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Processors pricing and smallholders' milk supply response in Malawi: An application of the nonlinear autoregressive distributed lag model

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Abstract.

The purpose of this paper is to analyse the effects that the practice of setting prices of milk sporadically has on the deliveries of milk to processors in Malawi. This is of particular importance due to two factors: first, Malawi has a significant inflationary process, which erodes quickly the real price paid to farmers, and second, the existence of an informal parallel market for milk which may absorb some of the milk that otherwise would go to the processors. If the real price paid by processors is not adjusted, the informal market becomes more attractive as farmers can sell there their milk with less quality control and at a similar price. This paper explores the response of deliveries of milk to processors to changes in the real price paid for milk, using a nonlinear autoregressive distributed lag (NARDL). The results indicates that the response differ by processor and in most of the cases is asymmetric. Managerial implications are explored.

Keywords: Smallholders supply response, milk pricing in developing countries, Malawi.
JEL codes: D210, O130

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1. Introduction

It is said that smallholder farmers can contribute to greater food supply for the world if the right type of support is put in place. This type of support includes, for instance, secure access to land and water, rural financial services to pay for seed, tools and fertilizer; roads and transportation to get their products to market, and technology to receive and share the latest market information on prices. Moreover, smallholder producers need stronger organisations, so they can have greater bargaining power in the marketplace and can influence national, regional and global policies related to agriculture (IFAD, 2014).

The production of milk in Malawi is mostly in the hands of smallholder farms and dairy is a key investment sector for the Government of Malawi and donor countries such as USA, Japan and Belgium are focusing part of their development aid on the sector. Nevertheless, the levels of production are low and local supply of fresh milk by smallholders only met about 60 per cent of the demand of the dairy processing industry. Thus, the latter often has no choice but to rely on imported milk powder which is used to reconstitute dairy products (e.g., Imani Development Consultants, 2004). In addition, low supply of milk to the dairy processing industry is also a direct consequence of many smallholders marketing milk in the informal market (Revoredo-Giha, 2012; Chitika, 2008; Imani Development Consultants, 2004).

One of the possible reasons why the supply of milk is low is that the prices paid to farmers are low and they are only adjusted in nominal term sporadically (Revoredo-Giha et al, 2013). This in an inflationary context like the Malawian implies that the purchasing power of farmers' income is eroded very quickly with inflation. Information about the supply response to prices is Malawi is limited and the only available known study is that in Revoredo-Giha et al. (2013), which considering a panel of 16 milk bulking groups, found that the price elasticity of the supply in the short term was equal to 0.6 whilst in the long term it was 1.44. This would indicate that farmers' revenues not only benefited from an increase in the price of milk but also from the increase in the quantity produced. Thus, an increase in 1 per cent in the real price would increase producers' revenues by 2.45 per cent. In addition, they found that negative value of the coefficient of the lagged price in the supply equation caused the long term effect to be not as high as it could have been. This was speculated as to be due to the reaction of the informal sector to an adjustment in the formal sector price.

Something that was not explored in Revoredo-Giha et al. (2013) and which is the topic of this paper is whether the supply response to prices is asymmetric. This is of particular interest given the aforementioned fact that nominal prices for milk are adjusted only sporadically and they are eroded in their purchasing power by inflation. This information is of managerial consequences for processors because if the supply is particularly elastic to decreases in the real price of milk, sporadic adjustments in the nominal price might mean that milk deliveries will also decrease substantively until the next price adjustment.

Thus, the purpose of this paper is test whether the farmers' milk supply response in Malawi is price asymmetric. This is done using a unique dataset that comprises deliveries to processors and prices received by farmers from January 2009 to July 2014.

The structure of the paper is as follows: it starts providing a background of the main features of the dairy sector in Malawi. It is followed by the empirical analysis, which comprises a presentation of the used data and the econometric methods used for the analysis. The next section presents and discusses the econometric results and the last section gives some conclusions.

2. An overview of the dairy sector in Malawi

The Malawian dairy sector constitutes a small proportion of the country's agricultural sector and livestock sub-sector. The sector mainly relies for milk supply on smallholder farmers who normally own between one and four dairy cows (Chitika, 2008). Most dairy (smallholder) farmers are situated around the three large cities in Malawi: Blantyre (the Southern Region), Lilongwe (Central Region) and Mzuzu (the Northern Region).

The estimate of the number of dairy farmers in the smallholder sector and the size of the total dairy herd in Malawi varies, not least because the informal sector is often not included in estimates. Based on the recent information received from sources at Bunda college of Agriculture, there are currently around 9,584 dairy farmers in three milk producing regions of Malawi, with 61 per cent of them located in the Southern region. However, a more recent brief from the Civil Society Agriculture Network (CISANET, 2013) puts this number at 16 thousand. It should be noted that the actual number of farmers may differ from the one above as farmers regularly drop out of dairy farming due to the loss of animals. The number also does not include farmers selling milk only outside the formal sector which is often the case in the Northern region, where formal sector is largely under-developed.

As regards the number of dairy cows, the Malawi Dairy Association (Department of Animal Health and Livestock Development, 2006) estimated the number of dairy cows at 30,000 whilst other sources give estimates of between 5,000 to 10,000 milking cows (CYE Consult, 2009). The Malawi Food Security Bulletin (2009) reported a total of 35,594 dairy cattle in the formal and informal sectors (Sindani, 2012). The real figures are subject to speculation as there is no system of cattle registration in Malawi (CYE Consult, 2009). According to the official estimates, there is an increasing trend in the numbers of dairy cattle in the country. Banda et al. (2012) estimate that there has been an increase of 65 per cent in dairy cattle population between 2004 and 2010, mainly as a result of the support from the government of Malawi and other stakeholders through importation of dairy cattle into the country.

