Vertical price linkages in food markets: Evidence from the tomato value chain of Northern South Africa

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Keywords	Abstract
	Price transmission in agricultural fresh produce markets is a subject of considerable interest to policymakers given that improved market performance for agricultural commodities promotes market development and maximization of social welfare. In northern South Africa, where tomato production dominates the country, studies exist on the general production, marketing, and consumption of fresh produce. However, the literature lacks an analytical component that is pertinent to the mechanism of price transmission and vertical linkages among successive marketing stages of tomato. This study employs the Houck approach and Error Correction modeling technique in an attempt to examine price transmission in South Africa's tomato markets. The results indicate a symmetric adjustment to price signals between farm and wholesale levels and an asymmetric adjustment between farm and retail levels. Even so, there is scope for ameliorating the effectiveness and efficiency of fresh produce markets in South Africa.

Introduction and background

The food market has generally experienced sustained rising consumer prices and it would interest agricultural economists and policy engineers to know whether farm gate prices are moving in the same fashion with the evident consumer price increases. With respect to tomato marketing in northern South Africa, it is apparent that consumers are increasingly vulnerable to continual price inflation of this agricultural commodity. However, it is uncertain whether the farmers' proportion of the consumer's Rand is symmetrical to these downstream price movements. The objective of this research paper is to answer whether intermediaries in the tomato value chain of northern South Africa are passing more rapidly cost increases while transmitting slowly and less completely cost savings.

As demonstrated by Vavra and Goodwin (2005), the impact of any impending positive or negative price shocks on value chain participants depends on several factors, such as the degree to which market players adjust to price signals, their response time, and the extent to which their adjustments to price shocks are asymmetric. This paper aims to analyze the tomato value chain of northern South Africa by employing the Houck approach and Error Correction modeling techniques, in an attempt to uncover these price transmission uncertainties amongst the three marketing levels: farm gate, wholesale and retail.

In South Africa, Alemu and Ogundeji (2010) report that efforts by the Department of Agriculture, Forestry and Fisheries, formerly known as the National Department of Agriculture, to bring stakeholders forward to explore the cause of rising food prices resulted in a deadlock as it could not be established where the problem of rising food prices emanated. Producers argued that they benefitted little from increased food prices and were under pressure from the cost price squeeze, whereas processors and retailers indicated that increasing prices were necessitated by the high costs of providing value addition in food markets.

According to Louw *et al*. (2006), the market changes in the agricultural sector of South Africa since the end of apartheid have brought about market concentration in the agro-food sector, as dominant market players tend to favour suppliers who can ensure and sustain high volumes and consistent quality. In the case of tomato, Sautier *et al*. (2006) indicate that only four tomato producers account for about 80% of the total tomato volume in the whole country. The Department of Agriculture, Forestry and Fisheries (DAFF) of the Republic of South Africa (2014) also confirms the presence of high market concentration in the tomato industry where the commercial sector contributes about 95% of the total production while the emerging sector contributes only 5%.

The tomato is the second most important and popular vegetable crop after potatoes in South Africa, accounting for about 18.2 % of the gross value of vegetable production in the country (DAFF, 2014). It is not only cultivated commercially but also grown by subsistence, resource-poor farmers and home gardeners. The industry employs approximately 22,500 people who jointly have at least 135,000 dependents (DAFF, 2014).

The study area was chosen based on its importance for tomato production in South Africa. Limpopo Province, which covers the northernmost region of South Africa, is the major tomato growing province in South Africa and accounts for 75% of the total national area planted under tomato. The National Agricultural Marketing Council's NAMC (2012) also shows that the majority of South Africa's tomato production happens in the Limpopo Province particularly by one major commercial producer. As tomato is not only cultivated commercially but also grown by subsistence, resource poor farmers and home gardeners, this study focuses on the well institutionalized and economically strong tomato production and marketing channels due to the players' dominant presence in the sector. The DAFF (2016) further confirms that the tomato commercial sector's contribution to total production multiplies that of the emerging sector by a factor of nineteen.

