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How Responsive to Prices is the Supply of Milk in Malawi?

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148- How Responsive to Prices is the Supply of Milk in Malawi?[1]

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Abstract

Dairy is a key investment sector for the Government of Malawi. Advocacy institutions operating in the country have successfully lobbied for increasing the duty applied for powder milk, with the aim of improving the price received by farmers. It should be noted that whilst an increase of the price paid to farmers would rise their revenues (assuming the same amount of milk delivery), it might also bring additional blessings, in the sense that if farmers respond to prices, they may rise their revenues beyond the increase in prices, and furthermore, they would expand their delivery of milk to processors offsetting the imports of powder milk and reducing their idle capacity in factories. Hence, the purpose of this paper is to measure the responsiveness of the deliveries of milk at the milk bulking groups to prices paid to farmers (i.e., the elasticity of supply faced by processors). This is done using a unique dataset that comprises information by milk bulking group from January 2009 to February 2013. The results indicate that the supply of milk is price responsive. The price elasticity in the short term is equal to 0.6 and in the long term is 1.44. This indicates that farmers' revenues not only benefit from an increase in the price of milk but also from the increase in the quantity produced. Furthermore, it indicates the possibility that domestic producers could offset imports of milk powder by processors, although answer to this requires further research.

Keywords: Milk supply, autoregressive distributed lags, panel data.

I. Introduction

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. Despite this consumption of milk products in Malawi remains very low, estimated at 4-6 kg/capita/year (Tebug, 2012), which is much lower than the Africa average of 15 kg/capita/year, and significantly lower than 200 kg/capita/year recommended by the World Health Organisation (WHO) and Food and Agriculture Organisation of the United Nations (FAO) (Banda, 2008).

One of the problems that dairy producers' face is the low prices that they receive. Although the reasons behind this are not fully clear, one of the causes seem to be the competition from

[1] This paper is based on the material from the Dfid-ESRC project "Assessing contribution of Dairy Sector to Economic Growth and Food Security in Malawi" (ES/J009202/1). We are grateful to Mr. Brian Lewis for providing the data information used in the analysis. All the opinions in the paper are sole responsibility of the authors.

imported powder milk, which is reconstituted by processors and used in dairy production instead of domestic fresh milk. Thus, in 2009 milk powder imports were available at very low prices. The imports were mainly from Europe, in particular from Ireland where exporters received subsidies to dispose of their surplus. As a result of the low imported prices it was difficult for Malawian dairy farmers to get a fair price for their produce and processors dropped the price paid to farmers from 68 to 50 Kwacha. This motivated institutions, such as the Malawi Milk Producers Association and VSO to lobby the government with the aim of increasing the levy on imported milk. Two were the main arguments as to why it would be in the interest of Malawi to do so. First, they argued that if imports were more expensive then processors would have to offer better prices to local farmers as they could not offer prices that are not in line with imports. As it was likely that the processors would shift to buying milk from local producers, these producers would get a larger income and so be able to improve their and their families' livelihoods. Second, the income generated by the levy would be channelled into a Dairy Industry Development Fund so that it could be invested in small-holder dairying and develop the dairy industry. The result of the campaign was successful and the duty applied to powder milk increase from 20 to 30 per cent in 2010 (VSO, 2011).

It is important also to take into account that according to Imani Development Consultants (2004), based on 2002-03 data, local supply of fresh milk by smallholders only met 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. Low supply of milk to the dairy processing industry is also a direct consequence of many smallholders marketing milk in the informal market (Chitika, 2008). Also, different estimates point out that processors operate with significant idle capacity (e.g., Imani Development Consultants, 2004), which has significant implications in terms of efficiency and competitiveness.

In the above context, whilst an increase of the price paid to producers would certainly rise their revenues (assuming the same amount of milk delivery), it might also bring additional blessings, in the sense that if farmers respond to prices, they may rise their revenues beyond the increase in prices, and furthermore, they would expand their delivery of milk to processors offsetting the imports of powder milk and reducing processors' idle capacity. However, if domestic production is not price responsive, then processors' face a further constraint in procuring raw material, i.e., milk.

