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Measuring the Degree of Integration on the Dairy Products Market in Malawi

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Contributed Paper prepared for presentation at the 89th Annual Conference of the Agricultural Economics Society, University of Warwick, England

13 - 15 April 2015

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Abstract

The purpose of this study was to analyse, using monthly data for the period 2006 – 2011 the degree of spatial market integration in Malawi considering two dairy products sold in the major four towns of the country. The analysis of spatial market integration is important, in order to assess the need to re-establish a dairy industry in the Northern part of the country. The empirical analyses comprised of the following steps. First, integration between prises from different regions were tested using Johansen's cointegration procedure, with the results indicating that in the long run prices in all the areas move in a similar direction. Second, two spatial equilibrium models were estimated a three regime bivariate threshold vector autoregressive model (TVAR) and a three regime Threshold vector error correction model (TVECM). The results suggested that transaction costs were not important between areas and therefore northern Malawi does not need to re-establish a dairy as surplus areas (Central and South) can supply it.

Keywords: Dairy products, Malawi, Spatial price transmission, TVAR, TVECM
JEL codes: Q10, Q11, Q18

1. Introduction

In 2012, Northern Malawi's only dairy- Northern Dairies Industries, went out of business after a long period of production problems (Revoredo-Giha et al., 2013), raising the question of whether prices of dairy products would increase in this region in comparison to other parts of the country.

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

In the aforementioned context, the question is whether the Government and donors should continue promoting dairy processing in the North of Malawi, a region characterised by a far more diversified production structure (Revoredo-Giha, 2012). Thus, this paper aims to understand if prices for the different dairy products are integrated throughout Malawi's major towns, i.e., they move together and the law of one price is satisfied. If prices are integrated then this would provide some evidence to suggest that the North should not redevelop a dairy since this implies that trade operates well between surplus areas and deficit areas. In addition to this, an understanding is sought of the transaction costs associated with the trade of dairy products to the north. This would help to provide evidence of whether a dairy should be re-established on the basis of large transaction costs.

As the price series in the analysis were found to contain unit roots, the aim of this paper is therefore, to test if the price series are cointegrated for two dairy products (fresh milk, and powdered milk) based on their location in the country. The urban areas are: Lilongwe, Blantyre, Zomba and Mzuzu with Mzuzu being the Northern city of interest. The Johansen cointegration procedure will be used as this allows some inference on the number of cointegrating relationships within the data. In order to account for transaction costs both a Threshold vector autoregressive model (TVAR) and Threshold vector error correction model (TVECM) are used.

The structure of the paper is as follows: it starts with a literature review, next the data used in the analysis is then followed by the methodology. The final section presents and discusses the results which are followed by the conclusions.

2. Literature review

This literature review will cover three parts: Dairy market structure, dairy farms and milk consumption in Malawi. This paper is focussed on understanding if Northern dairy product prices move in a similar direction to the rest of the country. Yet, it is important to understand some of the background surrounding the dairy sector in Malawi as improved milk availability through increased production is an aim of the Malawian government (Revoredo-Giha et al., 2013a). Tebug et al (2012) highlights how low prices offered to northern farmers is one of the six constraints for production of milk in the area. Therefore if milk prices are not cointegrated between the north and rest of the country then this could imply that the law of one price does not apply and there are market distortions.

Three milk processors exist in different locations of the country with Dairibord marketing the majority of dairy products (approximately 70%) (Revoredo-Giha et al., 2013a). The main operations of Dairibord are located in Blantyre which is in the South of the country (Dairibord Holdings Limited, 2014). The remaining dairies are "Suncrest Creameries" which is located in Blantyre and "Lilongwe dairies" which is based in Lilongwe (central Malawi) (Revoredo-Giha et al., 2013a). "Northern Dairies Industries" ceased production in 2012 due to financial problems and was based in the northern town of Mzuzu (Revoredo-Giha et al., 2013a).

Despite the failure of Northern Dairies Industries, it seems that the North of the country has greater farm diversity (small holder farms) in terms of livestock ownership and proportion of land used for market crops relative to the rural South (Jones, Shrinivas et al., 2014). It would appear that the majority of breeds of cows used in the north are "exotic" relative to the central areas which tend to use cross breeds (Tebug, Kasulo et al., 2012). The major constraint for northern farmers from a recent survey is "unreliable supply of improved animal genetics" which arises through problems of importing semen for artificial insemination (Tebug, Kasulo et al., 2012). This highlights how the breed of cow is important to milk production in Malawi and provides evidence as to why central and southern regions have dairies in operation.

There is also some evidence to suggest that a major constraint to dairy farming in the North is due to the higher transport costs associated with the long distance between farm and milk bulking group (MBG) (Tebug, Kasulo et al., 2012). This may provide one of the reasons why the exit of "Northern Dairies Industries" occurred. Transport costs have been mentioned by Mtumbuka et al (2014) as affecting overall transaction costs in Malawi.

Tebug et al (2012) suggest that involving dairy processors from the rest of the country could improve the marketing of milk products for these northern farmers. However with the recent closure of "Northern Dairies Industries", MBGs may have been scaled back to reflect less industry demand for raw milk. It should be noted that farmers do not necessarily sell all their milk to MBGs as some will be consumed by their family and or sold in rural areas. According to the Malawian Milk and Milk products act (1990) (Milk and Milk products act (1990)) all milk products sold in urban areas must be sterilised but this rule does not apply to rural areas hence the ability for farmers to legally trade their milk in these areas without the need for MBGs and eventual dairies to sterilise the product.

With regards to consumption, Jones et al (2014) found from their survey the highest level of consumption of dairy products (out of all the rural regions) occurred in the north. Unfortunately similar information for the northern town of Mzuzu could not be sourced.

The Johansen co-integration tests used in Goodwin et al (2001) found that the market pairs of agricultural commodities (corn and soybeans) studied were mostly found to be cointegrated. The authors highlighted that the strong likelihood of cointegration indicated that there was likely a long run relationship between the markets of interest in the spatial price transmission study (Goodwin and Piggott, 2001). Goodwin et al (2001) used the augmented dickey fuller test for investigating the presence of unit roots in the time series data.

If the long run price relationships are cointegrated then an understanding can be sought regarding if threshold effects are present. This is because the long run relationship allows an understanding of whether the law of one price applies to the good in question and threshold effects allows for an understanding of the short term deviations (Lo and Zivot, 2001). The law of one price is mentioned briefly as the focus of this paper is on spatial market integration. Goodwin et al (2001) studied threshold effects which could be attributed to transaction costs using a threshold autoregression and threshold error correction models. Their study found interesting results such as the difference in price between two locations in North Carolina would have to differ by 3.8% before being out of the "neutral band" thus invoking price adjustments (Goodwin and Piggott, 2001).

A more recent study which looked at transaction costs between different markets in Tanzania using a TAR model found that the closer the two markets (Dodoma and Iringa) then the lower the transaction costs (Van Campenhout, 2007). The results from the study's TAR and TAR with trend both indicate that the linkages between Dodoma and Iringa have the lowest threshold value of respectively 2.15% and 2.63% (Van Campenhout, 2007).

From a policy perspective an understanding of whether the north should re-establish its dairy is important for reasons discussed. Another area of concern for policy makers is that a market which is not working "efficiently" can make desired aims of macroeconomic policy implementation more difficult to achieve (Barrett, 2005).