Considering that several studies on price transmission in agricultural produce markets have been conducted in South Africa, (e.g., Mashamaite and Moholwa, 2005; Funke, 2006; Jooste *et al*., 2006; Kirsten and Cutts, 2006, Alemu and Ogundeji, 2010; Abidoye and Labuschagne, 2013), it is evident that the subject is of considerable economic interest. However, there is a gap in the literature on price transmission in tomato markets of Limpopo, despite the province's importance in the South African tomato industry. No up to date empirical evidence has been provided to explain vertical price linkages between farm, wholesale, and retail levels for Limpopo

produced tomatoes. Furthermore, it is unclear at what stage tomato prices are determined along the marketing chain. This lack of information hampers government efforts to manage any probable anti-competitive behaviour amongst market players. The question of how tomato marketing efficiency can be enhanced therefore remains unanswered given that very little awareness exists on the market's current economic performance.

The next sections will provide the limitations of the study, a discussion of price transmission, and some of the relevant methodological approaches used in food markets. Conceptual frameworks, analytical techniques as well as model specifications used in this paper are also presented. In addition, the paper will provide a discussion of the research findings, summary and conclusion.

Limitations of the study

While a large gap between upstream and downstream prices may be considered as a standard occurrence in most markets, it may not be too obvious how much the exact contribution of each total margin component is. Rather, this study does not focus on isolating the actual individual impacts of each middlemen activity or identify other additional costs incurred in transferring produce from the farm gate to the final consumer. Secondly, this study does not capture the impact of seasonal price fluctuations due to lack of readily accessible historical price information, particularly at the farm gate and retail levels. More work may be needed to first create open access price databases for probable future analyses. The researcher is also aware of the perishability nature of tomato which might complicate the product's marketing dynamics. This study, however, does not measure the exact influence of product perishability since the study scope is delineated to only one product which invalidates any basis for comparison.

Price transmission and associated methodological approaches in food markets

Price transmission is a broad concept that can be referred to in different ways. According to Colman (1995), price transmission is the extent to which a price series at one location causes changes in, or correlates with price changes at another location. Rapsomanikis *et al*. (2003) explained the concept based on three components, which are co-movement and completeness of adjustment (CCA), dynamics and speed of adjustment (DSA) and asymmetry of response (AoR). CCA entails full transmission of changes in prices in one market to the other at all points of time. DSA covers the process and rate at which change occurs in one market filter to the other market levels. The final component, AoR, entails

whether upward and downward movements in the price at one level are either symmetrically or asymmetrically transmitted to the other levels.

Similarly, Vavra and Goodwin (2005) gave four aspects as a basis for assessing asymmetric price transmission. The first is the aspect of magnitude, which is concerned with how big the response is at each level as a result of a shock of a given size at another level. The aspect of speed measures how fast or slow the adjustment process is and also considers whether there are significant lags in adjustment. The nature of price transmission considers whether any adjustment that follows positive and negative shocks at a particular marketing level displays asymmetry. The fourth aspect, which is direction, ascertains the extent to which adjustments contrast, depending on whether a shock is transmitted upwards or downwards the supply chain. Considering the four aforementioned aspects, four types of asymmetry can therefore be analyzed which include positive and negative asymmetry, asymmetry in magnitude, asymmetry in speed and asymmetry in both speed and magnitude. The literature on price transmission in agriculture offers several methodologies that one may apply in related studies. Several papers provide a broad spectrum of data types applicable to analysing vertical and spatial price linkages in agricultural markets. While Guvheya et al. (1998) used daily and weekly tomato price data that was collected from field surveys, Moghaddasi (2009) considered monthly price observations at farm and retail levels for two Iranian agricultural products, namely pistachio and date. Jeder, Naimi, and Oueslati (2017) analysed the transmission between retail and producer prices for main vegetable crops in Tunisia by means of annual time series data.

This study employed primary and secondary time series data. Random but consecutive daily tomato prices were collected concurrently at the farm gate, wholesale and retail levels for mixed grades of cooking tomatoes. The longitudinal dataset comprised a sample size of 50 price observations collected through daily market surveys which ran between May 2012 and 31 July 2012. All three data sets were measured in South African Rands/kg. The farm gate prices were observed at the Mooketsi farm gate, owned by the largest tomato producer in the southern hemisphere, while retail prices were gathered from five purposively selected major vegetable retailers operating in South Africa's northernmost provincial capital city, Polokwane. Furthermore, the study considered the National Fresh Produce Market daily tomato prices as a proxy variable for wholesale prices as a result of the absence of an active wholesale market within the borders of the study area.