Despite the overall growth in dairy cattle numbers (currently comprising about 5 per cent of the national cattle population, CISANET, 2013), the actual growth of livestock numbers per capita has been declining with the average in the last five years being lower than that recorded in the early 1970s (CYE Consult, 2009). According to the 2012 information from the Department of Animal Health and Livestock Development (cited in CISANET brief, 2013), only 13 per cent of smallholder farmers in Malawi own cattle. This reflects the lack of emphasis towards the livestock sector in the official agricultural strategies and policies. Furthermore, a poor performance in the cropping sector caused many farming families to expand their arable cultivation into areas traditionally grazed by livestock (CYE Consult, 2009).

As regards milk yields, according to Zimba et al. (2010) individual farmers produce about 7 litres of milk a day on average; however, they have the potential of producing up to 40 litres per day. It has been reported, though, that recent efforts by the Malawi Government and various international agencies to develop the sector resulted in an increase in the average milk production to up to 15 litres of milk per cow per day in improved dairy breeds (Chagunda et al., 2006; Tebug et al., 2012). However, according to the information from USAID (2012b), smallholders commonly produce around 8 – 10 litres of milk per cow per day, and only a few reach 15 – 20 litres per cow per day.

Concerning milk production, according to the figures from the 3 main milk producing associations in Malawi in 2012, smallholders produced around 13.5 million litres of milk, almost a 2-fold increase from the amount produced in 2006 based on the USAID data (USAID, 2007), 91 per cent of which was produced in the Southern region (Department of Animal Health and Livestock Development, 2009; USAID, 2007). Nevertheless, it should be mentioned that similar to the farmers and dairy cow numbers, estimates of milk vary significantly by source. Thus, the figures for milk production provided by the milk producing associations seem to vary quite significantly from the official estimates provided by the Department of Animal Health and Livestock Development of Malawi (DAHLD) and Ministry of Agriculture and Food Security of Malawi. According to the DAHLD, in 2008 the smallholder dairy sector produced about 49 million litres of milk (about 80 per cent of total milk production in the country), most of which was marketed through the informal channel (Department of Animal Health and Livestock Development, 2009). Another figure for the same year, based on the data from Malawi Annual Production Estimates (APES) shows that the amount of milk produced comprised 35 million litres (Ministry of Agriculture and Food Security of Malawi, 2008). This discrepancy reflects the difference in accounting systems between different governmental agencies in Malawi and sheds some doubts on the credibility of the data on milk production in the country.

There are two marketing channels for milk in Malawi – formal and informal, with the latter being dominant (Imani Development Consultants, 2004). The formal sector supplying processed milk to the consumers is mainly dependent on smallholders for their milk supply. The two channels differ in the way milk reaches the final consumer. In the formal sector, milk is processed and sold to the consumer via retail outlets, whereas in the informal sector milk is sold raw (and often diluted) to either vendors or direct to the consumers (Chitika, 2008).

Even though in Malawi it is illegal to sell raw milk to the consumers due to the health risks involved, this is still a common practice in the country (Barnard, 2006). The government advises smallholder dairy farmers to sell milk only through the formal channel (i.e. milk bulking groups or MBGs) as it provides an established market, and reduces the risk to public health. A large proportion of farmers, however, still sell milk through the informal market (Chitika, 2008). There are various reasons for farmers being involved in the formal and informal markets. According to Chitika (2008), smallholders sell milk in the formal market to smooth out consumption patterns as payments for the milk in the formal market are monthly (unlike instant cash received in the informal market) which acts as some kind of savings mechanism for the farmers. Further, in the formal market the farmers are able to sell higher volumes of milk. Apart from providing reliable markets, MBGs also play role in reducing farmer transaction costs in search for potential buyers (Chitika, 2008).

The main reasons for being involved in the informal market are: sometimes higher prices paid for milk than in the formal market, instant access to cash (no need to wait for one month), and almost guaranteed sale as no tests of milk quality are conducted in the informal sector, i.e. there is a little chance of milk being rejected because of its poor quality (Chitika, 2008). In the Northern region the situation is especially challenging, as the last remaining major dairy processor closed down in 2012, leaving the farmers with little or no choice on where to market their milk (Tebug, 2012). This often leads the farmers to either sell their milk through the informal channel, or makes them move away from the sector entirely. Based on the estimates by Chitika (2008) 19 per cent of the milk produced was consumed on farm (including for feeding the calf) or wasted, 57 per cent was marketed to the formal sector through milk bulking groups and the remaining 23 per cent was sold to vendors or direct to the consumers in the informal market.

An important part of the formal dairy marketing channel are the milk bulking groups (MBGs). These are local farmer associations and are focused around the three major cities (Blantyre, Lilongwe and Mzuzu) (Tebug et al., 2012). These associations have cooling centres where farmers within a radius of 8-10 km deliver their milk to keep it cool . According to the most recent data received from the milk producers' associations, there are currently approximately 54 registered MBGs in Malawi selling milk in bulk to the dairy processors. These MBGs belong to the regional milk producers' association. The Shire Highlands Milk Producers Association (SHMPA) in the Southern Region has the highest number of milk bulking groups - 25 (46 per cent of total). The Central Region Milk Producers Associations (CREMPA) has 17 milk bulking groups. As of 2012, Mpoto Dairy Farmers Association (MDFA) in the Northern region had the lowest number of MBGs from the three regions – 12 (or 22 per cent of total). It is worth noting that not all registered MBGs are fully operational, and therefore, the exact number of these MBGs is not clear. Particularly, this is the case in the Northern region, where the last remaining major dairy processor went out of business in 2012, breaking a fragile link between the farmers and the formal milk market in the region.

The milk delivered by the farmers (usually by bicycle or by foot) is bulked at the MBG cooling centres, and collected by the dairy processors on a (usually) daily basis. However, due to the poor road networks and frequent breakdowns of the collecting trucks, milk can often be more than a day old before collection (Chitika, 2008; CYE Consult, 2009). A bonus is sometimes paid for higher bulk quantities (Chagunda et al., 2006), although this is not a regular occurrence. There is no bonus paid for a high milk quality or butter/fat content as this is not checked at the MBGs. Further, no extra payment is made for milk delivered during the dry or low season when milk production normally decreases due to a shortage of feed (CYE Consult, 2009).