3. Data

The data for this study was provided by Malawi's National Statistical Office in the form of price indices (National Statistical Office of Malawi, 2013). For urban areas (Lilongwe, Blantyre, Zomba and Mzuzu) the following prices of products were formed: Fresh milk and Powdered milk. Data on other dairy related products were available such as Powdered milk-lactogen, cheese and margarine, yet these products are not the main focus of this paper. The data covers the years January 2006 until April 2011. Unfortunately more recent data is not available which could have accounted for the post closure of the dairy in the North. The data for fresh milk is produced by the MDI dairy which in 2011 was responsible for collecting 2.4% of milk bulking group raw milk (Revoredo-Giha, Leat, and Jumbe, 2013), therefore this milk product may not be considered representative of Malawian fresh milk. However, as this was the only fresh milk price data covered by Malawi's National Statistical Office it must be assumed that it was considered representative of other fresh milk price indices. As the powdered milk has a longer shelf life, it is assumed that this product is the more representative of all the dairy products in this study.

As is often the case, prices can grow exponentially over time, therefore natural logarithms have been created for both series (Verbeek, 2008: P297). Whilst the prices are in indices, this is acceptable for the threshold model used by Lo et al (2001).

Google maps provided data for the urban pairings in the form of table 1 (Google, 2014). Table 1 shows that the pairing of Mzuzu to Blantyre is furthest and takes the longest to complete by driving.

Table 1. Distances between main towns

Location pairs		Distance by road (km)	Google estimated driving time
Mzuzu to		-	-
	Lilongwe	358	4 hours, 36 minutes
	Blantyre	606	7 hours, 47 minutes
	Zomba	578	7 hours, 30 minutes

Source: Google Maps road distance search

Figures 1 to 2 show that in general product prices appear to be moving in the same direction with regards to their respective locations. Figure 1 does show a slight exception for the town of Zomba where in 2011 there was a relatively large reduction in the price of fresh milk. Figure 2 also shows a similar price reduction for the beginning of 2011 with regards to powdered milk sold in Mzuzu. Google (2014) provided the approximate distance time through their mapping service. This paper is not suggesting that the distance times are fully accurate but they offer an idea of how long dairy products would take to be transported. The authors of this paper did not visit Mzuzu while in Malawi hence why these times cannot be verified.

Figure 1. Urban fresh milk prices (see appendix)
Figure 2. Urban powdered milk –Anchor prices (see appendix)

4. Methods

4.1. Cointegration test

The conclusion of unit roots being present can be supported using the Augmented Dickey Fuller (ADF) test of different forms, such as including a time trend in addition to understanding the number of lags present. Both Goodwin et al (2001) and Abdulai (2000) used an ADF test though other unit roots tests such as the Philips-Perron unit root can be used. In order to determine the number of lags present in the ADF test, the Akaike's information criterion (AIC) can be used.

There are various methods for checking cointegration of the time series of interest. This study has chosen to use the Johansen procedure as it is quite likely that when using multiple time series, there is more than just one cointegrating relationship which exists (Verbeek, 2008:P358). Other studies have used the Johansen procedure to test for cointegration (Abdulai, 2000; Goodwin and Piggott, 2001). Essentially the Johansen procedure is comprised of a vector autoregressive model calculated by maximum likelihood method which allows for the number of cointegrating vectors (relationships) to be calculated (Verbeek, 2008). There is the suggestion that twelve lags are used for monthly data (Verbeek, 2008).

4.2. Threshold vector autoregressive model (TVAR)

The three regime bivariate (known as threshold multivariate) VAR model (TVAR), has been adapted from Lo et al (2001) study and created in R package "tsDyn" (Narzo, Aznarte et al., 2014). The general three regime TVAR is represented by equation 1 and has been adapted from Lo et al (2001).

$$p_{it} = \alpha^{(j)} + \phi_1^{(j)} p_{t-1} + \phi_2^{(j)} p_{t-2} + \cdots + \phi_k^{(j)} p_{t-k} + \epsilon_t^{(j)}, \text{ if } c^{(j-1)} \leq z_{(t-d)} \leq c^{(j)} \quad \textbf{(1)}$$

p_{it} represents the log price and location of the dairy product. k is the lag length and z_t represents the threshold variable. The delay parameter d has been highlighted by Goodwin et al (2001) and is equal to one in most applications. c represents threshold values and for the purposes of equation 1 and this study, only 2 values are calculated. Finally subscript j represents the threshold level which becomes apparent in equation 2.

A potential problem with using a delay parameter of one month (d=1) is that deliveries of fresh milk are unlikely to take place however as already stated in the data section, MDI dairy produce (fresh milk) a very low share of milk relative to other Malawian dairies. Yet for powdered milk, deliveries potentially could take place once a month as it can be stored for a longer time period.

The threshold values are subject to the three regimes (equation 2) whereby the model allows the share of observations in each regime to be calculated. Regime two is where observations lie within the two threshold values, while the other regimes give an idea of where observations deviate from the thresholds.

$$Regime\ 1: -\infty < v_{t-d} \leq c^{(2)}$$

$$Regime\ 2: c^{(2)} < v_{t-d} \leq c^{(1)}$$

$$Regime\ 3 c^{(1)} < v_{t-d} < \infty \quad \textbf{(2)}$$

Threshold two in the TVAR model has similarities to the "neutral band" of the threshold error correction model (TVECM) where observations which deviate from this regime would deviate from the equilibrium and thus be contained in other bands (Goodwin et al., 2001), yet the error correction model is not identical to the TVAR for brief reasons which will be discussed.

While the cointegration tests allows inference of long term price converges, the short term is where the TVAR model allows for an understanding of when deviations from the long term steady state appear (Balke and Fomby, 1997). The TVAR in equation 1 has similarities with the threshold error correction model (TVECM) of equation 3, yet the TVAR obviously

derives from autoregressive models (Lo et al., 2001). An alternative error correction model is the BAND TVECM whereby instead of the deviation returning to an "equilibrium point" it returns to a specified band (Balke and Fomby, 1997). However, there is the additional requirement placed on the cointegrating residuals such as remaining stable in outer bands and the middle regime not being cointegrated (Lo et al., 2001). Goodwin et al (2001) suggest that the TVAR condition of being symmetric can be restrictive and may imply that more observations are in the neutral zone relative to the TVECM. For this reason this paper will run both a TVAR and TVECM.

While Goodwin et al (2001)'s paper is concerned with both finding the threshold effects (in form of half life) and then performing a grid search in order to discover alternative regimes. This study is only interested in discovering the thresholds in order to understand if distance between locations increases the two calculated threshold values thus overall transaction costs. The TVAR model can use price indices as demonstrated by Lo et al (2001) with their application of using a monthly consumer price index in order to examine different household products such as meat prices between major US cities.