For decades, several analytical techniques have been applied in various price transmission studies across the literature. For instance, Guvheya et al. (1998) utilized the Houck procedure to test price transmission between wholesale and farm prices. Through use of an error correction model, Minot (2011) investigated the degree of transmission of world food prices to markets in Sub-Saharan Africa. Abdulai (2000) studied spatial price transmission and asymmetry in the Ghanaian maize markets using threshold cointegration tests by allowing for asymmetric adjustments towards long-run equilibrium relationships between price series.

In Malaysia, Mohamed et al. (1996) were able to determine the point of price determination along eleven vegetable value chains by examining the nature of price linkages of vegetables between farm, wholesale, and retail levels in selected vegetable markets through performing the Granger causality tests. Similarly, Moghaddasi (2009) was able to ascertain the optimal lag lengths of price causal relationships between successive marketing levels. An application of the Houck procedure also assisted them to ascertain whether price increases were transmitted more completely than price decreases in the Iranian date and pistachio markets. The study was also able to test for the speed of positive and negative price adjustments by means of an error correction model. .
Bolotova and Novakovic (2011) noted five major causes of price asymmetry between levels, as revealed in several literatures, which include the presence of market power and coordinated conduct of firms with market power, government regulations, repricing and transaction costs, shifts in supply and demand, and imperfect information. According to Karantininis et al. (2011), positive price transmission occurs when agents in the intermediate stages in the food supply chain exercise market power and thus influence the price adjustment process to their advantage both upstream towards farmers and downstream towards the final consumer. The market structure of each level and information advantage of one level compared to another are stated in Mohamed et al. (1996) as determinants of the efficiency of price transmission between the two levels.

Girapunthong et al. (2004) explored price asymmetry in the United States fresh tomato market. In an effort to analyze price relationships between the farm, wholesale and retail levels of this industry, the authors employed Ward's (1982) price asymmetry model. Granger causality tests were first used to determine the direction of causality. It was then established that price transmission was unidirectional from the farm to the retail level. The study did not find any asymmetric response in price transmission between producers and retailers. However, evidence of price asymmetry was found between wholesalers and
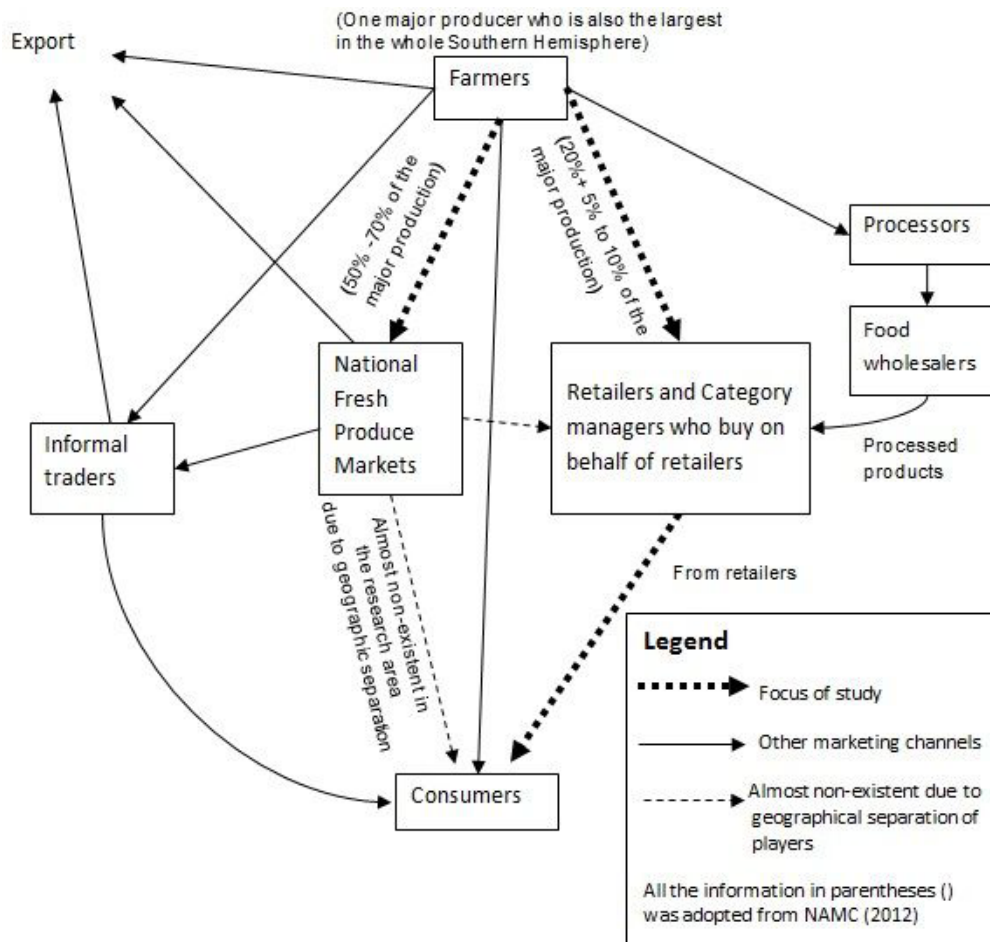
Figure 1: Marketing channels of tomato in the most northern province of South Africa, Adapted from: DAFF (2014); NAMC (2012)