It should be noted that another reason for studying the supply of milk is associated to possibility that market power can be applied to the demand for milk. As pointed out by Perloff et al. (2007), if the supply curve has no slope then monopsony or oligopsony power cannot be exercise.

As there are not known estimates of farmers' supply response in Malawi, the **purpose of this paper** is to measure the responsiveness of the deliveries of milk at the milk bulking groups to prices paid to farmers (i.e., the elasticity of supply faced by processors). This is done using a

unique dataset that comprises deliveries to milk bulking groups and prices received by farmers from January 2009 to February 2013. These data allow assembling a panel dataset.

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 econometrics carried out. The next section is a discussion of the econometric results and the last section present some conclusions.

II. 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). There is also an estate sub-sector which consists of 15 private large-scale dairy farms accounting for about 2,200 milking cows (Chagunda et al., 2006).

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[2] , 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.

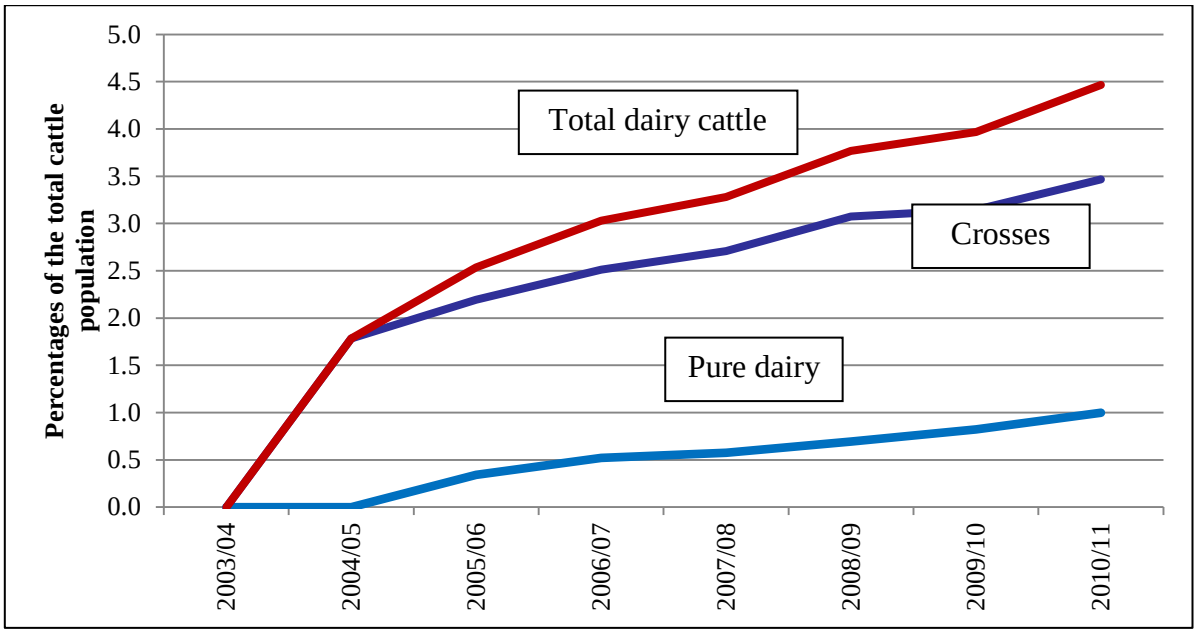
As regards the number of dairy cows, the Malawi Dairy Association (Department of Animal Health and Livestock Development, 2006) estimated the number of dairy cows at 30,000 whilst other sources give estimates of between 5,000 to 10,000 milking cows (CYE Consult, 2009). The Malawi Food Security Bulletin (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.

[2] Courtesy of Professor Timothy Gondwe, Bunda College.

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).

Figure 1: Increasing trend in dairy cattle numbers



Source: USAID (2012b)

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[3] (Chitika, 2008). In the Northern region the situation is especially challenging, as the last remaining major dairy

[3] Chimbaza (2010) estimates that 17 per cent of the milk delivered to the formal market are rejected due to the poor quality. This is a major cause for losses and reduced earnings by smallholder farmers in Malawi.

