Assessing the development strategies for the Malawian dairy sector: A spatial multimarket model

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Abstract

Dairy is a key investment sector for the Government of Malawi. The strategies proposed to develop the sector have been three: (1) reinforcement of the formal supply chain (i.e., farmers delivering milk to milk bulking groups and these to processors, who pasteurise it and transformed into a number of dairy products); (2) generation of mini dairies (i.e., micro-processing of milk delivered to a milk bulking

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group); (3) selling directly raw milk to consumers. The purpose of this paper is to explore the aforementioned strategies in terms of the sector economic growth and food security. To study them a spatial multimarket model was constructed for the Malawian dairy sector, which considers milk production in the three regions (North, Central and South), the different processors, consumers and the interaction with the informal market. The results from the simulation indicate that strategies (1) and (3) have more possibilities in terms outcomes than strategy (2). The paper also explores potential roles for the Government and donors.

Keywords: Dairy sector, Malawi, multimarket model, formal dairy market, informal market.

I. Introduction

Dairy is a key investment sector for the Government of Malawi, and donors such Belgium, Japan, USA and the UK have also been committed to its development. Several value chain analyses (IMANI Consultants, 2004; CYE Consult, 2009; Kawonga et al, 2012; M-Livestock Consultants, 2013) have discussed strategies to improve the dairy sector performance and raise its contribution to poverty alleviation and food security.

The strategies discussed by the aforementioned analyses have been three: (1) reinforcement of the formal supply chain (i.e., farmers delivering milk to milk bulking groups and these to processors, who pasteurise it and transformed into a number of dairy products); (2) generation of mini dairies (i.e., micro-processing of milk delivered to a milk bulking group); (3) selling of non-pasteurised of good quality milk directly to consumers.

The first strategy is based on the idea that there is the need to increase milk production in order to expand processors' production and to reduce the idle capacity in their plants. The second strategy proposes that farmers' situation could be improved (i.e., to get better returns) if their cooperatives could directly pasteurise, package and market the milk (i.e., skipping processors) as processors have oligopsony power and keep milk prices low for farmers; the third one, aims also at improving the returns of farmers but eliminates the need of pasteurising the milk, as this is to be sold raw to consumers such as in Kenya. This strategy also responds to the fact that it is not possible to curb the informal market for milk.

The purpose of this paper is to explore the impact that the aforementioned strategies could have on the sector economic growth and food security. This is motivated by the fact that the three strategies may have different effects on the smallholder agriculture (more than 80 per cent of the dairy production in Malawi is in the hands of smallholder farmers) and they imply different roles for government policy and governance of the dairy sector.

To study the aforementioned alternatives a spatial multimarket model was constructed for the Malawian dairy sector, which considers milk production in the three regions (North, Central and South), the different processors, consumers and the interaction with the informal market in each region. Multimarket models have a long tradition in partial equilibrium modelling and particularly in policy evaluation in agricultural sectors (Braverman and Hammer, 1986 and Sadoulet and De Janvry, 1995 for a review of models). They provide a way to represent the most important markets affected by a policy, leaving aside other markets where the effects of the policy would be negligible. An example of their use in an African dairy market can be found in Kaitibie et al. (2010), where it is used to study the effect of the policy change in the Kenyan dairy sector.

The results indicate that assumptions of strategies (1) and (2) may be flawed. Moreover, there is enough production of milk for the formal market to operate at full capacity; however, the major constraint is the demand for dairy domestic products given the low purchasing power of most of the population. Micro dairies suffer from two problems: first, efficiency in the pasteurisation of milk in comparison with processors, and second, the fact that they cannot offer higher prices to farmers (at least initially) because of they are concentrated on low value added products. Due to the latter, they cannot expand the supply of affordable of milk products for the population. Strategy (3), whilst has the potential of expanding the supply of low price milk to consumers, and therefore, improve food security, requires figuring out how to ensure that good quality milk is delivered to consumers.

The structure of the paper is as follows: it starts providing a brief overview of the dairy sector in Malawi. This is followed by a description of the multimarket model used to simulate the development strategies. Next, the empirical section of the paper presents the data, how the three strategies are implemented and the methods used to calibrate the parameters of the multimarket. The next section presents the results of the model and the final section provides the conclusions.

II. A brief overview of the Malawian dairy sector

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, according to the livestock census, the total figure for zebus (meat animals) for 2014 was estimated at 82,964 cows for Malawi, of which the North region had 31 per cent, the Centre 38 per cent and the South 31 per cent. The non-zebu animals (crosses and pure breed) were estimated in 42,293 cows of which, 8.4 per cent were in the North, 19.5 per cent in the Centre and 72.1 per cent in the South.

The Malawi livestock census also allows estimating milk yields per cow. The figure for zebus (meat animals) for 2014 was estimated at 0.195 kg/head/year and these were the same for the three regions. The milk yields of non-zebu animals were estimated 1.149 (about 6 times the yields of zebus) of which, 1.336 kg/head/year was in the North, 1.376 kg/head/year was in the Centre and 1.006 kg/head/year was in the South region.

Concerning milk production, the total production of milk for 2014 was estimated by the Malawi livestock census in 64,747 tonnes, of which about 25 per cent were produced by the zebu cows and the remaining by the non-zebus. Most of the production is located in the South, which represented in 2014 about 58 per cent of the total production; the Centre and the North region represented about 27 per cent and 15 per cent, respectively.

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 (Revoredo-Giha and Renwick, 2016).

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, 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 (Revoredo-Giha and Renwick, 2016). 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 (Revoredo-Giha and Renwick, 2016). 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.

The MBGs are cooling centres where farmers within a radius of 8-10 km deliver their milk to keep it cool and for processors to collect the milk. In the past, these were local farmer associations; however, since 2009 an emerging group of independent MBGs has appeared (called 'traders') and now represent more than 50 per cent of milk delivery to processors in the South region. The MBGs are located around the three major cities (Blantyre, Lilongwe and Mzuzu) (Revoredo-Giha and Renwick, 2016). 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 2014, 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.