both producers and retailers. Such evidence was interpreted to indicate that retail prices respond more when wholesale prices increase than when they decrease. On the other hand, wholesale prices were found to react more to decreasing producer prices than when they rise. This study adopts the Houck procedure mainly due to its ability to directly consider the impact of positive and negative variations of the time series data, as also alluded by Frey and Manera (2005). While the Houck procedure is normally chosen for its simplicity, Moghaddasi (2009) cautions that the approach should be applied consistently with unit root and cointegration tests to avoid spurious correlation problems. For more reliable inferences, the Houck procedure of analysing price asymmetry was therefore applied for data points which were not cointegrated according to the Johansen cointegration tests. The Error Correction approach was also adopted as a way to capture the positive and negative components of the residuals from the cointegration relationship between respective data series.

Conceptual framework and analytical techniques

Data collection was guided by the conceptual mapping of the key marketing channels shown in Figure 1. Figure 1 shows the different marketing channels that are evident in the most northern province of South Africa. The market has only one major producer who is also the largest in the southern hemisphere. According to NAMC (2012), 50%-70% of the major production is sent to the wholesale platforms called National Produce Markets. These national markets are geographically quite far from the study area and, as a result, none of the studied retailers usually buy from there. However, most of the local retailers use the national market prices as a benchmark for business decision making. NAMC (2012) further shows that 20% + 5% to 10% of the major production volume is sold directly to local retailers.

Figure 2 illustrates a consolidated mind map of the analytical conceptual framework applicable to this study and is in line with the literature on analyzing price transmission. Firstly, each pair of price series was examined for order of integration using the Augmented Dickey-Fuller tests (Dickey and Fuller, 1979). This was completed to ensure that the price series were integrated in the same order before the error correction model could be applied. Prior to performing Granger causality tests, the VAR Lag
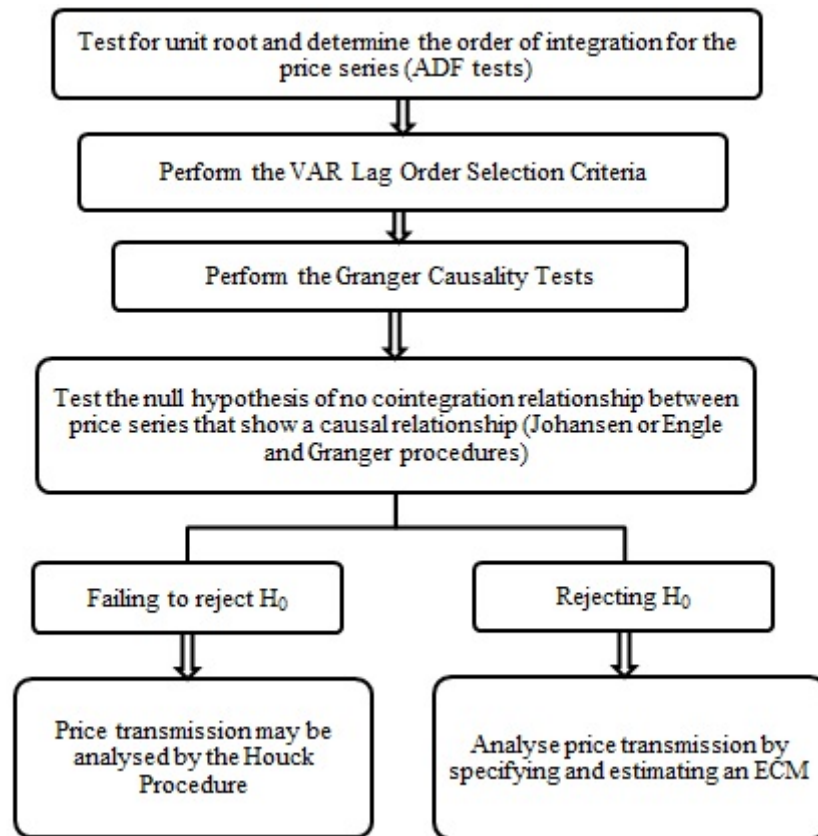
Figure 2: Mind map for analyzing vertical price linkages in the tomato value chain of Northern South Africa, Adapted from: Granger (1969); Houck (1977); Dickey and Fuller (1979); Ward (1982); Engle and Granger (1987); Moghaddasi (2009)