4.3. Threshold vector error correction model (TVECM)

The threshold vector error correction model (TVECM) is represented by three regimes with the regime one and three where observations would likely result in price transmission through "violation of spatial integration" (Greb et al, 2013). Equation 3 shows the three regimes of the TVECM and appears in Park et al (2007). The three regimes are represented by the Z_{t-d} which is the threshold variable. The error terms of the three regimes are assumed to equal one another. A lag of one was used based on the results of the ADF test from table 2.

$$\Delta P_t = \begin{cases} \theta_1 X_{t-1} + e_t^{(1)}, if \ -\infty = C^{(0)} \leq Z_{t-d} < C^{(1)} \\ \theta_2 X_{t-1} + e_t^{(2)}, \quad if C^{(1)} \leq Z_{t-d} \leq C^{(2)} \ and \\ \theta_3 X_{t-1} + e_t^{(3)} \quad , if \ C^{(2)} \leq Z_{t-d} \leq \ C^{(3)} = \infty \end{cases} \tag{3}$$

This paper acknowledges the problem of TVECM being possibly biased due to the selection of the trimming parameter which is whereby a minimum number of observations are set to be contained in each regime (Greb, von Cramon-Taubadel et al., 2013). However, this paper will continue to use the TVECM as it allows a comparison with Goodwin et al (2001)'s paper and

still allows for an understanding of thresholds. Greb et al (2013) discuss previous literature where the trimming parameter is set at between 15-20% of observations (observation made to be in each regime) which are described as potentially too high for small samples in well integrated markets. This study has set a trimming parameter value of 5% for most pairings. The only pairing which did not have this value was Mzuzu to Lilongwe, a value of 1% for powder milk was set as the model returned errors at 5%.

The TVECM is estimated using r package "tsDyn" and linear cointegrating parameter is estimated in the package (Narzo, Aznarte et al., 2014).

5. Results and Discussions

5.1. Cointegration test

The ADF test would imply that each price series shown in table 2 contains unit roots which are a condition for cointegration. The ADF test requires many steps in order to conclude that the data series is non stationary. The AIC selected one lag for each series, a manual approach could have been used but the AIC approach was felt to provide more consistency. All the data series were found likely to be integrated of the order of one I(1). In order to ascertain this, the last test required testing a null hypothesis of I(2) price series against the alternative hypothesis of a I(1) price series. The tau statistic concluded that the null hypothesis was rejected and the alternative hypothesis was accepted.

The Johansen cointegration test results (Table 3) for urban areas found it likely that four cointegrating vectors existed at 1% statistical significance level. This does provide evidence to suggest that there is a likely cointegrating relationship for the products with regards to their respective four markets (i.e. Lilongwe, Blantyre, Zomba and Mzuzu). This result helps to support the idea of the law of one price being applicable at least in the long run to these products in the different locations. However, it should be noted that the informal sectors of dairy marketing cannot be covered in this study owing to data constraints. The estimation of the cointegration of fresh milk raised a warning message and the test could not estimate the test statistic for first null hypothesis on there being zero vectors of cointegration. However, it seems very likely given the other null hypothesis results that the test statistic should allow rejection of the null hypothesis.

Table 2. Augmented Dickey Fuller test results

		Level Series Augmented Dickey Fuller (ADF) test statistic					First Differences ADF unit root test	
		tau value						
Product	Location	Constant & time trend	Constant	No constant or time trend	AIC Lag 1/	Type favoured	Unit root test statistic	Order of integration
Fresh milk	Lilongwe	-0.51	-1.99	1.61	1	No Trend or Drift	-5.43 2/	I(1)
	Blantyre	-0.85	-1.86	1.83	1	No Trend or Drift	-5.35 2/	I(1)
	Zomba	0.23	-1.45	-0.13	1	No Trend or Drift	-5.46 2/	I(1)
	Mzuzu	-1.49	-2.75	1.85	1	No Trend or Drift	-6.15 2/	I(1)
Powdered milk Anchor	Lilongwe	-1.60	-1.60	-1.41	1	No Trend or Drift	-5.66 2/	I(1)
	Blantyre	-3.34	-0.76	1.28	1	No Trend or Drift	-5.28 2/	I(1)
	Zomba	-2.03	-0.94	1.22	1	No Trend or Drift	-5.25 2/	I(1)
	Mzuzu	-1.66	-1.72	1.43	1	No Trend or Drift	-4.85 2/	I(1)

Notes:
1/ Akaike's Information Criteria (AIC) used for selecting lag length
2/ Denotes that H_0 I(2) is rejected in favour of H_1 I(1) in terms of order of integration (using tau statistic)
The ADF test requires use of other test statistics apart from tau, due to space constraints the other test statistics have not been included (such as phi)
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Table 3. Urban Cointegration tests

Johansen-Procedure: Maximal eigenvalue statistic (lambda max)

	Fresh milk				Powdered milk (anchor)			
Null	Without linear trend and constant				Without linear trend and constant			
Hypothesis	test	10pct	5pct	1pct	test	10pct	5pct	1pct
r <= 3	14.25	7.52	9.24	12.97	25.04	7.52	9.24	12.97
r <= 2	29.83	13.75	15.67	20.2	121.35	13.75	15.67	20.2
r <= 1	322.89	19.77	22	26.81	432.41	19.77	22	26.81
r = 0	NaN 1/	25.56	28.14	33.24	1164.1	25.56	28.14	33.24

Notes:
1/ "NaN" is a warning message displayed in "R" though it seems likely that the H_0 tests statistic for r=0 would be rejected at 1% statistical significance level
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

The cointegration results would imply that in the long run the theory of the law of one price holds which suggests that retailers price dairy products at a similar level. Yet, the

deviations from this level in the short term are where the threshold models are of particular interest, hence the focus of this paper on spatial market integration.

5.2 Threshold vector autoregressive and vector error correction models

The Urban threshold pairs are interested in the how the flows of dairy products go to the northern town of Mzuzu hence why all the pairings start with Mzuzu. In Goodwin et al (2001)'s paper the focus was on the main market trading town of Williamston for corn hence why this town was the last pairing as corn was being delivered there. The larger thresholds equates to larger transaction costs (Goodwin et al., 2001). Since Mzuzu is unlikely to be an exporter of dairy products it would not make sense to have it as the last pairing. There is the problem with the data range used as the most recent period is April 2011 which covers when "Northern Dairies Industries" was still in operation and this may have distorted the results slightly. However, it seems unlikely that "Northern Dairies Industries" were an efficient processor since it closed in 2012. Whilst table 4 & 5 show the TVAR and TVECM modelling results, graphical depictions of the TVAR results which help to illustrate the size of the thresholds can be seen in figures 3 to 8 in the appendix.

Table 4. Urban TVAR threshold values

Products	Market Pairs	Lower threshold value	Higher threshold value	AIC	BIC	Observations in each regime (%)		
						1	2	3
Fresh milk	Mzuzu - Lilongwe	5.80	6.18	-878.34	-810.33	21	64.5	14.5
	Mzuzu - Blantyre	5.80	6.14	-828.24	-760.18	21	50	29
	Mzuzu - Zomba	6.11	6.14	-766.45	-698.40	59.7	11.3	29
Powdered milk (anchor)	Mzuzu - Lilongwe	6.14	6.16	-785.77	-717.70	37.1	51.6	11.3
	Mzuzu - Blantyre	5.84	6.16	-727.26	-659.19	32.3	56.5	11.3
	Mzuzu - Zomba	5.50	6.13	-724.94	-656.88	32.3	56.5	11.3

Notes:
1/ Akaike's Information Criteria (AIC)
2/ Bayesian Information Criteria (BIC)
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Table 5. Urban threshold Vector Error Correction model results

Products	Market Pairs	Lower threshold value	Higher threshold value	AIC	BIC	Observations In each regime (%)		
						1	2	3
Fresh milk	Mzuzu - Lilongwe	-0.121	-0.002	-860.012	-804.707	8.10	80.60	11.30
	Mzuzu - Blantyre	-0.033	0.015	-813.055	-757.749	64.50	17.70	17.70
	Mzuzu - Zomba	-0.007	0.016	-769.027	-713.722	14.50	12.90	72.90
Powdered milk (anchor)	Mzuzu - Lilongwe	-0.019	0.143	-711.503	-631.290	36.10	47.50	16.40
	Mzuzu - Blantyre	-0.006	0.225	-713.822	-658.517	56.5	30.6	12.9
	Mzuzu - Zomba	-0.064	0.098	-737.164	-681.858	74.2	17.7	8.10

Notes:
1/ Akaike's Information Criteria (AIC)
2/ Bayesian Information Criteria (BIC)
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

The threshold values of urban fresh milk[1] (table 4) reveals that the largest gap between threshold values[2] is for the pairing: Mzuzu – Lilongwe. Yet in terms of where the majority of observations occur it would seem that the TVAR and TVECM have similar results. The relatively large thresholds may be a result of transportation costs. With regards to the frequency of observations for the pairing of Mzuzu – Lilongwe, the results suggest that the

[1] As fresh milk and powdered milk were found to dominate the dairy consumption shares of Malawians surveyed (Revoredo-Giha and Akaichi, 2013), the results from Table 4 are also available in the appendix in figures.