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[4]. 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.

[4] According to the unprocessed data from the dairy baseline survey in Malawi, carried out in February 2013 by Scottish Rural College (SRUC) and Bunda College of Agriculture, many smallholder farmers are located outside the recommended 8-10km distance from the nearest MBG, which makes delivering milk to the MBG more problematic and encourages sales in the informal sector.

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[5], deductions are also made for any credit given to the farmers or services supplied.

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).

Traditionally, apart from acting as an intermediary between the farmers and the milk processors and offering access to the formal market, MBGs have also played an important role in the dissemination of dairy innovations, facilitating access to information, providing farmers with information on basic aspects of dairy husbandry such as feeding techniques, health as well as reproductive management, and farm record keeping during training sessions and on-farm extension (Tebug et al., 2012).

[5] For example, both SHMPA and Land O'Lakes use the MGBs as the main source for their extension and development programmes (CYE Consult, 2009).

These services have been provided mainly by extension personnel from the Ministry of Agriculture and Food Security and by Non-Governmental Organisations (NGOs) (Tebug et al., 2012). However, in the recent years, the role of MBGs as training and facilitation centres have somewhat dwindled, which can be explained by the lack of the government focus on the role of MBGs in the development of the formal dairy sector (despite it being one of the key government priorities according to the Government of Malawi). As a result, most MBGs currently act as milk bulking associations only, gathering milk from smallholders, storing it in cooling tanks, and selling it on to the processors (Sindani, 2012).

The **formal milk processing sector** is currently dominated by 3 main dairy processing plants – Lilongwe Daiy, Dairibord Malawi and Suncrest Creameries, situated around the cities of Blantyre and Lilongwe. Main products produced by the processors are pasteurised milk, flavoured and plain yoghurt (chambiko), cream, butter and cheese (Sindani, 2012). As in other agricultural sub-sectors in Malawi, in the dairy sector there is usually little value addition in the chain from smallholder farmers to the final consumer (Chitika, 2008).

According to the CYE Consult (2009), Dairibord markets approximately 70 per cent, Suncrest 15 per cent and Lilongwe Dairy 10 per cent of all the milk processed in the country. The remaining 5 per cent used to be marketed by the Northern Dairies Industries based in Mzuzu, which went out of business in 2012 due to the cash flow problems and equipment failure (USAID and Malawi Dairy Development Alliance, 2012).

In an effort to increase the farmer access to the formal market in the Northern region, a mini-processing plant was opened by in 2011 by the Mpoto Dairy Farmers Association. Though this processor is also facing cash flow problems, it continues to collect milk and is the only processor currently available in the North. MDFA currently processes very limited amounts of milk but hopes to expanding its capacity to 1,000 litres per day in the future (USAID and Malawi Dairy Development Alliance, 2012).

The processing plants are mainly supplied by smallholders through Milk Bulking Groups and to a lesser extent by the estate sub-sector. It should be noted that all the dairy processors have an under-utilised capacity, this situation is exacerbated by the fact that, due to the low supplies of milk, with most of them only working at less than 40 per cent of capacity. As a result, the processors are unable to produce more value added products such as butter, cheese and yoghurts which would help improve the profitability of the processors (CYE Consult, 2009).

It is important to note, however, that some of this under-utilized capacity is due to the out of date machinery at the processing plants that needs replacing. This means that even if higher milk volumes were supplied by the Milk Bulking Groups, the processors would not be able to work at full capacity. Replacing the machinery is very expensive, and with some of the highest bank loan interest rates in Africa and business climate in Malawi not being very supportive of small enterprises, the processors are not willing to invest in upgrading the old equipment.

Despite this, Lilongwe Dairies has recently installed a new ultra-high temperature (UHT) line and the UHT milk proved quite popular amongst Malawi consumers due to its long shelf life and no need for refrigeration, which is a major bonus in a country with regular electricity shortages. The other two processors are reported to follow Lilongwe Dairies in installing UHT machinery. However, in order for the cost of the UHT line to be justified a large and regular volume of milk is needed (CYE Consult, 2009).