Order Selection Criteria was employed to determine the optimal lag length (Granger, 1969). Co-integration tests were then performed to check the presence of any long run co-integration relationships between the price series. In the event of any price series found to be co-integrated, price transmission would be analyzed using the Error Correction Model. Otherwise, a relatively less intricate alternative, such as the Houck procedure, would be applied.

Analytical model specification

$$\Delta WP_t = a_0 + a_1 iFP_t + a_2 iFP_t \qquad (1)$$

where ΔWP_t is the change in wholesale price, iFP_t is the increase in farm price, and dFP_t is the decrease in farm price. Given the relationship portrayed in equation 1, asymmetry or non-reversibility would occur in ΔWP_t if according to the t-test $a_1 \neq a_2$.

In order to ascertain whether retailers adjust to farm price increases the same way they do for decreases, an Error Correction Model (ECM) was used in accordance with the Engle and Granger (1987) two-step procedure. Equation 2 was specified and estimated using Ordinary

Least Squares,

$$\Delta lnRP_t = \alpha_1 + \sum_{i=1}^{5} \beta_i \Delta lnRP_{t-i} + \sum_{j=0}^{5} \phi_j \Delta lnFP_{t-j} + \alpha^+_2 ECT^+_{t-1} + \alpha^-_2 ECT^-_{t-1} + \varepsilon_\tau \quad (2)$$

where $\Delta lnRP_t$ = first differenced lnRP in period (t), $\sum_{i=1}^{5} \beta_i \Delta lnRP_{t-i}$ = the 1st, 2nd…5th lagged first-differenced values of lnRP, $\sum_{j=0}^{5} \phi_j \Delta lnFP_{t-j}$ = the 1st, 2nd…5th lagged first-differenced values of lnFP as well as its value in period (t), ECT^+_{t-1} = positive error correction terms lagged by one period, and ECT^-_{t-1} = negative error correction terms lagged by one period, α_1, β_i, ϕ_j, α^+_2, α^-_2 are estimated coefficients.

In equation 2, the error correction terms (ECT_{t-1}) measure deviations from the long-run equilibrium between farm level and retail level prices. ECT_{t-1} was segmented into ECT^+_{t-1} and ECT^-_{t-1} to facilitate the test for asymmetric price transmission.

Results and Discussions

The price of tomatoes over the period varied across the marketing chain under analysis, as shown in Figure 3, where the highest weekly average farm gate price was R1.85/kg, while the lowest was R1/kg, and the average
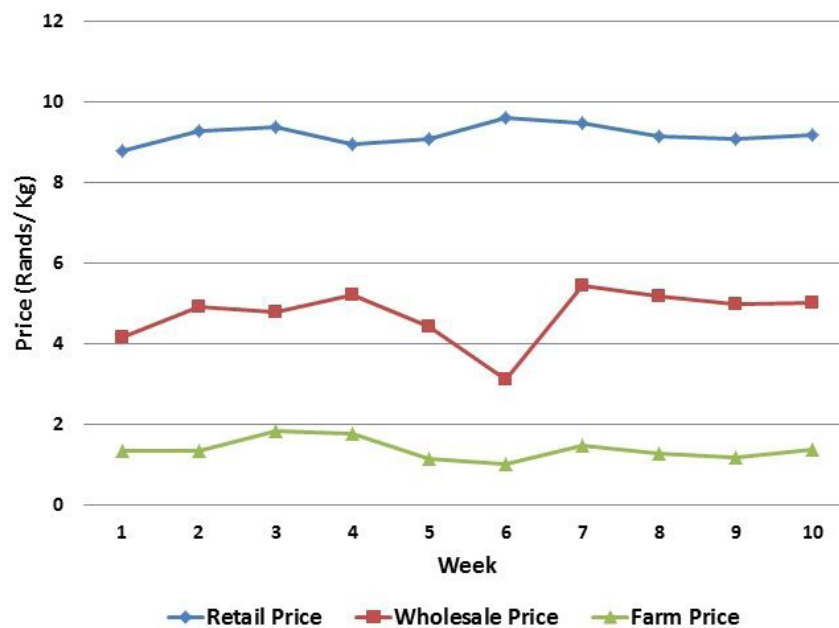
Figure 3: The general tomato marketing margin structure in northern South Africa, Source: Fieldwork, May 2012 - July 2012