[2] Threshold value measured by subtracting high and low thresholds

majority of observations are in the middle regime (i.e. regime 2) which is likely to be a result of the towns being close to one another, hence possible market integration. This highlights how the thresholds alone should not just be covered. The TVECM frequency observation results would suggest that deviations from the equilibrium are not usually large enough to exceed regime 2 (Goodwin et al., 2001).

This was a similar result for the pairing of Cofield and Williamston in the study by Goodwin et al (2001) which were close in terms of distance and had a majority of observations in regime 2.

The Mzuzu – Blantyre pairing is where the two models return somewhat different results. The TVAR indicates that the majority of observations are within regime 2 which is in contrast to the TVECM which indicates regime 1. As the TVAR model is assumed to be symmetric this may have overestimated the number of observations occurring in the neutral band.

If more data were available then a more seasonal understanding could be formed as there is low output of fresh milk produced in the dairies of Lilongwe. In 2011, Lilongwe took deliveries of approximately 9.7% of total raw milk (from Malawian milk bulking groups), with the remaining share going to dairies based in the south of the country (including Blantyre) (Revoredo-Giha, Leat and Jumbe., 2013). This would imply that a relatively small volume of milk is produced in Lilongwe and there may be little available for Mzuzu thus the transaction costs being higher for Blantyre fresh milk products. It must be emphasised that MDI fresh milk (which the data is sourced from) is the smaller dairy in Lilongwe.

With regards to powered milk, it seems that the lowest thresholds (i.e. transaction costs) found in both the TVAR and TVECM is for Mzuzu to Lilongwe. In addition to this both models found that the majority of observations are in regime 2 which implies greater market integration (Greb, von Cramon-Taubadel et al., 2013). This result seems credible since the distance is shortest and powdered milk does not require refrigeration vehicles. A recent survey suggests that powdered milk represents the largest share of weekly consumed dairy products and is often imported (Revoredo-Giha and Akaichi, 2013).

Due to the dominance of powdered milk in the sampled Malawian diet this is an important result since transaction costs are lowest for this pair which suggests that the market is working efficiently. There is also the possibility that as powdered milk can be stored without refrigeration facilities then warehouses in Lilongwe are able to store the products thus involving lower transaction costs. The distance to the Northern towns would support this finding that greater distance results in greater transaction costs.

The TVECM results for the other pairings differed to the TVAR. While the TVAR reported that majority of observations were in regime 2, the TVECM found that for both pairings they were either in regime 1 or 3. A possible explanation for the TVECM result could be that if Lilongwe is unable to provide powder milk then Blantyre must provide the powder milk which as Greb et al (2013) explain, distorts the spatial equilibrium thus resulting in price transmission. This could possibly result in positive price transmission though more data would be required in order to support this hypothesis. However, both models conveyed a similar finding that the thresholds were larger for the Mzuzu to Blantyre or Zomba relative to the Mzuzu - Lilongwe pairing.

While some of these findings are similar to Goodwin et al (2001) of further distance resulting in higher transaction costs, there are some differences in terms of the modelling. The TVAR model used in this study offered basic results and would have been improved if a Tsay's test was available such as in the case of Goodwin et al (2001) though (Abdulai, 2000)'s study did not use this test. The general findings of transaction costs likely to be higher based on larger distances is supported by the findings Mtumbuka et al (2014) which found a similar situation occurring for the Malawian bean market.

6. Conclusions

Prices of dairy products are very likely to be cointegrated in all the main towns, which suggest that at least in the long run the law of one price applies. This suggests that the market is relatively competitive as retailers are pricing dairy products at a similar level across Malawi. However, this does only represent the long run and formal sector.

The transaction costs calculated in the form of the threshold values imply that for fresh milk in Mzuzu, the lower transaction costs occur when paired with Blantyre rather than closer Lilongwe. Yet, the majority of pairings for the TVECM were in neutral regime 2 which implies that the two markets are relatively well integrated. There is the concern regarding Lilongwe's capacity of milk production, more data would be required to understand the situation.

With regards to powdered milk (product which has lower consumer storage costs and lower transportation costs), the transaction costs are likely to be small for the pairing of Mzuzu to Lilongwe and the majority of observations in the TVECM were in the neutral band. This suggests that this is a relatively well integrated market pair and requires no intervention in the form of improved infrastructure. While the data range was not recent enough to include the closure of Northern dairies, it does suggest that northern Malawi does not require a dairy

provided that transaction costs can be reduced for fresh milk. Future work should consider the use of a regularised Bayesian estimator for understanding market integration.

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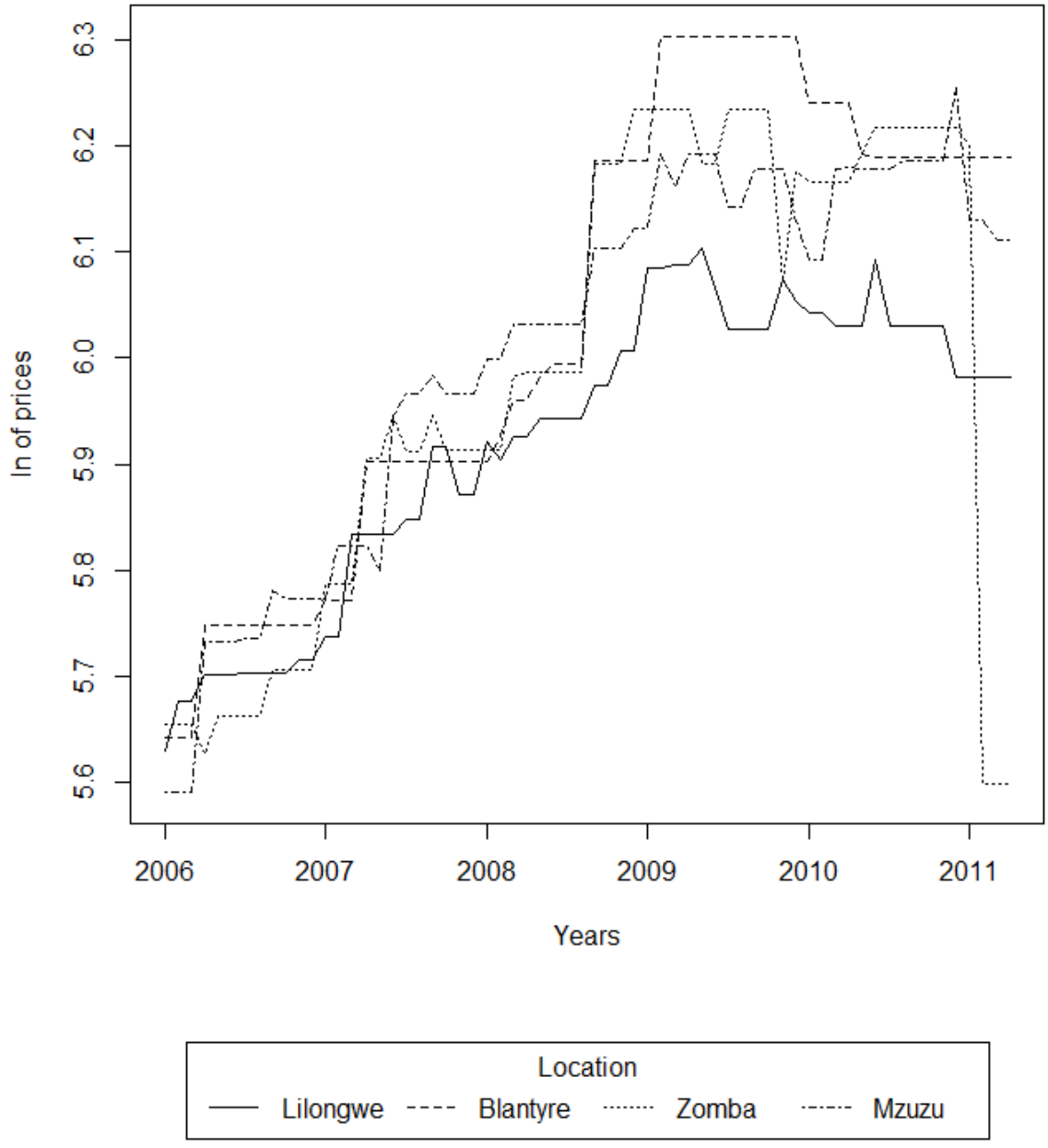
Appendix