The MBG staff tests milk for adulteration (with a lactometer) and acidity (with an alcohol test). There is no testing currently being conducted for bacterial count or fat percentage, i.e. the quality of milk is not checked at the MBGs. The volume of accepted milk is then measured and recorded against the name of the farmer, and all delivered milk is mixed together into the cooler. Milk not passing the basic tests is rejected and returned to the farmers, who later sell it to the vendors, i.e. the milk enters the informal market (CYE Consult, 2009).

The dairy farmers are paid for their milk (by the MBGs) on a monthly basis. There is a small deduction (0.5 Kwacha as of 2008) for each litre of milk in order to pay for the running cost of the cooling plant, maintenance and for the administrative costs of the milk bulking group (CYE Consult, 2009). As MGBs also act as centres for veterinary and livestock feed supplies, as well as farmer training and extension advice, artificial insemination services and credit , deductions are also made for any credit given to the farmers or services supplied. Figure 1 presents the evolution of the average nominal and real price of milk paid to farmers (deflated by the Malawian consumer price index base year 2000). Nominal prices are set up by processors sporadically, producing the observed pattern in real terms, namely that nominal prices are eroded quickly by inflation. Thus, whilst the nominal price shows a positive trends, real prices show a negative trend.

According to Sindani (2012), an average milk bulking group sells around 528 litres of milk per day. Due to the regular shortages of electricity in Malawi, the supply of electricity to different parts of the country is rationed. There are daily blackouts of minimum of 2 hours per area per day on average (Sindani, 2012). As most of the MBG are located in the remote areas, electricity supply is even more unreliable (CISANET, 2013). This leads to the fluctuations in the temperature of milk in the cooling tanks and, consequently, to the milk getting sour. When this happens, milk is not accepted by the dairy processors, and is usually either returned to the farmer, or is thrown away. This means that the farmer is not paid for the milk even though he had originally delivered good quality milk to the MBG (Sindani, 2012).

As a solution to electricity black outs, many of the milk bulking groups have acquired diesel or petrol powered generators as a backup. However, some of these do not have enough power rating to effectively cool the milk holding tanks (Sindani, 2012).

Additionally, frequent break downs of cooling tanks (often leaving farmers with no other choice but to travel long distances to sell their milk at the next MBG) and picking trucks, poor road networks near the MBGs, and transport breakdowns often contribute to the spoilage of milk in the tanks. Weather conditions during the rainy season also mean that the trucks are sometimes not able to access all the MBGs (CYE Consult, 2009).

Dairy processing in Malawi is very limited in scale and extent. It stands between the farmers and their Milk Bulking Groups (MBGs) and the formal distribution system which comprises street vendors and shops of various scale. There are basically three types of processor. Commercial Dairies – there are two of this type in Blantyre in the South (Dairibord Malawi and Suncrest Creameries), with a further two in the Lilongwe area in the Central region (Lilongwe Dairies and MDI). These enterprises primarily draw milk from MBGs. Privately owned small scale dairies - which utilise milk from their own dairy cow herds. There is one near Lilongwe (Katete Dairy Farm) and which only uses milk from its own herd; and one at Blantyre (Sable Farming) which also draws milk from a limited number of MBGs. Mini dairies – which are limited in number and process milk from smallholder farmers and are managed by the farmers themselves. Main products produced by the processors are pasteurised milk, flavoured and plain yoghurt (chambiko), cream, butter and cheese (Sindani, 2012). Table 1 presents some of of the parameters of processing by major processors.

Table 2 shows the broad pattern of milk deliveries to processors for the period 2009 to 2012 (calendar years). The table indicates a 50 per cent rise in total deliveries with all of the three major commercial processors experiencing an increase. The strongest performance has been with Lilongwe Dairies which has increased its intake by 75 per cent over the 4 years, with the vast majority of that rise coming from producers in the South. Lilongwe Dairies in 2012 accounted for approximately 54 per cent of MBG milk supplies with the bulk of its milk from the South. Dairibord is another major operator in the Southern region accounting for just over 30 per cent of milk deliveries. Suncrest Creameries is also a significant milk purchaser representing over 12 per cent of deliveries with the other operators being far more modest in scale. The situation with MDI has been complicated by a change in ownership in 2012. However, it is apparent that there is a very high level of concentration in milk purchasing.

3. Empirical work

This section starts presenting the data used in the econometric work followed by the methodology used in the analysis.

3.1. Data

The dataset used for the analysis was constructed based on the monthly reports produced by the Shire Highlands Milk Producers Association (SHMPA), which provide information of farmers' deliveries to milk bulking groups (MBGs) associated to the main Malawian dairy processors: Dairibord Malawi Limited, Lilongwe Dairies Limited, Suncrest Creameries Limited and Sable Farming Company and to small processors (named as 'Others'). They cover the period September 2008 until July 2014.

The analysis was focused only on the Southern region due to the fact that prices paid to farmer were only available for this region. This is not so important for providing an analysis of the Malawian milk supply because as according USAID (2012c), the Central Region Milk Producers Association (CREMPA) represents 9.5 per cent of the total production of milk, the Mphoto Dairy Farmers Association (MDFA) the 1.3 per cent, whilst the Shire Highlands Milk Producers Association (SHMPA), which provides the data for this analysis, represents 89.2 per cent of the total.

The dataset comprises the monthly quantity of milk delivered by farmers to the different milk bulking group; the prices paid by processors to the milk bulking group; the price received by farmers and the total discounts applied to milk prices. It should be noted that the number of actual number of farmers delivering milk is not available; therefore, it is not possible to estimate the average delivery per farmer. In order to carry out the analysis by procesors, the information was aggregated by processor, i.e., to milk delivered to each processors and the weighted average price paid by processor to farmers. The number of milk bulking groups by processor in the Southern region is depicted in Figure 2.