Overall, the smallholder dairy production systems in Malawi are based on low inputs with low outputs, which leads to a limited return, low productivity and slow herd growth (CYE Consult, 2009). Most smallholders lack capital, and their animal husbandry knowledge (e.g., keeping clean pens, availability of fresh water, ensuring the animals are dry and warm with full stomachs) is limited. Many smallholders are keeping livestock for the first time, and lack basic husbandry skills. The use of artificial insemination remains irregular due to lack of transport for technicians, and as a result the growth of the herd is slow. Calf mortality is high (reported to be 40 per cent) (CYE Consult, 2009).

Low productivity in the smallholder sector is further influenced by the weak agricultural credit system, unorganised market structure, unfavourable weather due to the climate change, small land holding sizes and inadequate technology development (CYE Consult, 2009). Thus, the main factors associated with the dairy sector in Malawi can be summarised as following:

- Large number of smallholders (providing about 80 per cent of total milk production in the country)
- Small and declining farm sizes (usually under 0.5ha)
- Lack of investment in smallholder dairy farms including lack of financial resources to purchase livestock / limited access to credit (Sindani, 2012)
- Erosion of extension services including inadequate training of farmers' extension agents - the Department of Animal Health and Livestock Development (DAHLD) has extension staff but they are not attached to MBGs, and they lack transport, so their services are often of no use to a smallholder (Sindani, 2012). According to the CISANET brief (2013), the extension officer / farmer ratio is as high as 1/3000
- Lack of farmer knowledge and training, poor knowledge transfer, advice and training opportunities
- Only a relatively small percentage of milk produced by smallholders is sold through formal channels (Chitika, 2008)
- A processing sector comprised by three major companies that use only up to 40 per cent per cent of their capacity. However, the processing sector still meets its margins by targeting the affluent part of the urban population (the upper 3 per cent) (Chitika, 2008)
- A large reliance on imported milk powder (Buck, 2008)
- A high percentage of the milk sent to the formal channel (est. 17 per cent) is rejected due to poor quality (Chagunda et al., 2010)
- Lack of farmer organisations / cooperatives at the level below Milk Bulking Groups (CISANET, 2013). The establishment and participation of effective and representative

farmer organisations which are able and willing to communicate with members is essential. This will require support and capacity development

- Weak institutional structures (little or no contact between the key stakeholders in the dairy sector)

III. Empirical work

This section starts presenting the data used in the econometric work followed by the results of the estimations.

III.1 Data

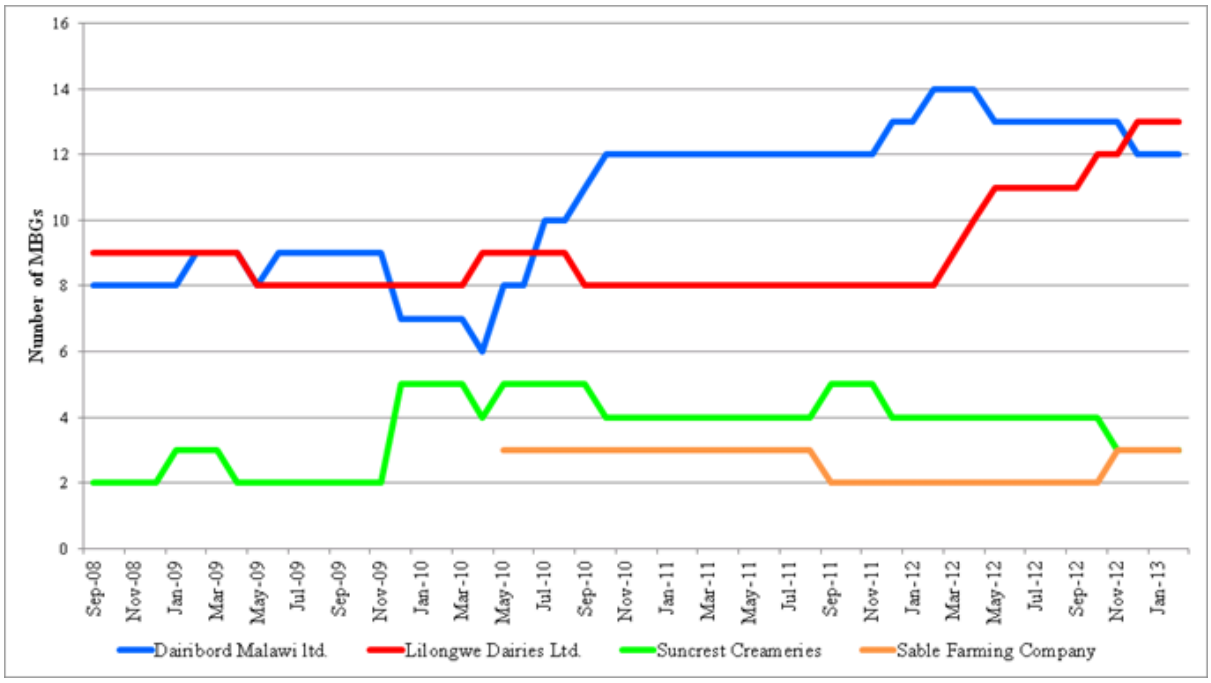
The dataset used for the analysis was constructed based on the monthly reports produced by the Shire Highlands Milk Producers Association (SHMPA), which provide information of farmers' deliveries to milk bulking groups (MBGs) associated to the main Malawian dairy processors: Dairibord Malawi Limited, Lilongwe Dairies Limited, Suncrest Creameries Limited and Sable Farming Company. They cover the period September 2008 until February 2013.