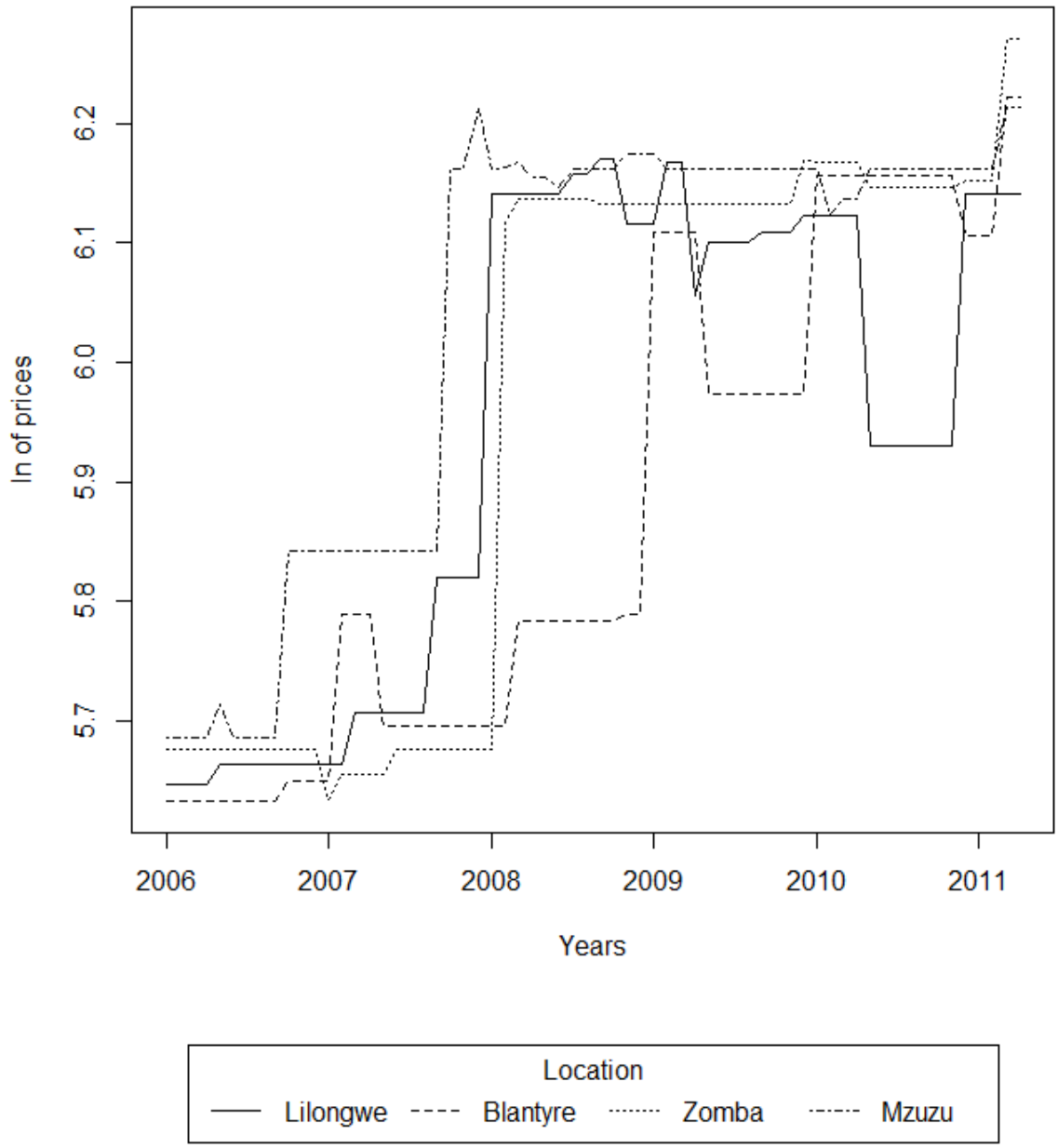
Figures

Figure 1. Urban fresh milk prices



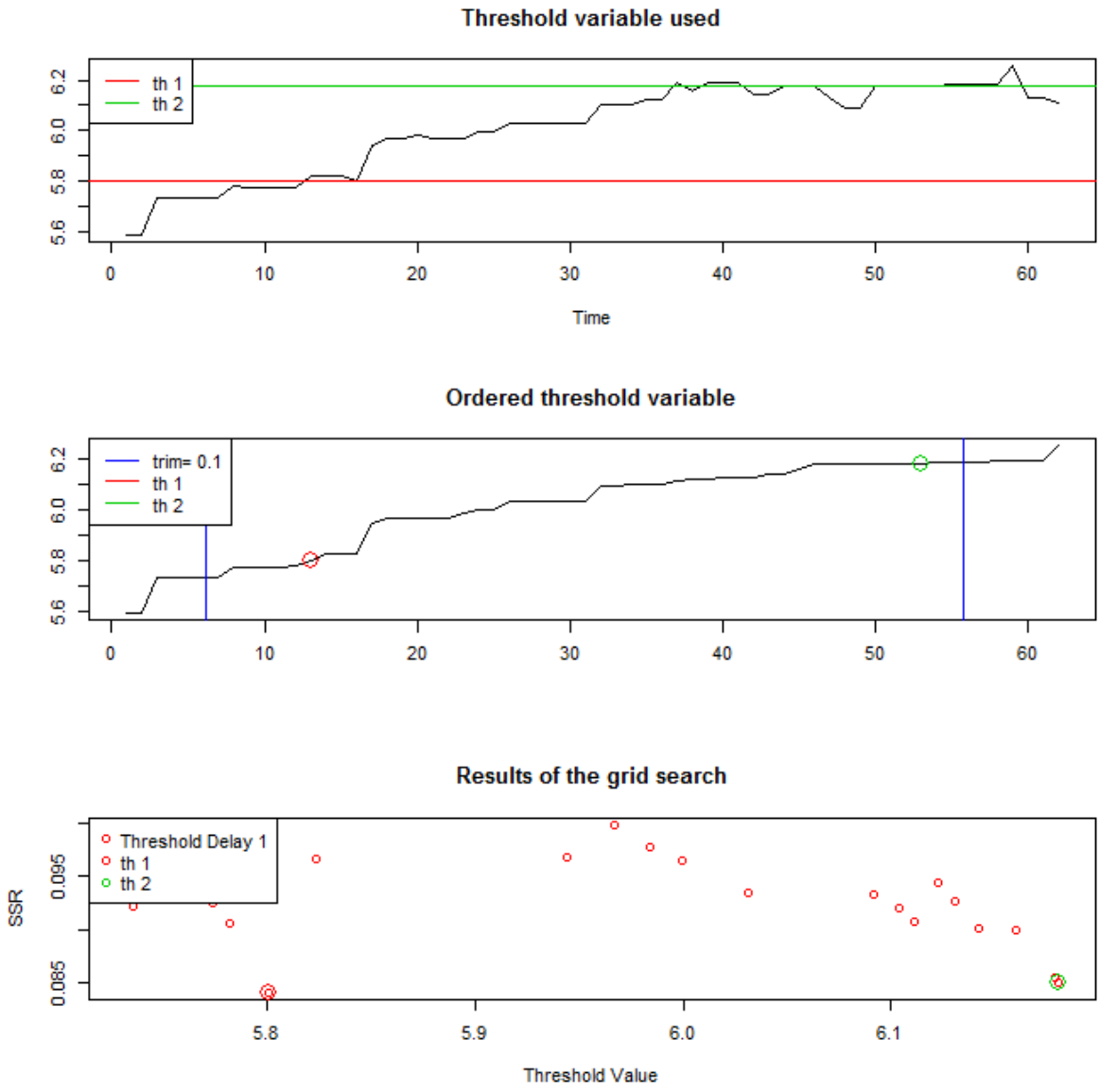
Source: National Statistical Office of Malawi