Table 3 provides information about descriptive statistics for the dataset used in the analysis and Table 4 presents the results of the Phillips-Perron tests for unit roots. As shown in the Table, most of the variables have a unit root, which makes it needed the use of a cointegration approach for analysing the supply response to prices.

Since the value of milk prices are affected by the inflationary process, it is necessary to deflate them. Thus, the consumer price index base year 2000 was used as a deflator. In addition, to reduce the variability of the series and to obtain elasticities, the series were expressed in logarithms.

3.2. Methods

The purpose of this section is to introduce the main characteristics of the approach used to test asymmetry in the supply response to changes in prices. This is done using the nonlinear asymmetric cointegration approach based on the estimation of the nonlinear autoregressive distributed lag model (NARDL), which follows the work of Shin et al. (2011). The starting point is asymmetric the long-run regression:

$$(1) \qquad y_t = \beta_0 + \beta^+ x_t^+ + \beta^- x_t^- + u_t$$

$$(2) \qquad \Delta x_t = v_t$$

Where y_t and x_t are $I(1)$ variables (milk deliveries and the real price, respectively), u_t and v_t are independent and identically distributed random variables with zero mean and finite variance. x_t is decomposed as $x_t = x_0 + x_t^+ + x_t^-$, where x_t^+ and x_t^- are partial sum processes of positive and negative changes in x_t.

$$(3) \qquad x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0)$$

$$(4) \qquad x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0)$$

As shown in Shin et al (2011) from a nonlinear ARDL(p,q) model such as (5):

$$(5) \qquad y_t = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} \left(\theta_j^+ x_{t-j}^+ + \theta_j^- x_{t-j}^-\right) + \varepsilon_t$$

It is possible to derive a nonlinear error correction model such as (6):

$$(6) \quad \Delta y_t = \rho\left(y_t - \beta_0 - \beta^+ x_t^+ - \beta^- x_t^-\right) + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1}\left(\varphi_j^+ \Delta x_{t-j}^+ + \varphi_j^- \Delta x_{t-j}^-\right) + \varepsilon_t$$

Where β_0, β^+ and β^- are the asymmetric long-run parameters, γ_j, φ_j^+ and φ_j^- are parameters characterizing the short term dynamics. Equation (6) can be estimated by ordinary least squares (OLS) and cointegration tested using a Wald F test of the null hypothesis $\rho = \beta^+ = \beta^- = 0$ and using the bounds testing approach of Shin et al. (2011).

4. Results and discussion

Table 5 presents the final results of the estimation of the milk supply equations. These are the product of applying a general-to-specific approach (Hendry, 1995), which starts by considering a NARDL equation with a large number of lagged variables. These lags are eliminated in a process of testing them (together with the properties of the equation residuals) until a final specification is obtained. Whilst equations in Table 5 provide the dynamics of the relationship between the supply of milk and prices, Table 6 presents the resulting long term coefficients and the cointegration test.

Overall, the results indicate a good fit in all equations (note that the dependent variables are in deviations). All the equations were tested for normality of the residuals (Jarque Bera test), autocorrelation (Breusch- Godfrey test), autoregressive heteroscedasticity (ARCH test) and specification problems (Ramsey-RESET test). Furthermore stability of the equations was tested using CUSUM (cumulative sum) of squares test. None of the test showed problems with the equations.

Four factors should be noted from the outset, first, each company seems to face their own dynamic, i.e., there no two supply response that can be considered the same. The reason could be found on the fact that each company faces different milk bulking groups and these have different characteristics. The second factor is that all the equations consider the inclusion of a trend (cubic in case of Suncrest Creameries) which may indicate persistence. Excepting the case of 'other processors' the shows growth at decreasing rates. The third overall factor is the presence of some seasonality, which differs by company. The seasonal term are identified in the equations by a month only. The fourth is the fact that there are some specific shocks that affect the different supplies. These are identified in the equations by a month and a year.

A feature of the error correction model is that the term in brackets can be interpreted as disequilibrium. How rapidly converges this disequilibrium converges to zero, i.e., to the equilibrium, depends on the value of ρ in equation (6), which are presented in Table 6. For most of the supply equations these values fluctuate around -0.45, i.e., the first period (month) 45 per cent of the disequilibrium is corrected (Dairiboard being -0.43, Lilongwe Dairies -0.46, Sable Farming -0.46 and Others -0.47) being the exception Suncrest Creameries which is -0.26 (although this value is made of two lags, the one period lag is -0.42 and the second period is 0.19). All these parameters were significant at 5 per cent. These results indicate that shocks that affect the supply response take a while in being absorbed.

As for the individual results as mentioned these were different for each company:

Dairiboard - According to Table 5 the responses of the milk deliveries to changes in the price of this company are asymmetric. The short term impact of an increase in the real price paid of milk is equal 0.52, though significant only at 10 per cent. However, the second lags coefficient to positive and negative price shocks are both statistically significant at 1 per cent. This indicates that an increase in the price paid by Dairiboard in real terms only has a strong response after two months. It is also important to mention that the impact in the milk supplied to the company is not strong in the short term as the coefficients are lower than one. The long term effect indicates an asymmetric effect with very little impact for an increase in price and an elastic effect to a decrease in price (i.e., 1.13). This indicates that Dairiboard stays better by avoiding its price to drop in real terms because there in a strong negative effects on its suppliers of milk.