farm gate price for the whole period was R1.37/kg. The highest wholesale price was R5.45/kg, while the lowest was R3.10/kg and the whole period average was R4.73/kg. The highest retail price was R9.60/kg, while the lowest was R8.79/kg and the average was R9.20/kg. Figure 3 shows the five day weekly average margin structure. The relationship between weekly average prices of tomato at three levels is presented in absolute terms. The vertical distance between each price reflects the estimated margins between the respective price levels at each point in time.

The Granger Causality tests suggested two unidirectional causality relationships: from farm gate to retail level and from farm gate to wholesale level. Furthermore, farm gate prices were found to influence both wholesale and retail prices, which may be symptomatic that prices are determined at the farm level along the tomato marketing chain. Farm gate and retail price series were found to be co-integrated, thus justifying the use of the Error Correction procedure. On the other hand, there was no cointegration relationship found between farm gate and wholesale price series, thus, the Houck Approach was applied giving the following results in Table 1.

Table 1 shows that for 46 degrees of freedom, the calculated t-value (0.01714) does not exceed the critical t -value even beyond the 0.98 significance level for a two-tailed test. Therefore, we cannot reject the null hypothesis that the coefficients for farm price increases and decreases are equal. Thus, it can be concluded that

the effect of increasing farm gate prices on wholesale or retail prices is statistically not different from that of decreasing prices. In simpler terms, price transmission from the farm level to the wholesale stage of Limpopo produced tomatoes is symmetric, which indicates some degree of efficiency in price information dissemination between these two levels.

The results in Table 2 provide empirical evidence of price asymmetry between the farm and the retail levels of the tomato marketing chain in northern South Africa. The positive error correction term (ECT^{+}_{t-1}) is statistically significant at a level of 5%, whereas the negative error correction term (ECT^{-}_{t-1}) is insignificant. This may suggest that upstream price increases for the tomato value chain in northern South Africa cause a more substantial movement in downstream prices than is the case when upstream prices decrease.

A comparison between the absolute values of the estimated coefficients of both ECTs (0.676644 and 0.415170) reveals that positive error correction terms provoke appreciably greater changes in retail prices than negative error correction terms. These results may point to the possible existence of an asymmetric price transmission between the farm level and the retail level in the tomato value chain of northern South Africa. Another explanation of this asymmetry could be the likely profit maximizing behaviour of retailers, who seemingly react faster to profit threatening situations than to price movements that favor them. Such inter-temporal profit

Table 1: Results of the Houck procedure for Farm-Wholesale Price transmission

Variable	Coefficient	Std. Error	t-statistic	Prob.
Constant	0.010911	0.175601	0.062134	0.9507
iFPt	0.929481	1.418683	0.655171	0.5156
dFPt	0.890212	1.567608	0.567879	0.5729
Var (a1) 2.012662		Var (a2) 2.457396		Cov (a1,a2) -0.388695
Degrees of freedom 46			Calculated t-value (0.01714)	

Table 2: Empirical Results of the Error Correction Model for Farm-Retail Price Transmission