Dairy processing in Malawi is very limited in scale and extent. It stands between the farmers and their MBGs and the formal distribution system which comprises street vendors and shops of various scales. 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).

Figure 1, based on information from Revoredo-Giha and Renwick (2016), presents the estimated distribution of milk in Malawi for the period 1993 to 2013. The thick black line represents the total production of milk; the light gray line shows the evolution of the supply of milk to MBGs. The difference between the two lines represents size of the informal market, which clearly receives over 60 per cent of the milk produced (the grey dotted line measures the evolution of the size of the informal market as a percentage of the total production and it measured in the right vertical axis).

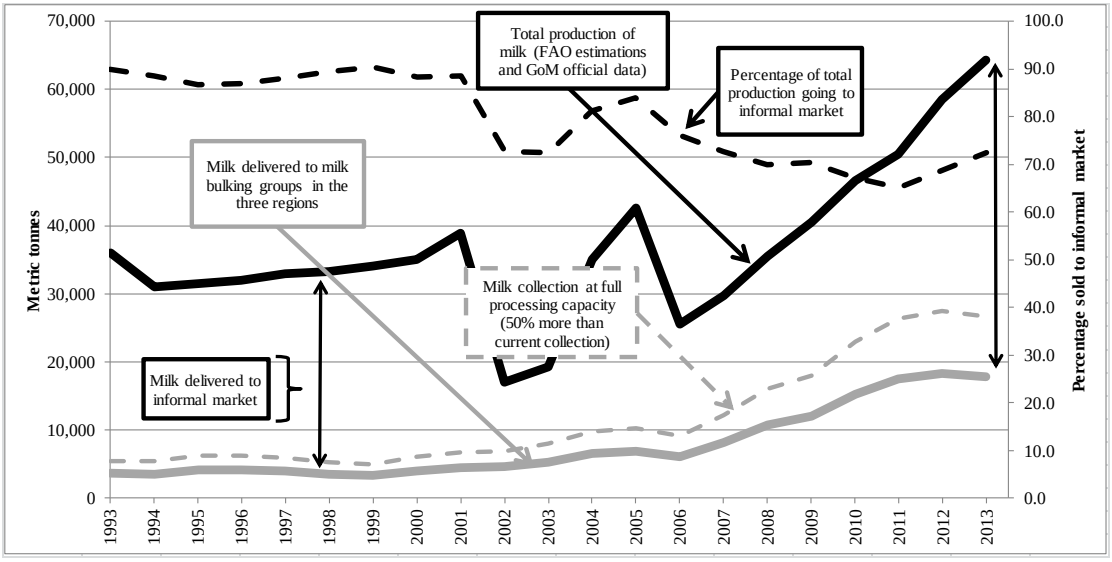

Figure 1 - Malawi formal and informal dairy market.
Source: Based on Revoredo-Giha and Renwick (2016).

An interesting implication coming from Figure 1 is that it would be possible for processors to expand their milk collection and to be operating at full capacity. This is shown by the grey dotted line above the actual milk collection; however, to reach this situation, higher prices paid to farmers would be needed and this would affect the different variables of the sector. This is something that will be explored later in the paper with the help of the multimarket model.

III. A multimarket model of the dairy sector

Let us consider the following partial equilibrium model for the Malawian dairy sector. The starting point of the model is the production of milk, which to simplify will be considered to come either from the native zebu or from other breeds (these include exotic breeds or mixed breeds). Hence, the supply of milk from zebus (Y_i^Z) from region i, where i=North (N), Central (C), and South(S). The total production of milk from zebus is given by equation (1).

$$(1) \qquad Y_i^Z = y_i^Z \cdot V_i^Z$$

Where y_i^Z is the milk yield per zebu in region i and V_i^Z is the number of zebus in region i. It is assumed in the model that all the milk coming from the zebus is consumed in the farms (i.e., it is not marketed). Therefore, this is presented in equation (2):

$$(2) \qquad C_i^Z = Y_i^Z$$

Y_i^Z can therefore be considered as milk going/consumed to the informal market. The next step is to characterise the supply of milk produced by non-zebu cows (Y_i^{NZ}). This is given by equation (3), which is analogous to equation (1).

$$(3) \qquad Y_i^{NZ} = y_i^{NZ} \cdot V_i^{NZ} = y_i^{NZ}\left(P^N, P_I^N, W^F\right) \cdot V_i^{NZ}$$

Where y_i^{NZ} is the milk yield per non-zebu cow in region i and V_i^Z is the number of non-zebus cows in region i. It is hypothesised that the yields are a function of the average price paid by the i MBGs (P^i), the price paid by the informal market in region i (P_I^i), and the price of inputs (W^F). The number of non-zebu cows is assumes to be exogenous, as in the past it has depended on donors, Government policy or the pass on programme.

In the Northern region it will be assume that all the milk from non-zebus will go to the milk bulking group (MDFA) (B_N), i.e., (4):

$$(4) \qquad B_N = \phi_N \cdot Y_N^{NZ} = \phi_N\left(P^N, P_I^N\right) \cdot Y_N^{NZ}$$

Where ϕ_N is the proportion of the production of milk from non-zebus in the North, which is a function that depends on P^i and P_I^N. Note that $\phi_N < 1$ because the remaining part goes to the informal market. All the milk collected in the North and pasteurised by MDFA is assumed to be sold within the region. This is given by (5):

$$(5) \qquad YP^{MDFA} = \alpha_{MDFA}\left(B_N\right)$$

Where α_{MDFA} is the proportion of the milk collected by the North milk bulking group for MDFA that is being pasteurised. It is expected that this proportion to be lower than 1 due to losses.