Lilongwe Dairies - Table 5 show that the responses of the milk deliveries to changes in the price of this company are also asymmetric. The short term impact of an increase in the real price paid of milk is equal 0.50, i.e., inelastic and significant only at 1 per cent. Note that decrease in the real price in the short term only decreases the milk supply by 0.15 per cent. Thus, for Lilongwe Dairies the adjustment in prices pays in the short term. Furthermore, there is an addition negative effect in the second period (i.e., measured by the second lag) but it is equal only to 3 per cent. The long term coefficients -see Table 6-, reflect clearly the asymmetric effect. Thus, an increase in the real price improves the supply by 1.2 per cent (elastic response), whilst the decrease in the price in real terms has a minor effect on the supply (or nil as the parameter is not significant). This indicates that Lilongwe Dairies can actually adjust its price sporadically and its supply will almost remain the same (ceteris paribus) until the new price adjustment. This result speaks well in terms of the reliability of their milk suppliers. Also, it may be associated that this company has been growing (in 2012 it represented about 48 per cent of the milk delivered in the Southern area) capturing and opening new milk bulking groups.

Suncrest Creameries - The responses of the milk deliveries to changes of the price of this company are asymmetric and very slow in comparison with the other companies. The autoregressive terms involve two periods, and the effect of an increase in the real price paid for milk does not have effect but after three periods. Similarly the short term impact of a decrease in the increase in the real price is not seen immediately, takes 4 month and it is inelastic. Nevertheless, as shown in Table 6 the long term responses are quite elastic. Thus, the effect of an increase in the real price paid to farmers duplicates the milk supply (the coefficient is equal to 2) and the effect of a decrease in price is smaller although also elastic (i.e., 1.68). The dynamics of the price collection indicates that a policy of price adjustments only improves the collection of Suncrest Creameries in the long term and a do not bring more milk in the short term; therefore, it is not useful to reduce their spare capacity in the short term.

Sable Farming – Table 5 shows that the short term responses of the milk deliveries to changes of the real price for of this company are quite strong and the dynamics is very rich (i.e., the effect persists several lags) and the response again is symmetric. The short term impact of an increase in the real price paid of milk is equal to 4 and highly significant. The effects of a decrease in the real price do not start until the second period and effects take five periods. The long term effect indicates asymmetric effects that are quite elastic (i.e., 19 and 16). These results although statistically significant they need to be taken cautiously as they are based only on 47 observations and the fact that the company only has 2 milk bulking groups; therefore, the supply responses might be show more violence. The implications are that increases in real prices have a strong positive in the short term and long term but decrease in price also have a strong effect and need to be avoided as they erode quickly the milk deliveries.

Others - According to Table 5 the response of the milk deliveries to changes of the price of this residual group are symmetric. The short term impact of an increase in the real price paid of milk is equal 0.25, and of a decrease is 0.27. Both values are significant at 1 per cent. The long term coefficients also indicate a symmetric effect, which is price inelastic.

5. Conclusions

Smallholder producers are a key part for the development of the milk sector in Malawi and they represent about 80 per cent of the milk that supplies the processing industry, which operates with significant idle capacity. In addition, milk production is an important source of income for farmers and therefore an effective device to fight poverty.

Because of the complaints that the prices paid to farmers are low and they are only adjusted in sporadically nominal term (in the context of an inflationary process), it is important to review the effect of this practice has on the supply of milk perceived by processors. Thus, the purpose of this paper has been to study the milk supply response to changes in real prices and in particular to test whether the farmers' milk supply response in Malawi is price asymmetric (particularly since the real prices decrease significantly after an adjustment).

The approach used to estimate the milk supply response to changes in prices and to test asymmetry consisted using the nonlinear asymmetric cointegration approach based on the estimation of the nonlinear autoregressive distributed lag model (NARDL), which follows the work of Shin et al. (2011). This was applied to a unique dataset that comprises deliveries to processors and prices received by farmers for the period January 2009 to July 2014.

The estimations were obtained applying a general-to-specific approach, which starts by considering a NARDL equation with a large number of lagged variables. These lags were eliminated in a process of testing them (together with the properties of the equation residuals) until a final specification was obtained. The resulting equations provided the dynamics of the relationship between the supply of milk and real prices for the short and long term.

Overall, the results indicate a good fit in all equations and all the tests did not show any econometric problem. Four factors were noted from all the supply equations: first, each company seemed to face their own dynamic, i.e., there were no two supply response that can be considered the same; The reason could be found on the fact that each company faces different milk bulking groups and these have different characteristics. The second factor was that all the equations considered the inclusion of a trend (cubic in case of Suncrest Creameries) which may indicate persistence. Excepting the case of 'other processors' they showed growth at decreasing rates. The third factor was the presence of some seasonality, which differed by company. The fourth factor consisted of the fact that there were some specific shocks that affect the different supplies.

A feature of the error correction model is that the term in brackets can be interpreted as disequilibrium and the estimated equations provided with how rapidly the supply recovers from shocks. For most of the supply equations values of the correction fluctuated around -0.45, i.e., the first period (month) 45 per cent of the disequilibrium is corrected being the exception Suncrest Creameries which is -0.26 (although this value is made of two lags, the one period lag is -0.42 and the second period is 0.19). These results indicate that shocks that affect the supply response take a while in being absorbed.

As for the individual results, as regards Dairiboard, the results indicated that it is beneficial for the company to avoiding its price to decrease in real terms because there in a strong negative effects on its suppliers of milk. For Lilongwe Dairies the estimation implies that they can actually adjust its price sporadically and its supply will almost remain the same (ceteris paribus) until the new price adjustment. This result speaks well in terms of the reliability of their milk suppliers. Also, it may be associated that this company has been growing (in 2012 it represented about 48 per cent of the milk delivered in the Southern area) capturing and opening new milk bulking groups.

The dynamics of the price deliveries for Suncrest Creameries indicates that a policy of price adjustments only improves the milk collection in the long term and a price policy do bring more milk in the short term; therefore, it is not useful to reduce their spare capacity in the short term.

