intercept	1	-9.33***	-9.21***

Table A2.2: Univariate properties of the Maize meal and white maize prices (Jan 2008 – Sep 2016)

Series	Model	Lags	ADF	PP
LMaize Cost	Trend and Intercept	1	-2.37	-2.25
D(LMaize Cost)	No trend, no intercept	1	-7.99***	-7.99**
LMaize Meal	Trend and Intercept	0	-0.92	-1.11
D(LMaize Meal)	No Trend, no intercept	1	-5.59***	-9.78***

Table A2.3(a): Gregory and Hansen (1996) Cointegration 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

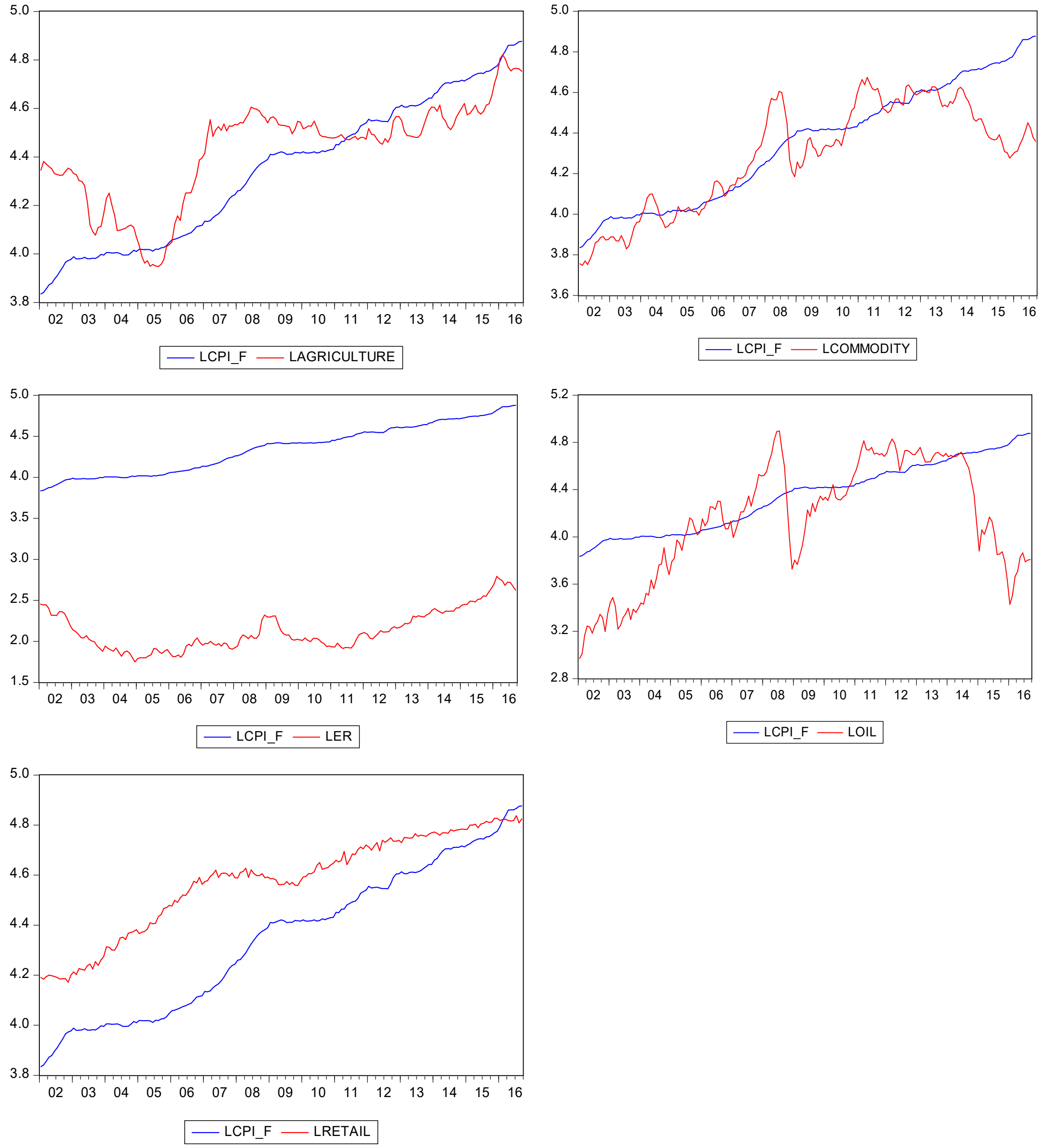
Table A2.3(b): Gregory and Hansen (1996) Cointegration tests with level and trend shift (Maize to Maize Meal)

	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

Table A3.1: Univarite properties of the data

Series	ADF ($H_0 = Non\ stationarity$)	PP ($H_0 = Non\ stationarity$)	KPSS ($H_0 = Stationarity$)	Conclusion
LCPIF	-2.23	-1.99	0.103*	LCPIF is I(1)
D(CPIF)	-2.64**	-6.52***	0.006	
LOIL	-1.58	-0.71	0.839***	LOIL is I(1)
DLOIL	-9.4***	-9.33***	0.357*	
LER	-0.54	-0.27	0.836***	LER is I(1)
DLER	-9.45***	-9.33***	0.078	
LWorld	-1.81	-1.54	0.291***	LCommodity is I(1)
D(LWorld)	-10.1***	-10.07***	0.03	
LRetail	-1.21	-1.26	0.294***	LRetail is I(1)
D(LRetail)	-2.98***	-16.08***	-0.088	
Lagriculture	-2.26	-1.93	0.103	Order of integration uncertain. ADF, PP and KPSS test contradictory
D(Lagriculture)	-8.85***	-8.91***	0.093	

Table A3.2: Graphical representation of considered drivers in relation to food inflation



Appendix A4.1: Univariate properties of inflation in food sub-sectors (ADF tests)

Series	ADF ($H_0 = Series\ has\ a\ unit\ root$)	Conclusion
Food inflation	-2.18	Series has a unit root
Bread and Cereals	-1.82	Series has a unit root
Meat	-2.91**	Series is stationary
Fish	-1.15	Series has a unit root
Milk, eggs and cheese	-2.32	Series has a unit root
Oils and Fats	-5.26***	Series is stationary
Fruit	-2.99**	Series is stationary
Vegetables	-4.17***	Series is stationary
Sugar and related products	1.43	Series has a unit root
Other	-1.28	Series has a unit root

Where *** denotes a 1% level of significance, ** a 10% level of significance and * a 10% level of significance

Appendix A4.2: Univariate properties of inflation in food sub-sectors that account for a structural break (Zivot and Andrews test)

		Test Statistic		
	Break Date	**Intercept**	**Trend**	**Both**
Food inflation	2009/05	-4.54	-3.48	-4.56
Bread and Cereals	2009/05	-4.47	-3.27	-4.48
Fish	2009/12	-4.48	-2.8	-4.46
Milk, eggs and cheese	2009/11	-4.91*	-3.75	-4.91*
Sugar and related products	2014/11	-0.83	-2.66	-3.19
Other	2010/02	-3.76	-2.76	-3.68

Where *** denotes a 1% level of significance, ** a 10% level of significance and * a 10% level of significance