In the case of the Central region, the amount of milk that goes to the milk bulking groups which deliver to processor j (B_C^j) is given by (6):

$$(6) \qquad B_C^j = \phi_C^j \cdot Y_C^{NZ} = \phi_C^j\left(P_C^j, P_I^C\right) \cdot Y_C^{NZ}$$

Where ϕ_C^j is the proportion of the production of milk from non-zebus that goes to processor j in the Central region and j=Lilongwe Dairies (LD-1), Suncrest Creameries (SC-2), Dairibord Malawi (DM-3), Sable Farming (SF-4), MDI (MD-5). Similar nomenclature is used for the prices paid to farmers by processor j (i.e., P_C^j). Note that not all the ϕ's will be greater than zero as some of the dairy processors do not collect milk in the Central region. In addition, the sum of the ϕ's sums less than one, since part of the produced milk will find its way to the informal market. P_I^C is the price prevalent in the informal market.

The equation of the milk going to milk bulking groups in the South is similar to the Central region and given by (7):

$$(7) \qquad B_S^j = \phi_S^j \cdot Y_S^{NZ} = \phi_S^j\left(P_S^j, P_I^S\right) \cdot Y_S^{NZ}$$

The quantity of milk pasteurised by the processors (YP^j) is given by equation (8):

$$(8) \qquad YP^j = \alpha_j\left(B_C^j + B_S^j\right)$$

Where α_j is the proportion of the milk collected in MBGs for processor j that is being pasteurised. Note that α_j is lower than 1 because some of the milk is lost, and also the processors use part of the collected milk to other purposes (e.g., chambiko, liquid yoghurt, yoghurt, ice cream).

The total supply of pasteurised milk in region i (CP_i) is given by (9):

$$(9) \qquad CP_i = \sum_{j=1}^{J_i} s_i^j \cdot YP^j$$

Where s_i^j is the share of the production of pasteurised milk from processor j that it marketed in region i, where J_i is the number of processors selling in region i. Finally, note that the total consumption/purchases of pasteurised milk, can be in some cases understood as residual demand, are given by equation (10):

$$(10) \qquad CP_i = C_i - CM_i - CI_i$$

Where C_i is the total consumption of milk in region i, CM_i is the total consumption of powder milk and CI_i is the total consumption of unpasteurised milk coming from the informal market. It is assumed in the model that whilst processors can sell in several regions, the informal market can only sell milk within its region.

Note that the actual consumption of pasteurised milk depends on the retail price set for the product. This price, although suggested by processors, is ultimately set by retailers as shown in Akaichi et al. (2013). Therefore, the price paid by consumers, i.e., the retail price in region i, (P_i^R) is given by (11):

$$(11) \qquad P_i^R = P_i^{W,j} \cdot \left(1 + m_i^j\right)$$

Where m_i^j is the retail marketing margin set by retailers up over the basis of the prices proposed by processor j $P_i^{W,j}$.

Given the above expressions, the total size of the informal market (I) is given by (11):

$$(12) \qquad I = \sum_{i=N}^{S} Y_i^Z + (1-\phi_N) \cdot Y_N^{NZ} + \left(1 - \sum_{j=1}^{6} \phi_C^j\right) \cdot Y_C^{NZ} + \left(1 - \sum_{j=1}^{6} \phi_S^j\right) \cdot Y_S^{NZ}$$

The total milk marketed to the formal sector is equal to (13):

$$(13) \qquad M = \phi_N \cdot Y_N^{NZ} + \sum_{j=1}^{6} \phi_C^j \cdot Y_C^{NZ} + \sum_{j=1}^{6} \phi_S^j \cdot Y_S^{NZ}$$

Let us consider that the plant of capacity (i.e., engineering plant capacity) of processor j is equal to PC^j , then the observed idle capacity of processor j, as a ratio of the plant capacity, can be expressed as PC^j (13):

$$(14) \qquad IC^j = \frac{\left(\phi_C^j \cdot Y_C^{NZ} + \phi_S^j \cdot Y_S^{NZ}\right)}{PC^j}$$

The structure of the model presented in equations (1) to (14) is represented by Figure 2. Three features are important to highlight: The first one is related to the different types of consumers. These are those that demand milk of high quality (H), which comes from the formal sector (i.e., processors and retailers) and/or from imports; and those that consume raw milk from the informal market. The key difference between both groups is there income (i.e., their purchasing power is different). Moreover,

given the country's poverty level, the group that demands milk type L is much larger than the one that demands milk type H.