The results for Sable Farming show a response that is quite elastic (i.e., long term coefficient were 19 and 16). These results although statistically significant are somewhat suspicious as they are based only on 47 observations and the fact that the company only has 2 milk bulking groups; therefore, the supply responses might be show more violence. The implications are that increases in real prices have a strong positive in the short term and long term but decrease in price also have a strong effect and need to be avoided as they erode quickly the milk deliveries. Finally, other minor processors (grouped under the heading 'Others') show a response that was symmetric and inelastic (though statistically significant) to change in prices.

Overall the results indicate the need for this type of analysis by processor as they allow tracking the response of the milk that is delivered to their plants to their pricing policy, even more in a context where all the processors are operating with important spare capacity. Furthermore, they also point out the usefulness of the data collected by SHMPA for managerial purpose.

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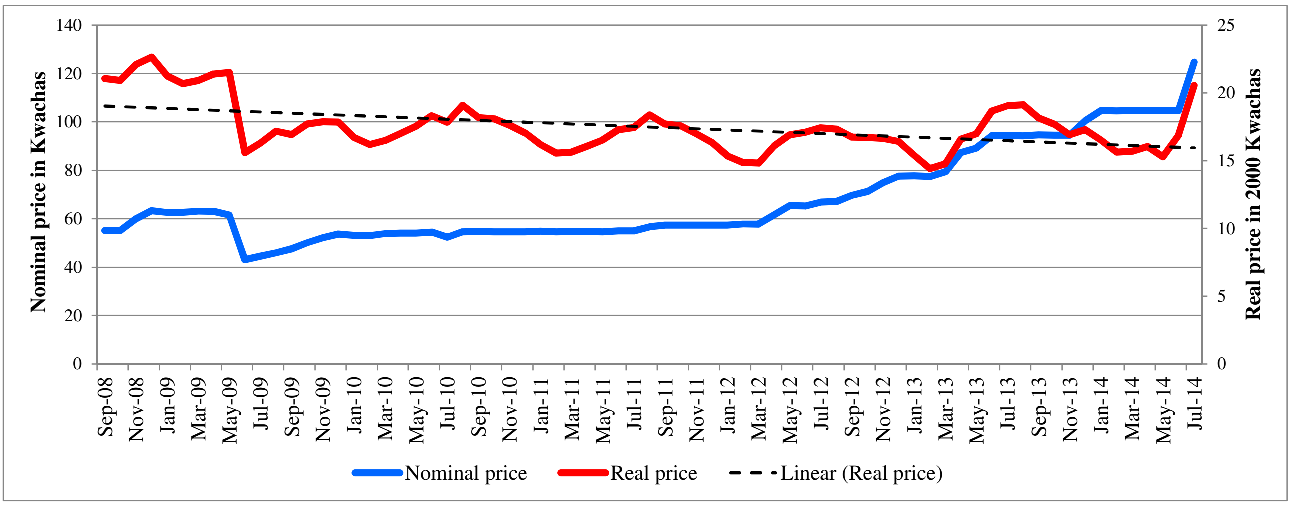
Tables and Figures

Figure 1: Nominal and real weighted average price of milk paid to farmers by processors



Source: Own elaboration based on Shire Highlands Milk Producers Association (SHMPA) data.

Table 2: MBG Deliveries to processors (thousand litres)

	Dairibord Malawi Ltd.	Suncrest Creameries	Sable Farming Company	Lilongwe Dairies Ltd.			MDI	Total
				South	Central	Total		
Thousand litres								
2009	4,153	1,829	--	4,734	841	5,576	417	11,973
2010	4,660	2,045	312	6,817	805	7,622	598	15,237
2011	5,987	2,121	466	7,260	1,288	8,548	416	17,538
2012	5,527	2,143	286	8,608	1,179	9,787	287	18,029
Shares (%)								
2009	34.7	15.3	--	39.5	7.0	46.6	3.5	100.0
2010	30.6	13.4	2.0	44.7	5.3	50.0	3.9	100.0
2011	34.1	12.1	2.7	41.4	7.3	48.7	2.4	100.0
2012	30.7	11.9	1.6	47.7	6.5	54.3	1.6	100.0

Source: Based on data provided by Brian Lewis (SHMPA) and Jonathan Kaphela (CREMPA).