It is important to note that 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; therefore, it sensible to focus the analysis on the latter.

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.

Although the dataset provides information for 36 MBGs, not all of them were observed during the entire span of the data as some of them were established later. The number of MBGs in some of the cases has tended to increase since 2008 as shown in Figure 1 for Dairibord and for Lilongwe Dairies.

Figure 2: Number of MBGs by processor 2008-2013



Source: SHMPA.

In order to provide a more robust analysis considering the entire period, 16 MBGs out of the 36 were chosen. The selected MBGs were: Blantyre, Bvumbwe, Chandamale, Chisitu, Chonde, Dwale, Matapwata, Mikolongwe, Nachambo, Namahoya, Namitambo, Nanchefu, Okhalavo, Thuchila, Thunga and Ulemu. Table 1 provides information about the representativeness of the selected MBGs. It is clear that there have been a decrease in the proportion that the selected MBGs represent on the SHMPA total milk collection. Nevertheless the 16 MBGs still are more than 60 per cents

Table 1: Representativeness of the MBGS used in the empirical analysis

	Total monthly average delivered (litres)	Sample monthly average delivered (litres)	Sample (% of total)
2009	910,951	859,813	94.4
2010	1,166,404	981,368	84.1
2011	1,330,701	1,062,335	79.8
2012	1,388,673	963,941	69.4
2013 1/	1,221,132	785,922	64.4

Source: SHMPA.
Note: 1/ January and February only.

Table 2 provides information about descriptive statistics for the dataset used in the analysis.

Table 2: Descriptive statistics of the data

	Milk delivered to milk bulking groups	Price paid by processors	Price paid by farmers
Mean	59,976.7	62.0	58.2
Median	60,347.5	58.5	56.0
Maximum	156,785.0	86.4	81.5
Minimum	2,034.0	50.0	45.0
Std. Dev.	32,753.5	8.3	8.1
Skewness	0.4	1.1	0.9
Kurtosis	2.9	3.8	3.5
Observations	800	800	800

Source: Based on information from SHMPA.
Note: Considers 16 MBGs that were observed for the entire period.

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.

III.2 Econometric results

The first step for the econometric modelling the supply response is to explore whether the panel dataset is stationary. If the stationarity of the dataset is rejected, then it is necessary to test whether the series are cointegrated. The literature suggests that panel-based unit root tests have higher power than unit root tests based on individual time series. This is particularly important for the case in hands as the time series are relatively short.