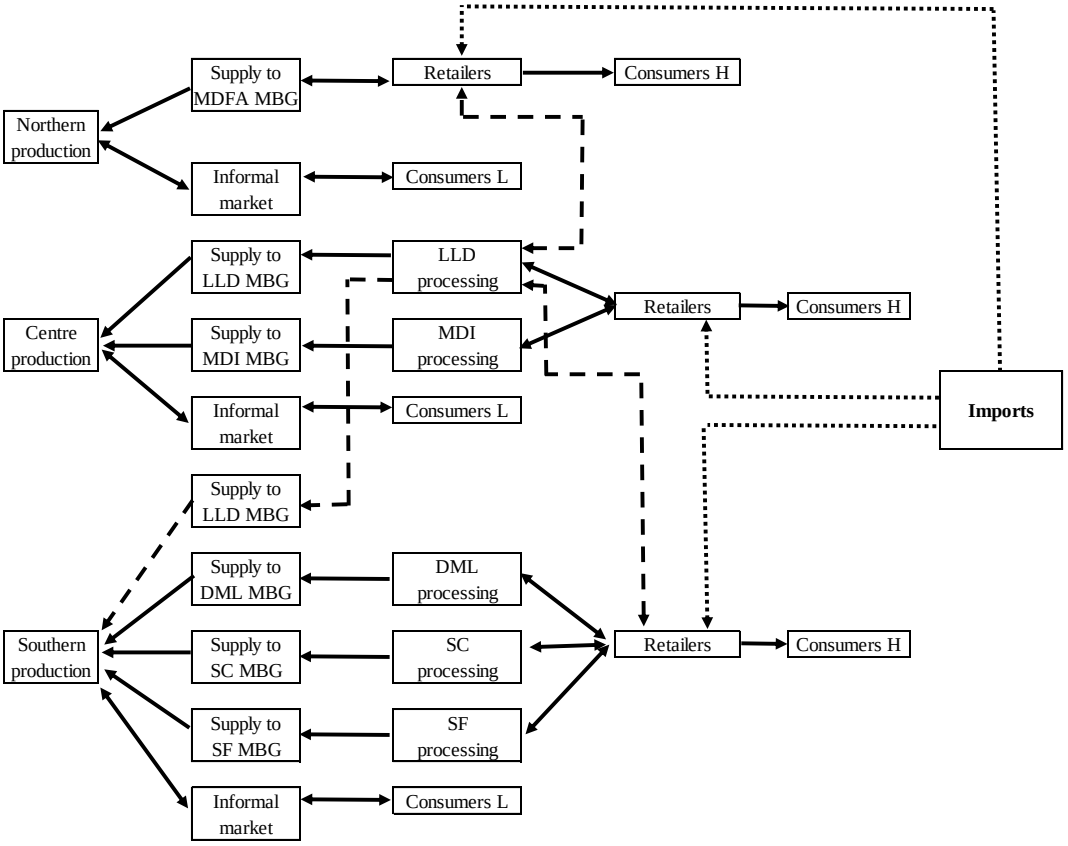

Figure 2. Overall structure of the model

The second feature is that Lilongwe Dairies, which is the most important processor in terms of volume, processes milk in the Central region; however, it collects milk from the South and Central region and they sell their products all over the country (their operations outside the Central region are represented by dashed lines).

The third feature is the fact that retailers' imports are destined to consumers who demand high quality, and therefore, imports compete with domestic processors products.

IV. Data, development strategies and calibration of the model

The purpose of this section is to provide a brief description of the data, the way that the different development strategies were going implemented and the approach to calibrate the behavioural relationships in the model such as the production of milk, the supply of milk to milk bulking groups and the demand for milk in the informal market.

IV.1 Data

The data used for the model were compiled from a number of sources and it is presented in Tables 1 to 3. The information on production, Table 1, is from the livestock census carried out by the National Statistical Office of Malawi. The information is broken down by Zebus (meat purpose animals) and Non-zebus (dairy animals), which is the adding up of pure breeds and crosses.

Table 2 considers the distribution of the total milk produced, shown in Table 1, and presents its distribution between the formal market (i.e., to the different processors) and the informal market. The source of these data was the information provided by the Malawi Milk Producers Association (MMPA), the Central Milk Producers Association (CREMPA) and the Shire Highland Milk Producers Association (SHMPA) (South region).

Note that in Table 2, due to lack of information, the milk going to the informal markets include all the milk produced and that was not been delivered to processors. Therefore, it includes, in addition, to raw milk that is delivered by to consumers by informal dealers, milk that remains at the farms or that it is lost.

Table 3 presents the average prices paid by processors to the MBGs and the prices received by farmers after deductions by the MBGs. The difference between the two prices covers the costs of the functioning of the MBGs as well as any training or inputs provided by the MBGs. The difference also contains inefficiencies in the running of the MBGs.

The source of these data is information collected by SHMPA on a monthly basis. To our knowledge there is no such information for the North or Central region (except on specific cases). However, the South region produces most of the milk that goes to processing (81 per cent of the total milk collection in MBGs in 2014).

Anecdotal evidence indicates that the prices in the Central region are similar to those in the South region, as expected by the fact that Lilongwe Dairies collects milk from both regions. The price paid by the MBG in the North region seems to be higher due to the difficulty to attract suppliers (anecdotal evidence indicates the price to be about 30 per cent higher than in the South; however, it represents less than 1 per cent of the collection).

Table 1: Milk production information by region and country

	Zebus 1/			Non zebus 2/			Total		
	Dairy cows Heads	Yield Ton/head	Production Tonnes	Dairy cows Heads	Yield Ton/head	Production Tonnes	Dairy cows Heads	Yield Ton/head	Production Tonnes
Northern region									
2010	22,301	0.195	4,341	2,699	1.407	3,798	25,000	0.326	8,139
2011	23,098	0.195	4,496	2,974	1.363	4,054	26,072	0.328	8,550
2012	23,808	0.195	4,635	3,316	1.303	4,320	27,124	0.330	8,955
2013	24,750	0.207	5,114	3,329	1.352	4,501	28,079	0.342	9,615
2014	25,720	0.195	5,006	3,535	1.336	4,723	29,255	0.333	9,729
Central region									
2010	25,881	0.195	5,041	4,610	1.306	6,021	30,491	0.363	11,062
2011	27,366	0.151	4,130	5,649	0.946	5,344	33,015	0.287	9,474
2012	28,499	0.195	5,548	6,579	1.328	8,735	35,078	0.407	14,283
2013	30,051	0.195	5,850	7,077	1.483	10,497	37,128	0.440	16,347
2014	31,546	0.195	6,141	8,253	1.376	11,358	39,799	0.440	17,499
Southern region									
2010	19,876	0.203	4,036	20,046	1.169	23,435	39,922	0.688	27,471
2011	19,768	0.219	4,328	23,860	1.541	36,768	23,860	1.722	41,096
2012	21,007	0.223	4,691	27,059	1.132	30,639	27,059	1.306	35,330
2013	23,436	0.195	4,562	28,595	1.183	33,816	28,595	1.342	38,378
2014	25,697	0.195	5,002	30,505	1.066	32,517	30,505	1.230	37,519
Total									
2010	68,058	0.197	13,418	27,355	1.216	33,254	95,413	0.489	46,672
2011	70,232	0.184	12,954	32,483	1.421	46,166	82,947	0.713	59,120
2012	73,313	0.203	14,874	36,954	1.182	43,694	89,261	0.656	58,568
2013	78,237	0.198	15,526	39,001	1.252	48,814	93,802	0.686	64,340
2014	82,964	0.195	16,149	42,293	1.149	48,598	99,560	0.650	64,747

Source: Based on Malawi Livestock Census.