Table 1: Production capacity and utilization major dairy processors

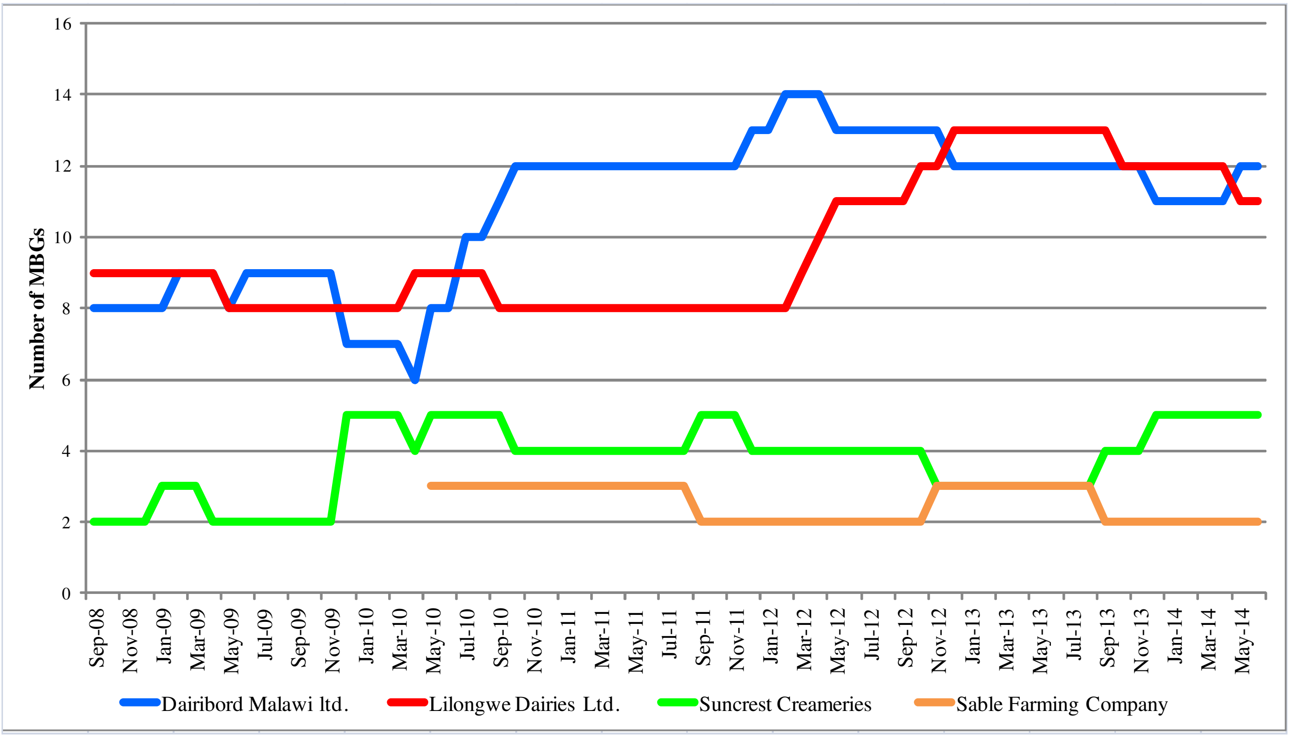
Company	Location	Production Capacity Thou. lt/day	Idle capacity 2012 (%) 1/	Main Dairy Products
Dairibord Ltd.	Blantyre	40	30-33	Pasteurised Milk,Flavoured Yoghurt and Chambiko
Suncrest Creameries Ltd.	Blantyre	25-30	40-50	Pasteurised and Steri Milk, Drinking, Yoghurt
Lilongwe Dairies	Lilongwe	75	35	Pasteurised Milk, (Flavoured) Yoghurts
Katete Farms	Lilongwe	10	23	Pasteurised Milk,
MDI	Lilongwe	30	98	Pasteurised Milk,

Source: CYE Consult, 2009.

Notes

1/ Own estimation based on milk deliveries data from SHMPA and CREMPA.

Figure 2: Number of Milk Bulking Groups by processor



Source: Shire Highlands Milk Producers Association.

Table 3: Descriptive statistics of the data

Statistics	Monthly deliveries (Litres)					Real prices paid to farmers (2000 MK)				
	Dairibord	Lilongwe Dairies	Suncrest Creameries	Sable Farming	Other	Dairibord	Lilongwe Dairies	Suncrest Creameries	Sable Farming	Other
Mean	421,078.8	589,696.0	197,593.8	29,386.5	11,409.1	17.4	17.5	17.5	16.7	17.6
Median	416,991.0	602,082.0	169,275.0	22,681.0	11,198.0	16.9	17.1	17.0	16.5	17.9
Maximum	590,437.0	835,496.0	494,413.0	55,066.0	26,860.0	22.1	23.2	22.5	19.8	21.4
Minimum	261,398.0	327,045.0	113,708.0	7,376.0	277.0	14.1	14.5	14.1	14.1	5.2
Standard deviation	86,415.7	134,081.7	81,293.3	14,641.8	5,655.4	1.9	2.0	1.9	1.4	2.5
Skewness	0.1	-0.4	2.1	0.0	0.6	0.8	1.1	0.7	0.2	-1.8
Kurtosis	2.0	2.2	6.8	1.5	3.1	3.3	3.8	3.1	2.4	10.3
Jarque-Bera 1/	3.0	3.5	94.6	4.8	4.8	8.6	15.2	6.7	1.3	188.1
Probability	0.2	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.5	0.0
Observations	71	71	71	51	69	71	71	71	51	68

Notes

1/ Normality test (null hypothesis that the variable is normal). Probability stands for the probability of accepting the null hypothesis.

Table 4: Unit root tests of variables

	Phillips-Perron unit root tests									
	Dairibord		Lilongwe Dairies		Suncrest Creameries		Sable Farming		Other	
	Test	Sig.	Test	Sig.	Test	Sig.	Test	Sig.	Test	Sig.
Variables in levels										
Monthly deliveries	-2.73		-3.21		-1.08		-3.79	*	-5.90	*
Real prices	-2.13		-2.91		-3.38		-2.65		-7.57	*
Variables in first differences										
Monthly deliveries	-7.48	*	-10.58	*	-10.11	*	-8.62	*	-12.27	*
Real prices	-5.99	*	-6.78	*	-9.99	*	-5.50	*	-45.08	*

Notes: All the variables are in logarithms. Unit root test considering intercept and trend. * indicates that the null hypothesis of unit root is rejected at 5 per cent significance.

Table 5: Final estimation

Final equations by company

Dairibord - ΔLog(MDEL1)

	Coeff.	Std. err.	Sig.
Intercept	5.5019	0.9855	0.00
Log(MDEL1(-1))	-0.4388	0.0795	0.00
LP1+(-1)	0.5183	0.3050	0.09
LP1+(-2)	-0.4963	0.1833	0.01
LP1-(-2)	0.4939	0.1846	0.01
Trend	0.0239	0.0068	0.00
Squared trend	-0.0002	0.0000	0.00
Dummy - February	-0.2145	0.0331	0.00
Dummy - March	-0.0843	0.0362	0.02
Dummy - April	-0.0896	0.0360	0.02
		Sig.	
Observations	69		
Adjusted R squared	0.53		
Log-likelihood	87.90		
Residuals' tests			
Jarque-Bera	4.17	0.12	
Breusch-Godfrey	0.81	0.44	
ARCH	1.28	0.28	
Ramsey RESET	0.02	0.88	