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_1)	0.005415	0.006804	0.795845	0.4324
$\Delta \ln RP_{t-1}$	0.036386	0.219423	0.165826	0.8694
$\Delta \ln RP_{t-2}$	0.071384	0.193480	0.368947	0.7148
$\Delta \ln RP_{t-3}$	0.292458	0.179287	1.631227	0.1133
$\Delta \ln RP_{t-4}$	0.212064	0.165728	1.279590	0.2105
$\Delta \ln RP_{t-5}$	0.137968	0.166174	0.830265	0.4129
$\Delta \ln FP_t$	-0.034864	0.039986	-0.871903	0.3902
$\Delta \ln FP_{t-1}$	-0.010371	0.036280	-0.285854	0.7770
$\Delta \ln FP_{t-2}$	0.055103	0.033396	1.649987	0.1094
$\Delta \ln FP_{t-3}$	0.068348	0.034386	1.987644	0.0560*
$\Delta \ln FP_{t-4}$	0.030513	0.036056	0.846270	0.4041
$\Delta \ln FP_{t-5}$	-0.119578	0.035030	-3.413587	0.0019***
ECT^+_{t-1}	-0.676644	0.276938	-2.443305	0.0207**
ECT^-_{t-1}	-0.415170	0.448446	-0.925797	0.3619
R-squared 0.580677			Durbin Watson stat. 2.350648	

maximization conduct by retailers may also be a result of their reluctance to incur any price adjustment costs, which are usually fixed despite of whether the upstream price movements are positive or negative. As retailers evade price adjustment expenses, there can be a situation where consumers still spend more for a unit of tomatoes from the retailers whether farm gate prices have increased or decreased. This finding concurs with Jaffry (2005), who indicated that in the presence of asymmetric price transmission, consumers may not benefit from

price reductions which tend not to be fully passed on to them. Ben-Kaabia and Gil (2007) also confer that retailers usually benefit from any shock that affects supply or demand conditions, regardless of whether it is positive or negative. Retailers react faster when their margins are squeezed than when they are stretched (Kirsten and Cutts, 2006).

Conclusion

While it is evident that the market for tomatoes in South Africa has been characterized by soaring consumer prices at times, this study targeted at providing a possible empirical explanation of the relationship between upstream and downstream prices for this commodity. Efforts were aimed at investigating price transmission along the marketing chain for tomatoes in northern South Africa by using data collected simultaneously at three marketing levels: farm gate, wholesale and retail. It was also key to answer the question on whether intermediaries in the tomato value chain of northern South Africa pass more completely any cost increases while transmitting less entirely cost savings.

Findings indicated the existence of a large gap between what consumers paid for each unit of tomatoes purchased from retailers, and the amount farmers received for the same quantity from retailers in northern South Africa. Furthermore, the producers' portion of the consumers' Rand was low in absolute terms, since according to the study results, a major part of tomato retail prices constituted total gross marketing margins. However, further studies may need to focus on measuring the individual impacts of each middlemen activity, as well as making market data available on the actual cost drivers along each specific tomato value chain.

Overall, price transmission was found to be more efficient between the farm gate and the wholesale levels than between the farm gate and retail levels. In response to farm price changes, retailers tend to make quicker positive price adjustments than negative price adjustments when there are price increases at the farm level, rather than price reductions, as retailers' profits are threatened whenever farm prices increase than when they decrease. Differences in efficiency of price transmission between various market levels could constitute a result of dissimilarity in the way marketing information is transmitted amongst market players. For instance, the major wholesalers of tomato in South Africa, such as the National Fresh Produce Markets with their online price publishing system, are very transparent as far as price information is concerned. Such price information symmetry allows every stakeholder to be aware of the market prices of tomato over time which leaves no room for artificial price

manipulation by the wholesalers. It is recommended that a similar price broadcasting system be adopted by retailers so that their price information is made public at times to facilitate the price monitoring exercise.

The asymmetric price transmission detected between the farm and retail levels may prompt one to conclude that the responsible authorities, such as the National Marketing Council and the Republic of South Africa's National and Provincial Departments of Agriculture, may need to intervene through intensified monitoring of pricing mechanisms in the South African tomato retail markets. This can be achieved through making it compulsory for all key retailers and commercial farmers to individually submit periodic food pricing reports to the provincial agricultural marketing directorates. The government may also launch an online survey system where all key players are mandated to update their pricing information on an ongoing basis to facilitate the gathering of central market information. Such data collection will also help build an open access food price database that will facilitate and ease food economic analyses.

Acknowledgements

Conflict of Interests

The author hereby declares that there are no conflicts of interests.

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