Three panel unit root tests were considered for the analysis of unit roots in the data, namely Im, Pesaran and Shin (2003), and two Fisher-type tests using augmented Dickey-Fuller and Perron-Phillips (PP) tests (Maddala and Wu (1999) and Choi (2001)). Theses tests consider that the unit root process can be different amongst the cross sections (i.e., a heterogeneous panel) and also consider the null hypothesis that the series have a unit root.

Table 3 presents the results of the unit root tests. All the tests reject the hypothesis that the log of milk delivered and the log of the real price received by the farmers are non stationary.

As the series are stationary, the next step was to fit the supply response relationship. This was done using Hendry's general to specific methodology (Hendry, 1995) and the starting point was to consider an autoregressive distributed lag model considering enough lags of the

dependent and independent variables and reduce the model by testing redundant parameters and whether the residual are independent and identically distributed.

Table 3: Panel unit root test

	Statistic	Prob.**	Cross-sections	Obs
Sample: Jan 2009 to Feb 2013				
Exogenous variables: Individual effects, individual linear trends				
Newey-West bandwidth selection using Bartlett kernel				
Variable: Log(milk deliveries to MBGs)				
Im, Pesaran and Shin W-statistic	-4.00	0.00	16	781
ADF - Fisher Chi-square	74.54	0.00	16	781
PP - Fisher Chi-square	60.67	0.00	16	784
Variable: Log(price paid to farmers in real terms)				
Im, Pesaran and Shin W-statistic	-9.00	0.00	16	728
ADF - Fisher Chi-square	136.90	0.00	16	728
PP - Fisher Chi-square	69.87	0.00	16	784

Source: Own elaboration based on SHMPA data.
Note: The null hypothesis of the test is that the series have unit roots (assumes individual unit root process).

The final model after the process of elimination of variables as an AD(1,1), which is given by equation 1. In addition, the equation also considered a quadratic trend and dummy variables to account with seasonality factors.

$$(1)\quad \log\left(M_{t,i}\right)=\alpha_{0i}+\alpha_1\log\left(M_{t-1,i}\right)+\alpha_2\log\left(\frac{P_{t,i}^{M}}{P_t}\right)+\alpha_3\log\left(\frac{P_{t-1,i}^{M}}{P_{t-1}}\right)+\alpha_4 t+\alpha_5 t^2+\alpha_6 d_{1t}+\alpha_7 d_{5t}$$

Where $M_{i,t}$ is the monthly quantity delivered of milk by farms in period t to the i milk bulking group, $P_{t,i}^{M}$ is the average monthly price paid to farmers for milk at each milk bulking group, P_t is the consumer price index, t is a trend, d_{1t} is a seasonal dummy for January, d_{5t} is a seasonal dummy for May. The α's are parameters.

Equation (1) was estimated by generalised least squares (GLS) considering fixed effects (α_{0i}) and a covariance matrix that considered cross sectional terms, given the heterogeneity of the panel. Note that the equation can be GLS because the prices are exogenously set by the

processors, and therefore, they are uncorrelated with the residuals. The estimation results are presented in Table 4.

Table 4: Fixed effects estimation of supply response

Dependent Variable: Log(Delivered milk)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.944	0.33	5.88	0.00
Milk price	0.604	0.10	6.13	0.00
Milk price t-1	-0.219	0.10	-2.21	0.03
Log(Delivered milk t-1)	0.707	0.03	27.45	0.00
Trend	0.013	0.00	7.18	0.00
Squared trend	-0.000	0.00	-7.39	0.00
Dummy January	0.038	0.02	2.19	0.03
Dummy May	0.076	0.02	4.03	0.00
Effects Specification				
Cross-section fixed (dummy variables)				
Weighted Statistics				
R-squared	0.999	Mean dependent variable		14.114
Adjusted R-squared	0.999	S.d. dependent variable		5.581
S.E. of regression	0.194	Sum squared residuals		29.140
F-statistic	30127.170	Durbin-Watson statistics		2.070
Prob(F-statistic)	0.000			
Unweighted Statistics				
R-squared	0.932	Mean dependent variable		10.793
Sum squared residuals	29.419	Durbin-Watson statistic		2.146

Source: Own elaboration based on SHMPA data.