Notes:

1/ Refers to the beef herd. Number of cows estimated based on FAOSTAT figures (6% of the difference of total zebu cattle minus slaughtables).

2/ Refers to the pure and crosses dairy cattle. Cows estimated as the difference between cattle minus slaughtables.

Table 2: Processors' and informal market shares by region 1/

	Processors' collection share (%) 2/							Informal sector share	Total
	MDFA	DML	LLD	SCC	Sable	MDI	**Total**		
	%							%	
Northern region									
2010	3.0	0.0	0.0	0.0	0.0	0.0	3.0	97.0	100.0
2011	3.3	0.0	0.0	0.0	0.0	0.0	3.3	96.7	100.0
2012	3.2	0.0	0.0	0.0	0.0	0.0	3.2	96.8	100.0
2013	1.8	0.0	0.0	0.0	0.0	0.0	1.8	98.2	100.0
2014	1.9	0.0	0.0	0.0	0.0	0.0	1.9	98.1	100.0
Central region									
2010	0.0	0.0	13.1	0.0	0.0	9.8	22.9	77.1	100.0
2011	0.0	0.0	23.7	0.0	0.0	7.6	31.3	68.7	100.0
2012	0.0	0.0	13.3	0.0	0.0	3.2	16.5	83.5	100.0
2013	0.0	0.0	8.1	0.0	0.0	2.6	10.7	89.3	100.0
2014	0.0	0.0	9.3	0.0	0.0	2.3	11.6	88.4	100.0
Southern region									
2010	0.0	19.5	28.6	8.6	1.3	0.0	58.0	42.0	100.0
2011	0.0	16.0	19.4	5.7	1.2	0.0	42.3	57.7	100.0
2012	0.0	17.7	27.6	6.9	0.9	0.0	53.1	46.9	100.0
2013	0.0	16.8	23.4	6.7	1.1	0.0	48.0	52.0	100.0
2014	0.0	14.0	25.5	16.6	0.4	0.0	56.5	43.5	100.0
Total									
2010	0.3	13.8	22.5	6.0	0.9	1.8	45.3	54.7	100.0
2011	0.3	12.7	18.2	4.5	1.0	0.9	37.6	62.4	100.0
2012	0.3	12.4	22.0	4.8	0.6	0.6	40.8	59.2	100.0
2013	0.2	11.6	18.0	4.7	0.7	0.6	35.7	64.3	100.0
2014	0.2	9.3	19.2	11.1	0.3	0.5	40.7	59.3	100.0

Source: Based on Malawi Livestock Census, SHMPA and MMPA data.

Notes:

1/ Shares with respect to the milk produced by the non-zebu herd.

2/ MDFA=Mpoto Producers Association, DML=Dairibord Malawi, LLD=Lilongwe Dairies, SCC= Suncrest Creameries, Sable=Sable Farming Company, MDI= MDI Lilongwe.

Table 3: Average price paid by processors and paid to farmers (Kwachas/litre)

	Dairibord Malawi Ltd.	Suncrest Creameries	Sable Farming Company	Lilongwe Dairies Ltd. South	Lilongwe Dairies Ltd. Central	Lilongwe Dairies Ltd. Total	MDI	Region Central	Region South	Total
Thousand litres										
2009	4,153	1,829	--	4,734	841	5,576	417	1,258	10,716	11,973
2010	4,660	2,045	312	6,817	805	7,622	598	1,403	13,834	15,237
2011	5,987	2,121	466	7,260	1,288	8,548	416	1,704	15,834	17,538
2012	5,521	2,143	286	8,614	1,179	9,792	287	1,465	16,564	18,029
2013	5,776	2,319	363	8,068	865	8,933	275	1,140	16,526	17,666
2014	4,621	5,493	141	8,447	1,073	9,519	268	1,341	18,701	20,041
Shares (%)										
2009	34.7	15.3	--	39.5	7.0	46.6	3.5	10.5	89.5	100.0
2010	30.6	13.4	2.0	44.7	5.3	50.0	3.9	9.2	90.8	100.0
2011	34.1	12.1	2.7	41.4	7.3	48.7	2.4	9.7	90.3	100.0
2012	30.6	11.9	1.6	47.8	6.5	54.3	1.6	8.1	91.9	100.0
2013	32.7	13.1	2.1	45.7	4.9	50.6	1.6	6.5	93.5	100.0
2014	23.1	27.4	0.7	42.1	5.4	47.5	1.3	6.7	93.3	100.0

Source: Based on data provided by MMPA, SHMPA and CREMPA.

IV.2 Implementation of the different development strategies

This section present the way that the different strategy alternatives, namely (1) strengthening the formal sector; (2) micro-processing; and (3) selling directly raw milk were implemented in the simulation.

Strengthening the formal sector

The assumption behind this strategy is that the way to strengthen the formal sector is by expanding the MBGs collection of milk (i.e., the milk supplied to processors) in order to reduce the idle capacity of processors, which should reduce processors' average costs by reducing the average fixed costs. However, in order to increase the milk collection, this simulation assumes that processors need to increase the price paid to farmers (through the MBGs) in such an amount that processors would operate at full capacity (about 50 per cent).

Micro processing

It is difficult to anticipate how this strategy would operate because although several MBGs have aspirations to become micro-processors of dairy products, the Government do not have a plan to proceed with the investment. The attempts to establish micro-dairies have been supported by international donors (e.g., JICA in the case of Bvumbwe).