Figure 2. Urban powdered milk –Anchor prices



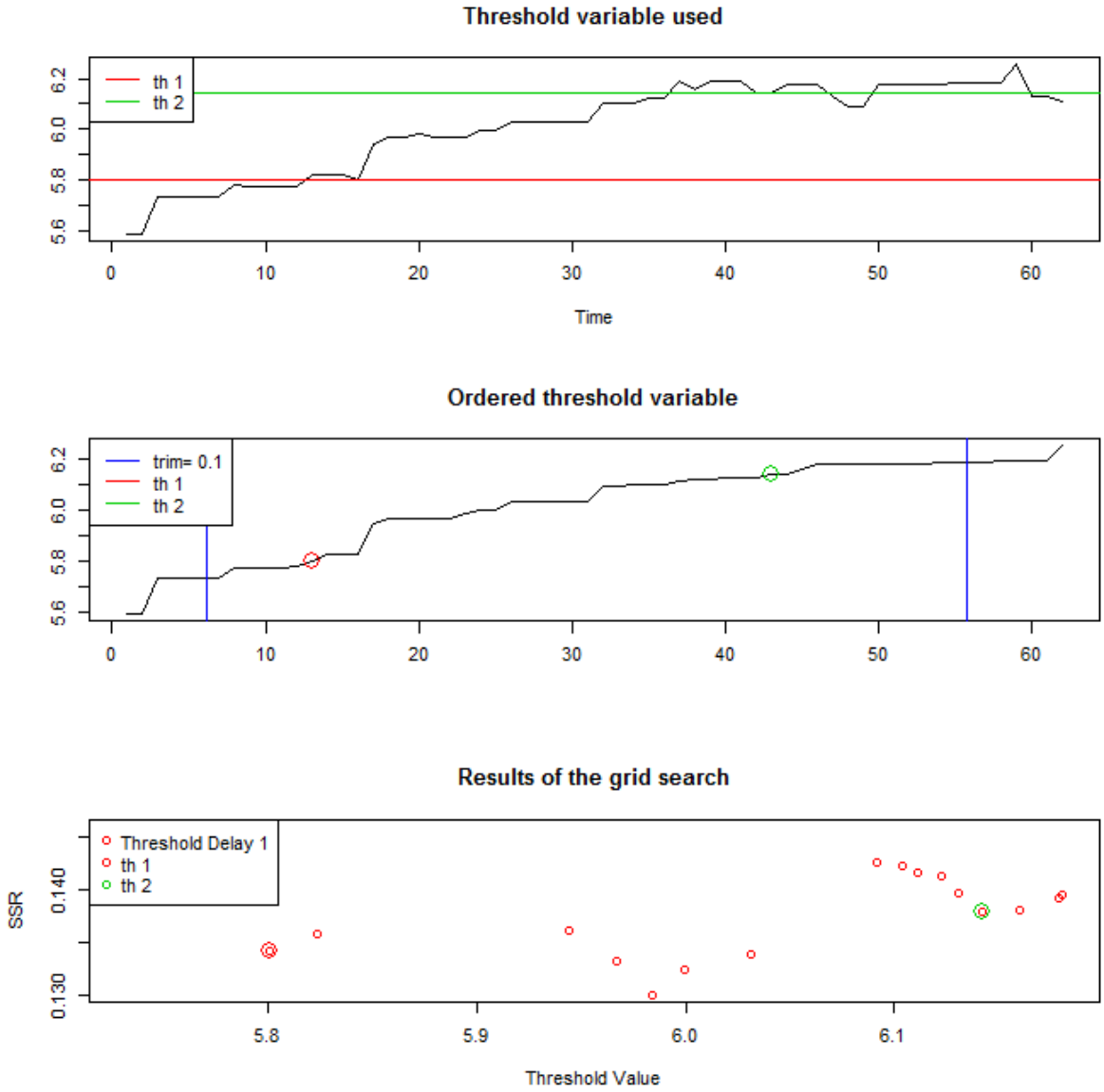
Source: National Statistical Office of Malawi