All the variables are significant at 5 per cent significant and in addition, the residuals were tested for autocorrelation using the Breusch Godfrey test, rejecting the presence of autocorrelation.

A feature in Table 4 is particularly interesting and it is the negative value of the price lag. One could speculate that this could be either due to a reaction of the underlying informal sector to the adjustment in the formal sector price. This reduces the full effect of the increase of price. Unfortunately in the absence of data series for the informal sector, it is difficult to know how it responds to changes in processors' prices.

IV. Discussion

As shown in Hendry (1995), the AD(1,1) model encompasses a number of dynamic functional forms such as the partial adjustment model or the error correction model.

Particularly, given that all the parameters are significant, equation (1) can be rewritten in terms of an error correction equation, which is easier to interpret.

The error correction model from an equation such as (1) is given by (2), where the static solution of the model could be derived from the expression in brackets by equating it to zero. Table 5 shows equation (1) re-estimated as an error correction model.

$$(2)\quad \Delta\log\left(M_{t,i}\right)=\alpha_2\Delta\log\left(\frac{P_{t,i}^{M}}{P_t}\right)+(\alpha_1-1)\left[\begin{array}{c}\log\left(M_{t-1,i}\right)-\frac{\alpha_{0i}}{\alpha_1-1}-\frac{\alpha_4 t}{\alpha_1-1}-\frac{\alpha_5}{\alpha_1-1}t^2-\frac{\alpha_6}{\alpha_1-1}d_{1t}-\frac{\alpha_7}{\alpha_1-1}d_{5t}\\ -\frac{\alpha_2+\alpha_3}{\alpha_1-1}\log\left(\frac{P_{t-1,i}^{M}}{P_{t-1}}\right)\end{array}\right]$$

Table 5: Error correction estimation of the response

Dependent Variable: Δ(LOG(MILK))
Cross-section weights (PCSE) standard errors and covariance
Cross-section fixed

Parameters	Coefficient	Std. error	t-Statistic	Prob.
α_2	0.645	0.100	6.470	0.000
α_1	0.703	0.026	26.723	0.000
α_0^*	6.271	0.815	7.696	0.000
α_4^*	0.039	0.006	7.005	0.000
α_5^*	-0.001	0.000	-7.108	0.000
α_6^*	0.205	0.067	3.074	0.002
α_7^*	0.248	0.070	3.568	0.000
$\alpha_2^*+\alpha_3^*$	1.446	0.272	5.310	0.000

Weighted Statistics

R-squared	0.248	Mean dependent variable	-0.005
Adjusted R-squared	0.227	S.D. dependent variable	0.221
S.E. of regression	0.195	Sum squared residuals	28.862
F-statistic	11.429	Durbin-Watson statistic	2.071
Prob(F-statistic)	0.000		

Unweighted Statistics

R-squared	0.207	Mean dependent variable	-0.003
Sum squared residual	29.146	Durbin-Watson statistic	2.142