In this simulation it has been considered that mini dairies are established in all the farmers' MBGs (disregarding the origin of the investment funds and the total costs, aspects that although are very important, no information is available). It should be noted that it is assumed that MBGs in the hand of traders will continue delivering to processors, which is consistent with the fact that in most of the cases processors

helped to establish those MBGs. In addition, it will be assumed, based on evidence observed at Bvumbwe cooperative (one of the few mini dairies that were in operation for a while) that mini dairies would be producing just pasteurised milk in plastic sachets. Thus, the price of the milk that consumers will pay is the paid price to famers plus the cost of pasteurisation and marketing. Furthermore, this also means that these MBGs will not be able to pay a high price to farmers because of the low value added of their final product (i.e., pasteurised milk).

As the transformation of farmers' MBGs to micro dairies, means that they cannot continue supplying processors. Under this scenario, it is assumed that processors increase the price they pay for milk in order to collect enough milk from the traders' MBGs. This is done by concentrating on products with higher added value.

Selling directly raw milk

This scenario consists of farmers selling directly raw milk to consumers. This situation would be such as in Kenya, where this is allowed. Strictly speaking this scenario is not very different to the current situation since there is no enforcement of the law against selling of raw milk.

To explore this scenario, it was assumed that the MBGs in the hands of farmers, stop collecting milk to deliver it to processors and instead they will just be in charge of supervising the quality of milk. It is because of this that the price of milk sold as raw milk will be lower than the current price paid for milk to farmers at the farmers' managed MBGs. As in the previous scenario, it is assumed that MBGs in the hands of traders continue supplying processors, and processors increase their price paid for milk in order to capture a higher quantity of milk, which goes to products with higher value added.

IV.3 Model calibration

As explained in the previous section, several of the possible results depend on how the different stakeholders react to changes in prices under the different scenarios. The purpose of this section is to briefly present the way that the main relationships were estimated/calibrated in the model. The relationships were calibrated using information available for 2014.

Production of milk

The aggregated production of milk for each region was calibrated using the positive mathematical programming approach (Howitt, 1995). The formulated dairy model consisted of deciding the quantity of feeding given to the dairy cows. The feeding is assumed to be purchased by producers and their quantity to have effects on the milk

yield per cow. Note that in this problem the number of cows was left as an exogenous variable.

The reason for above formulation of the dairy problem (in contrast of a more typical one where yields per cow are exogenous based on average yields and the farmer decides the number of cows to put under production) is due to the structure of the observed production in Malawi, where cows are given to producers either by donors, Government, and/or through the pass-on scheme; therefore, the number of animal in each farm is to some extent exogenous, farmers will collect all the milk produced by the animals. However, milk prices constrain the amount of purchased inputs that the farmers can buy affecting the yield per cow. The problem is one of a household production model and it can be more clearly appreciated in the following answer by Mr. Brian Lewis, advisor with the Shire Highlands Milk Producer Association interviewed in June 2013 to the question what the main driver for producers (e.g., more cows, better feeding, better training) was. He answered: "the main driver? is price, when the milk price is good, farmers want to produce, they feed their cows better, get their cows in calf quicker, everything works; there's money to pay for veterinary bills, to rear the heifers properly, the whole thing works. When the price of milk is poor everything is the opposite, farmers don't want to spend money on treatment for their cows, so the cows don't do very well, the heifers grow in four years instead of two years, the cows are producing eight litres instead of fifteen litres after they calf. It comes the time to do AI [artificial insemination] and they say I cannot afford it […] the fundamental thing is money".

The mathematical programming model is given by (15), which assumes that yields increase at decreasing rates with the amount of purchased inputs:

$$
\begin{aligned}
&\underset{C}{\text{Max}}\ \pi_i = P_i^F\left(\alpha_{0i} + \alpha_{1i}F - \alpha_{2i}F^2\right)V_i^{NZ} - w \cdot F_i \\
&\text{s.t.} \\
&w \cdot F_i \le \overline{M}
\end{aligned}
\qquad (15)
$$

Where π_i is the gross margin in region i, V_i^{NZ} represents the number of non-zebu cows, F_i is the quantity of purchased inputs, P_i^F is the average price received by the farmer, w is the purchased inputs price, $\overline{M}$ is the money constraint for the purchase of inputs, and α_{0i}, α_{1i}, α_{2i} are parameters of the average milk yield per animal.

Supply of milk to MBGs

Results from Revoredo-Giha et al. (2013, 2015) indicate that processors face a stable supply of milk that is responsive to prices and they set milk prices that are paid to

MBGs. Therefore, the inverse supply of milk faced by each processor was calibrated using information from Table 2 and Table 3 according to:

$$(16) \qquad \underset{B_j}{Max} \ \pi_j = P_j^W \cdot Q_j^R(B_j) - P_j \cdot B_j$$

Where P_j^W is the average wholesale price for processor j products. $Q_j^R(B_j)$ is the quantity of an aggregated retail dairy product (measure in milk quantity) made of the delivery of B_j milk; P_j is the price of milk paid by processor j. To simplify the problem, it will be assumed that $Q_j^R(B_j)$ can be expressed as $Q_j^R(B_j) = B_j/\lambda_j$, where λ_j is the conversion factor from milk to dairy products and $\lambda_j \geq 1$. The inverse supply of milk faced by processor j is assumed to be linear and equal to $P_j = \alpha_{0j} + \alpha_{1j}B_j$. Replacing the expression (16) becomes (17):

$$(17) \qquad \underset{B_j}{Max} \ \pi_j = P_j^W \cdot \left(\frac{B_j}{\lambda_j}\right) - (\alpha_{0j} + \alpha_{1j}B_j) \cdot B_j$$

Maximising processor j profits (17) with respect to B_j one obtains (18):

$$(18) \qquad P_j^W = (\alpha_{0j} + 2\alpha_{1j}B_j) \cdot \lambda_j$$

Combining (18) with the definition of P_j one obtains the calibrated values for α_{0j} and α_{1j} in terms of observed data:

$$(19) \qquad \alpha_{1j} = \frac{\frac{P^W}{\lambda_j} - P_j}{B_j}$$
$$\alpha_{0j} = P_j - \alpha_{1j}B_j$$

Demand for milk at the informal market

There is no information about the demand for milk at the informal market, besides anecdotal information, which indicates that the price is around the price of milk paid by the MBGs for milk, in some cases somewhat higher and in other cases lower (Chitika, 2008). Due to this, it was assumed that the informal market is represented by a perfectly elastic demand where all the milk not being delivered to the formal market finds its way and the price is assumed to be equal to the average price paid by the MBGs of the region.