Lilongwe Dairies - ΔLog(MDEL2)

Coeff.	Coeff.	Std. err.	Sig.
Intercept	5.9512	1.0691	0.00
Log(MDEL2(-1))	-0.4687	0.0845	0.00
LP2+(-1)	0.5071	0.1977	0.01
LP2+(-2)	0.0393	0.0232	0.10
LP2-(-1)	-0.1526	0.0979	0.12
Trend	0.0014	0.0040	0.72
Squared trend	-0.0001	0.0000	0.00
Dummy - February	-0.1384	0.0273	0.00
Dummy - September	-0.0487	0.0283	0.09
Dummy - November	-0.0882	0.0275	0.00
Dummy - February-2013	-0.2469	0.0644	0.00
		Sig.	
Observations	69		
Adjusted R squared	0.65		
Log-likelihood	105.13		
Residuals' tests			
Jarque-Bera	3.23	0.19	
Breusch-Godfrey	1.34	0.26	
ARCH	1.05	0.35	
Ramsey RESET	0.08	0.78	

Suncrest Creameries - ΔLog(MDEL3)

Coeff.	Coeff.	Std. err.	Sig.
Intercept	2.5527	0.9965	0.01
Log(MDEL3(-1))	-0.4284	0.1035	0.00
Log(MDEL3(-2))	0.1946	0.1005	0.06
LP3+(-3)	1.0078	0.2456	0.00
LP3+(-4)	-0.5862	0.1745	0.00
LP3-(-4)	0.5872	0.1805	0.00
Trend	0.0371	0.0144	0.01
Squared trend	-0.0010	0.0003	0.00
Cubed trend	0.0000	0.0000	0.00
Dummy - February	-0.1085	0.0450	0.02
Dummy - May-2010	-0.2178	0.1027	0.04
Dummy - April-2014	-0.2715	0.1042	0.01
		Sig.	
Observations	67		
Adjusted R squared	0.48		
Log-likelihood	71.83		
Residuals' tests			
Jarque-Bera	0.72	0.69	
Breusch-Godfrey	0.83	0.44	
ARCH	0.16	0.85	
Ramsey RESET	0.03	0.86	

Sable Farming - ΔLog(MDEL4)

Coeff.	Coeff.	Std. err.	Sig.
Intercept	3.3274	1.0124	0.00
Log(MDEL4(-1))	-0.4594	0.0887	0.00
LP4+(-1)	-4.1360	1.0225	0.00
LP4+(-5)	-4.6226	1.2525	0.00
LP4-(-2)	2.5550	1.5540	0.11
LP4-(-3)	-5.2388	1.7712	0.01
LP4-(-4)	5.5068	1.5421	0.00
LP4-(-5)	4.5837	1.2038	0.00
Trend	0.0184	0.0233	0.43
Squared trend	0.0031	0.0007	0.00
Dummy - June	0.5989	0.1484	0.00
Dummy - July	0.7847	0.1399	0.00
Dummy - August	0.5644	0.1416	0.00
Dummy - November	0.4332	0.1488	0.01
		Sig.	
Observations	47		
Adjusted R squared	0.62		
Log-likelihood	16.24		
Residuals' tests			
Jarque-Bera	0.23	0.89	
Breusch-Godfrey	0.35	0.70	
ARCH	0.55	0.57	
Ramsey RESET	0.14	0.71	

Other - ΔLog(MDEL5)

Coeff.	Coeff.	Std. err.	Sig.
Intercept	5.0978	0.7621	0.00
Log(MDEL5(-1))	-0.4744	0.0806	0.00
LP5+(-1)	0.2523	0.0877	0.01
LP5-(-1)	0.2735	0.0906	0.00
Trend	-0.0297	0.0106	0.01
Squared trend	0.0003	0.0001	0.01
Dummy - February-2009	-1.6091	0.2637	0.00
Dummy - May-2010	-1.3406	0.2413	0.00
Dummy - April-2014	-0.8825	0.2438	0.00
		Sig.	
Observations	67		
Adjusted R squared	0.86		
Log-likelihood	7.88		
Residuals' tests			
Jarque-Bera	0.08	0.95	
Breusch-Godfrey	2.23	0.11	
ARCH	0.71	0.49	
Ramsey RESET	0.37	0.54	

Note: The Jarque-Bera test is a normality test under the null hypothesis that the residuals are normal. The Breusch-Godfrey test, considers the null hypothesis that the residuals are free of autocorrelation. The ARCH test considers the null hypothesis that the residuals do not follow an autoregressive heteroscedastic process. Finally, the Ramsey RESET test is a general specification test for the linear regression model, with the null hypothesis that the added non-linear combinations of the fitted values are equal to zero. As regards the variables LPi+ and LPi- refer to the partial sum processes of positive and negative changes in log of prices, i.e., $\log(p_t)$, for company i.

Table 6: Long term parameters and cointegration test

	Long term parameters				
	Dairibord	Lilongwe Dairies	Suncrest Creameries	Sable Farming	Other
Error correction term	-0.44 **	-0.47 **	-0.26 **	-0.46 **	-0.47 **
	0.08	0.08	0.09	0.08	0.08
Intercept	-12.54 **	-12.70 **	-11.32 **	-7.24 **	-10.75 **
	0.10	0.05	0.40	1.30	0.37
Increases in price	-0.05	-1.17 **	-2.07 **	19.06 **	-0.53 **
	0.51	0.34	0.70	3.99	0.22
Decreases in price	-1.13 **	0.33	-1.68 *	-16.12 **	-0.58 **
	0.37	0.22	0.91	3.61	0.26
Cointegration test	25016.90 **	64625.35 **	1556.29 **	160.80 **	1416.65 **

Note: Cointegration tested using a Wald F test of the null hypothesis $\rho = \beta^{+} = \beta^{-} = 0$ and using the bounds testing approach of Shin et al. (2011).