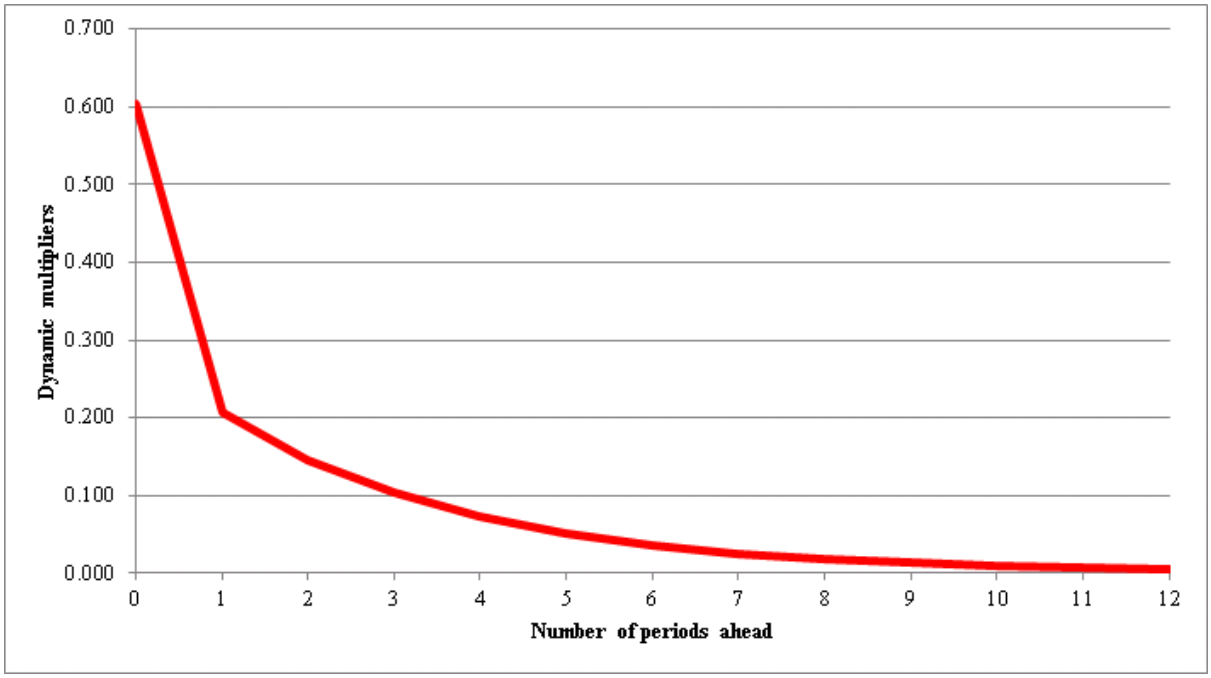
Note: * stands for the long term solution parameter in equation (2)

According to Table 5, the short term impact of an increase in the real price paid of milk is equal 0.645 (significant at 1 per cent), but in the long term that coefficient becomes 1.446 (significant at 1 per cent).

A nice feature of the error correction model is that the term in brackets can be interpreted as a disequilibrium. How rapidly $\Delta \log(M_t)$ converges to zero, i.e., to the equilibrium, depends on the value of $(\alpha_1 - 1)$, which is -0.29 (significant at 1 per cent).

Figure 3 provides the future impact of an increase in the real price of milk on the supply. The multiplicative effect exhibits a decay pattern. As shown in the figure the current period brings about 44 per cent of the full effect and after one month about 56 per cent of the effect.

Figure: Impact multipliers of output of the effect a current increase in price



Overall, the results indicate that the supply of milk that processors face is responsive to real increases of real prices (i.e., above the inflation rate), whilst in the very short term the impact is below the change in real prices (0.6), after three months the effect is above one (i.e., becomes price elastic).

The aforementioned result is interesting because it indicates that not only farmers' revenues would increase by more than the change in prices but also processors would not necessarily find their supply of raw materials diminish as farmers' milk could compensate at least part of the powder milk that they cannot import.

Whilst the above result is positive, it is important to note that further information is needed about the operation of the processing sector, namely their actual processing capacity and also their costs and their output prices. With this information it would be possible to deduce how

much the sector could expand, just based on domestic milk and how affordable the output could be in order to increase the affordability of milk to a wider population.

V. Conclusions

The purpose of this paper has been to measure the responsiveness of the deliveries of milk at the milk bulking groups to real prices paid to farmers (i.e., the elasticity of supply faced by processors). This was done using a unique dataset that comprises information by milk bulking group from January 2009 to February 2013.

Overall, the results indicate that farmers' supply of milk is price responsive. The price elasticity of the supply in the short term is equal to 0.6 whilst in the long term is 1.44. This indicates that farmers' revenues not only benefit from an increase in the price of milk but also from the increase in the quantity produced. Furthermore, it indicates the possibility that domestic producers could offset imports of milk powder by processors, although answer to this requires further research.

The negative value of the price lag in the equation in indicates that the long term effect is not as high as it could be. One could speculate that this could be due to the reaction of the underlying informal sector to an adjustment in the formal sector price. This could reduce the full effect of the increase of price, as some of the milk would be derived to the informal sector. Unfortunately in the absence of data series for the informal sector, it is difficult to know whether this is so.

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