V. Results and discussion

The full model, together with the calibrated relationships, was implemented in a MS Excel Workbook and solved and simulated with the aid of Visual Basic routines.[2] The results are presented in Table 4, which considers the baseline result (2014 situation) and three discussed strategies/scenarios: strengthening the formal sector ("Formal market"); micro processing ("Micro dairies"); and selling directly raw milk ("Raw milk market"), which presented below:

Strengthening the formal sector

The column "Formal market" in Table 4 presents the results for strengthening the formal sector. As shown in the Table, producers are encouraged to deliver more milk to the processors through higher prices. The milk collection increases by about 50 per cent.

The higher prices paid by processors not only increase the collection of milk by MBGs but also encourage a rise in the total production of milk in the three regions. Production in the South increases the most with respect to the baseline (14.1 per cent). This compensates the reallocation of milk from the informal to the formal market such that the milk destined to the informal market still grows.

The growing in the production of milk implies that the per capita consumption of raw milk and processed milk (from domestic origin) will increase (note that the high socioeconomic group in urban areas also consumes imported dairy products). In the case of the raw milk, this is due to the fact that surplus milk will go the informal market.

Note that wholesale prices of processed products will increase due to the rise in the cost of the milk (processors are paying a higher price for it); however, it could be expected that not all of this cost will be passed to urban consumers (they make the demand for processors) due to the fact that the expansion of production will reduce the average fixed costs, which are currently high due to idle capacity. It is important to point out that under this scenario it being assumed that the additional production by processors will be sold at high prices (if not in the domestic market, probably abroad in the neighbour countries).

A potential role for Government and donors under this scenario is to improve the public infrastructure (e.g., roads, energy), which certainly would provide positive externalities and reduce the operational costs of the dairy processors. Although, not simulated, this could bring an expansion of the domestic dairy industry.

[2] The simulation workbook is available from the authors upon request.

Table 4: Results from the simulation

Summary of variables	Baseline 1/	Development strategies					
		Strategy (1) Formal market		Strategy (2) Micro dairies		Strategy (3) Raw milk market	
		Result	Change 2/	Result	Change 2/	Result	Change 2/
Total non-zebu production of milk (tonnes)							
North	4,723	4,917	4.1	4,723	0.0	4,444	-5.9
Centre	11,358	12,254	7.9	11,597	2.1	9,552	-15.9
South	32,517	37,109	14.1	34,601	6.4	32,842	1.0
Average price paid to farmers (2014 Kwachas/ltr)							
North	147.0	169.0	15.0	154.0	4.8	133.0	-9.5
Centre	114.1	140.1	22.8	123.2	8.0	107.6	-5.7
South	113.9	149.4	31.2	147.6	29.6	119.0	4.5
Per capita consumption of domestic milk - raw (kg/year) 3/							
Malawi	1.9	2.7	42.3	1.6	-13.2	2.3	21.8
Per capita consumption of domestic milk - processed (kg/year) 3/							
Malawi	45.6	67.8	48.8	26.8	-41.2	27.0	-40.7
Total demand for milk - processors							
North	90	135	49.6	90	0.0	0	--
Centre	1,316	1,920	45.9	0	--	0	--
South	18,361	27,349	49.0	11,535	-37.2	11,728	-36.1
Demand for milk - farmers MBGs 4/							
North - MDFA	90	135	49.6	90	0.0	0	--
Centre - Lilongwe Dairies	1,316	1,920	45.9	1,408	7.0	0	--
South - Lilongwe Dairies	4,962	7,240	45.9	5,309	7.0	0	--
South - Dairibord Malawi	4,439	6,803	53.2	4,811	8.4	0	--
South - Suncrest Creameries	2,530	3,796	50.0	2,736	8.1	0	--
South - Sable Farming	138	207	50.0	138	0.0	332	140.0
Demand for milk - traders MBGs							
South - Lilongwe Dairies	3,331	4,859	45.9	6,439	93.3	6,439	93.3
South - Dairibord Malawi	97	149	53.2	245	151.9	245	151.9
South - Suncrest Creameries	2,863	4,295	50.0	4,712	64.6	4,712	64.6
Total supply to the informal sector (tonnes)							
North	4,633	9,788	111.3	4,633	0.0	4,444	-4.1
Centre	10,042	16,825	67.5	10,188	1.5	9,552	-4.9
South	14,156	14,412	1.8	10,211	-27.9	21,114	49.1
Average wholesale price (Kwachas/ltr) 5/							
North	194.0	200.8	3.5	213.4	10.0	--	--
Centre	181.7	199.1	9.6	206.0	13.4	--	--
South	200.3	220.7	10.2	272.6	36.1	219.8	9.7

Note:
1/ Corresponds to the 2014 situation.
2/ Change with respect the baseline.
3/ Raw milk comes from the informal market and is consumed in rural areas and by 80% of the urban population.
4/ In the case of strategies 2 MBGs operate as microprocessors and strategy 3 MBGs do not collect milk only check quality.
5/ Processors' price.

Micro processing

Under this scenario the mini dairies will compete with processors on the supplies of milk. As explained, all the farmers-managed MBGs are assumed to become micro

dairies. It is important to note that under the assumption that they will only produce pasteurised milk (low value added product) these MBGs cannot afford to pay high prices to farmers for the raw milk. However, as they slightly increase the payments to farmers, there is a small rise in the milk collected by those MBGs (about 7 per cent).