Figure 3. Fresh milk threshold graphs Mzuzu - Lilongwe



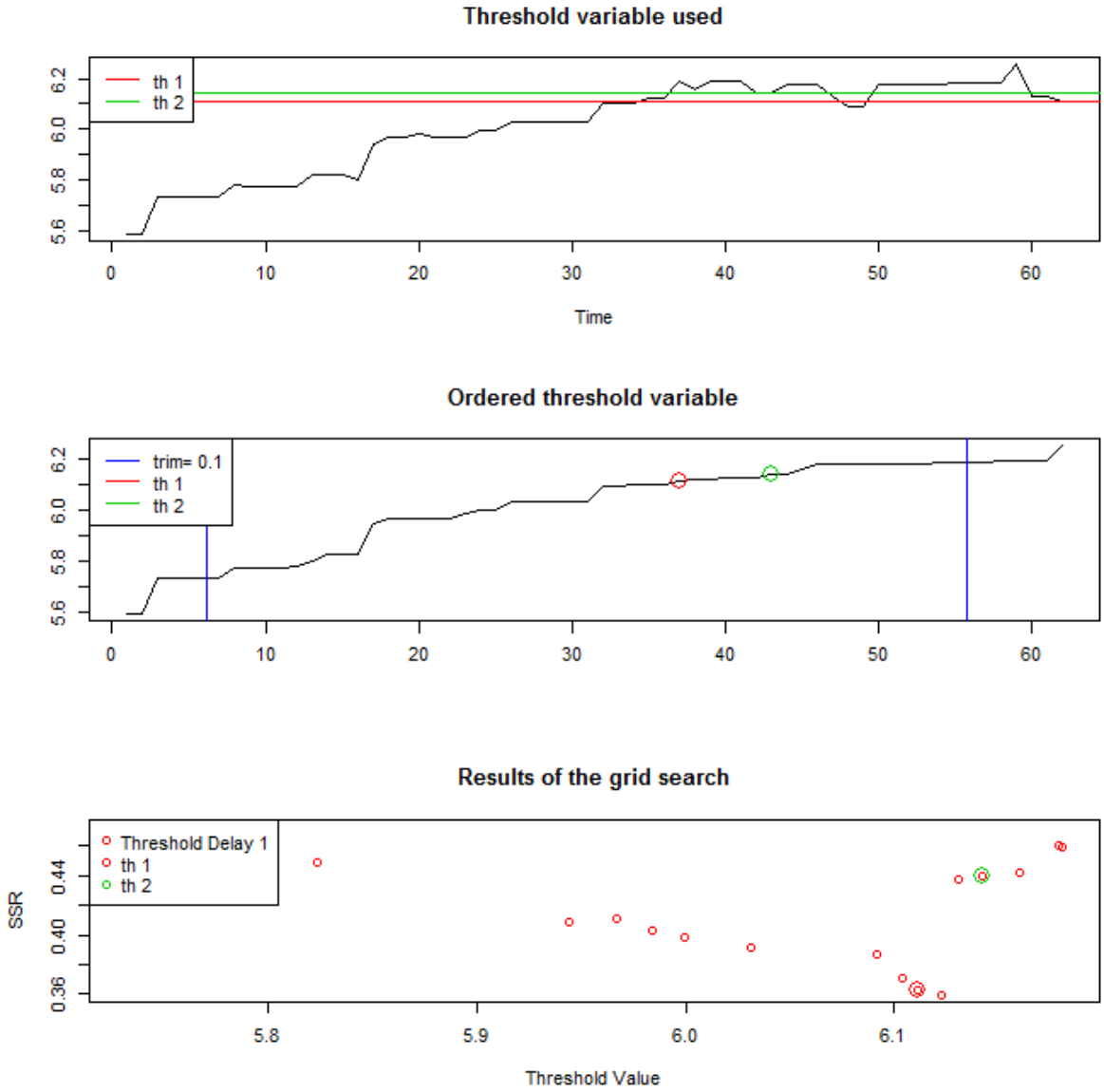
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Figure 4. Fresh milk threshold graphs Mzuzu - Blantyre



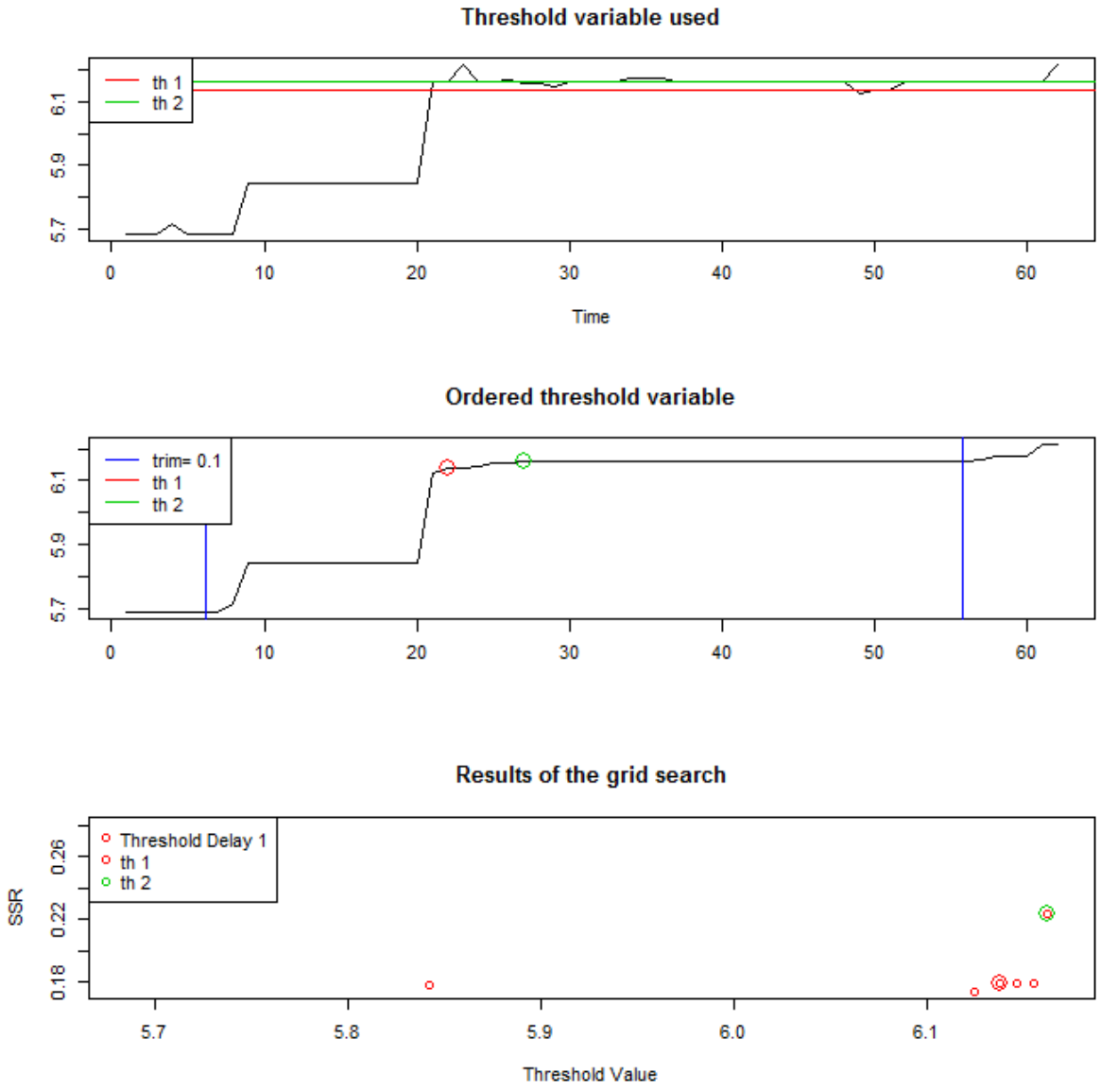
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Figure 5. Fresh milk threshold graphs Mzuzu - Zomba



