Inferring the big picture from data: Combining different data sources to understand the operation of the dairy sector in Malawi

Cesar Revoredo-Giha, Luiza Toma and Faical Akaichi
Scotland's Rural College, Land Economy, Environment and Society Research Group
SRUC, King's Buildings, West Mains Road,
Edinburgh, United Kingdom
cesar.revoredo@sruc.ac.uk, luiza.toma@sruc.ac.uk

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 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 using census data and milk collection data, 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.

1. 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 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 with the description of the multimarket model used to simulate the development strategies and the data. The next section presents and discusses the results of the model and the final section provides the conclusions.

2. 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):

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

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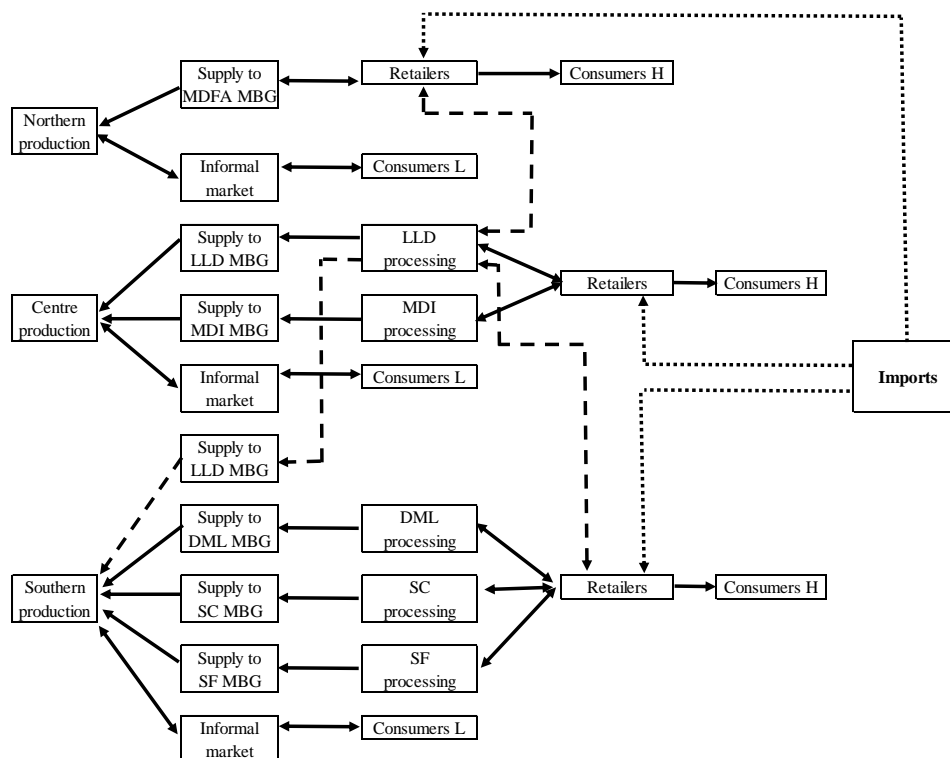
The second feature is that Lilongwe Dairies, which is the most important processor in terms of volume, processes milk in the Central region; however, it collects milk from the South and Central region and they sell their products all over the country (their operations outside the Central region are represented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

The data used for the model were compiled from a number of sources (Revoredo-Giha and Toma, 2016). The information on production, were from the livestock census carried out by the National Statistical Office of Malawi. The information was broken down by Zebus (meat purpose animals) and Non-zebus (dairy animals), which is the adding up of pure breeds and crosses. The distribution of the total milk produced was from 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).

3. Results and discussion

The full model was implemented in a MS Excel Workbook and solved and simulated with the aid of Visual Basic routines. The results are presented in Table 1, 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:

Table 1: 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.

3.1 Strengthening the formal sector

The column "Formal market" in Table 1 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.

3.2 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 1, 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.

3.3 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 1, 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. In addition, 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.

4. Conclusions

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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