The scenario also shows that processors increase substantively their collection from traders' MBGs due to their higher prices. This is needed due to the fact that otherwise they have an enormous increase in their idle capacity, which was estimated in 30 per cent in the baseline scenario. Nevertheless, as shown in Table 4, their collection is down due the loss of the farmers' MBG. This situation affects particularly Dairiboard Malawi, which depended to great extent of farmers' MBGs for their milk collection.

It is highly probably that under this scenario, processors will decide not to produce anymore pasteurised milk and they just concentrate on products with more value added. This (and also the fact that the change in situation will increase their costs) is expressed on the rise in their wholesale price. In the medium term, there is the possibility that processors will expand the number of MBGs under traders in order to capture more milk.

Under this scenario, it is expected that the consumption of the per capita milk will decrease in both the raw milk and the processed milk market. The decrease in the raw milk market is because the product micro dairies is pasteurised milk, which is more expensive than raw milk and can only be afforded by the more affluent group.

It should be mentioned although it is not capture in the model that there is the implicit assumption that the micro dairies will successfully make the transition from collecting milk to processing and marketing it. This is a very important assumption as experience shows in the case of the Bumbwe cooperative, which stopped operating in 2012 due to low margins, management problems and the inability to satisfy food safety standards (M-livestock consultants, 2013). For this scenario to succeed, Government and donors will require significant investment not only on the facilities but also on training (including business management) to ensure the sustainability of the enterprise.

Selling directly raw milk

The results of this scenario show that farmers' MBGs will stop collecting milk but will be in charge of controlling milk quality, whilst traders' MBGs will continue supplying processors. In this sense, the scenario has commonalities with the micro dairies scenarios.

Under this scenario, farmers would be selling directly raw milk avoiding the cost of pasteurising (milk will be boiled by households). Urban households, who can afford

it, will probably substitute pasteurised milk by imported dried milk and the remaining of the urban population will consume raw milk.

Processors are under this scenario to focus on dairy products with greater value added, which as in the previous scenario will increase wholesale prices. Furthermore, as show in Table 4, milk collection for processors will concentrate in the South of the country (assuming that in the short term no additional MBGs in the hands of traders are established).

Due to the fact that the prices for selling milk are lower it is expect that the aggregated production of milk will decrease, except in the South, where could be expect to remain at similar levels as in the baseline. Note that prices paid to farmers in the South are higher because processors will concentrate their milk collection there at high prices.

It should be noted that under this scenario the amount of milk sold raw increases, and therefore, the per capita consumption of milk of poor urban and rural population will also rise; whilst the per capita consumption of processed milk from domestic origin will decrease. This scenario shows a trade off between economic growth (via production of greater value added) and production destined to massive consumption (food security).

A role for the Government and donors under this scenario is to create the conditions to ensure that the quality of the milk that is sold is good and safe. Given the potential size of the informal market, this could be a laborious and expensive task. The lessons from the Kenyan process will be important under this strategy.

VI. Conclusions

The purpose of this paper has been to explore the different development strategies for the Malawian dairy sector in terms of economic growth and food security. The studied strategies have been three: (1) reinforcement of the formal supply chain (i.e., farmers delivering milk to milk bulking groups and these to processors, who pasteurise it and transformed into a number of dairy products); (2) generation of mini dairies (i.e., micro-processing of milk delivered to a milk bulking group); (3) selling directly raw milk to consumers.

To study the aforementioned alternatives a spatial multimarket model which considers milk production in the three regions (North, Central and South), the different processors, consumers and the interaction with the informal market was formulated. The model was calibrated using the available data up to 2014.

The results from the simulation indicate under the first scenario that if processors are able to increase the prices paid to farmers in order to expand their milk collection, it is

possible to expand both the amount of milk going to processed products together with the sales of raw milk (this is due to the fact that milk production reacts to prices). Under this conditions, market prices of dairy products (i.e., wholesale prices) are expected to increase due to the higher milk prices paid by processors but probably not as much as the increase in milk prices due to the reduction in processors' average fixed costs (i.e., due to the fact that there is a reduction in their idle capacity). The increase in the milk prices paid by processors is expected to raise the price of milk in the informal market (if the former is a reference or indicator for the latter) and therefore make milk less affordable in the informal market.

Under the second scenario, micro dairies, the situation indicates that production will remain basically the same except than in South due to the higher price paid by processors to traders' MBG to collect more milk. Micro dairies, which are an aspiration for farmers' MBG, will in the short term only be able to produce pasteurised milk, which has low value added and therefore pay farmers a low price for their milk. This will imply that production in the North and Central regions, will in the best case situation, remain the same (assuming that the micro dairies operate properly, which might be given past experiences, not very probable) and showing growth in the South.

The third scenario, allowing the selling of raw milk, it is similar to the second scenario, the difference is that farmers' MBG will only have the role of supervising the quality of milk; therefore, the price paid of raw milk will expected to be lower. Due to this, the production of milk might be expected to decrease in the North and Central regions and increase in the South. The amount of raw milk consumed is, as expected, found to increase. The scenario will therefore imply a substitution of pasteurised milk for raw milk at lower prices. This could improve food security of those consuming raw milk.

Overall, what strategy should Malawi follow in terms of dairy development? The results from the exercise indicate that either the development of the formal sector or the following the Kenyan approach have possibilities, since micro dairies would require a potential high investment and will bring a very uncertain outcome.

It is important to note that given the size of the informal market, selling directly raw milk to consumers is an option that it is already present. This means that the current situation is something in between the first and the third scenario. In this context, probably the role of the Government and donors should be to ensure that the raw milk that it is sold in the informal market it is of good quality and the formal dairy sector benefit with improvement of infrastructure (particularly roads and electricity power), which will reduce their costs.

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