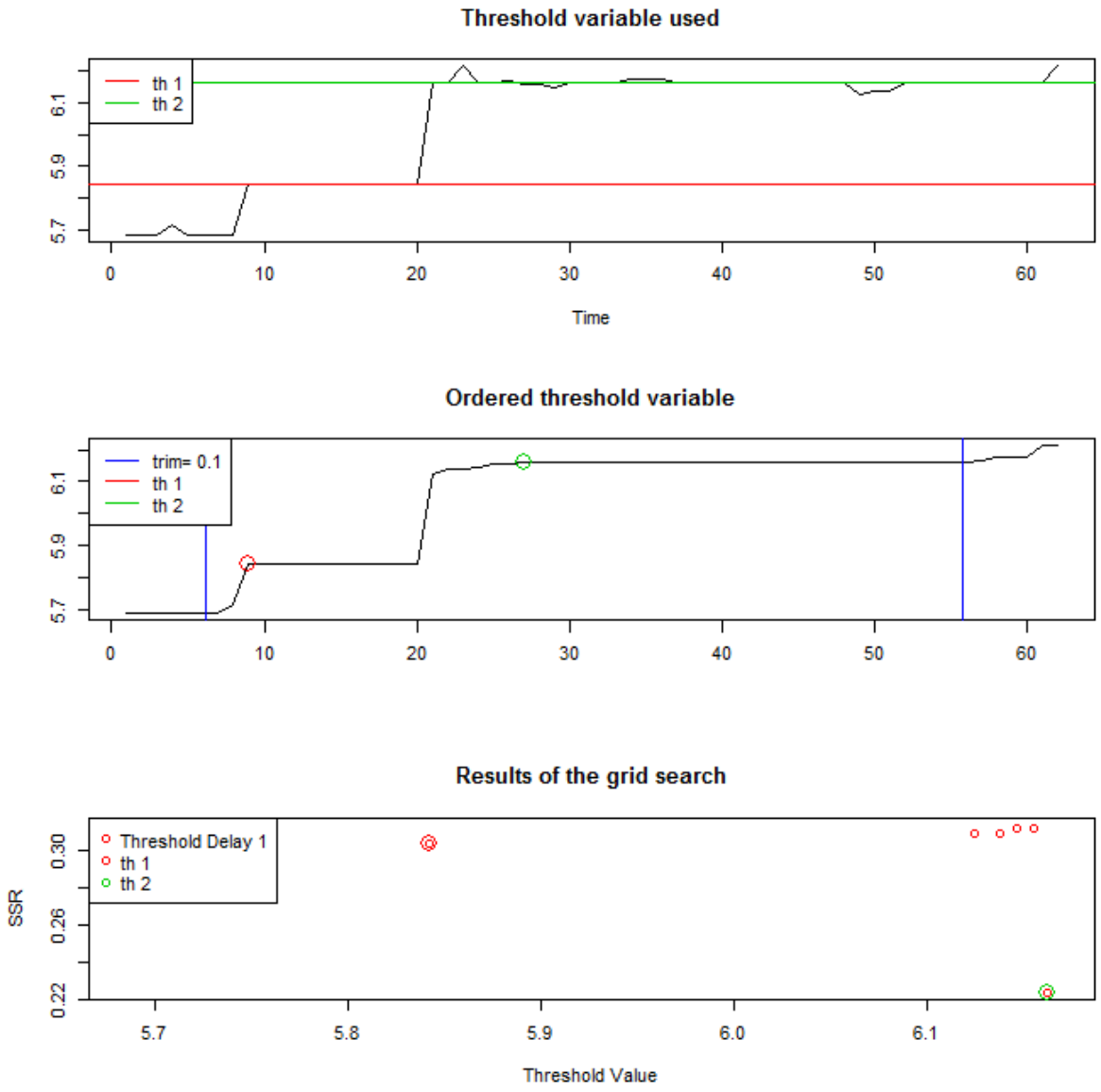
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Figure 6. Powdered milk threshold graphs Mzuzu - Lilongwe



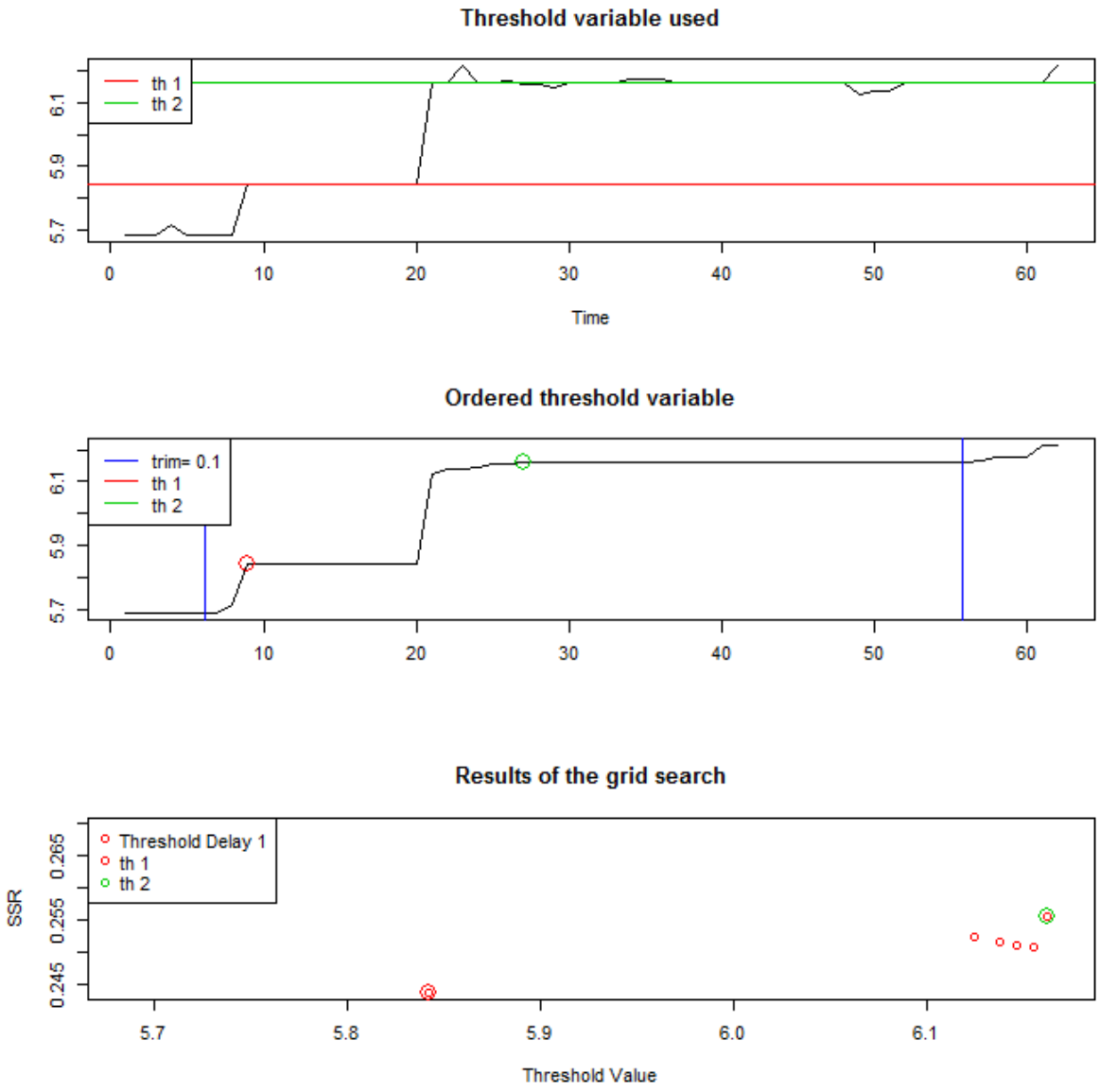
Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Figure 7. Powdered milk threshold graphs Mzuzu - Blantyre



Source: Own elaboration based on data obtained from National Statistical Office of Malawi

Figure 8. Powdered milk threshold graphs Mzuzu - Zomba



Source: Own elaboration based on data obtained from National Statistical Office of Malawi