Market systems in Malawi: combing farmgate and market price data

Bjorn Van Campenhout[*] and Bob Baulch[†]

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Introduction

Spatial heterogeneity in agro-climatic conditions, geology and seasonality means that in some areas harvesting of a crop is well under way, while other areas are still in the lean season. This results in different demand and supply conditions in different areas, giving rise to situations where the price of a homogenous commodity is much lower in one area (where producers are now flooding the market with newly harvested commodity) than in another area (where consumers are eagerly waiting for the first fields to be harvested). In extreme cases, this may give rise to localized famines even when there is sufficient aggregate food supply.

An effective means against excessive price differences between two locations for a single homogeneous commodity is special arbitrage. Traders buy the commodity in the area where the price is low and ship this to the area where the price is high. The difference in price minus the costs incurred by shipping the goods, is the profit made by the trader. If sufficient traders enter the business, the increased demand in the low price market will increase demand for the commodity, thereby increasing the price in this area (assuming no change in supply). The high price area will attract traders that want to sell their product there, and the increase in supply (assuming

[*]Development Strategy and Governance Division, International Food Policy Research Institute and LICOS Center for Institutions and Economic Performance, KULeuven, Belgium - corresponding author: b.vancampenhout@cgiar.org

[†]RMIT University, Ho Chi Minh, Vietnam

constant demand) will reduce the price of the commodity. This mechanism is so fundament to neo-classical economics that is considered a law: law of one price.

Studies on market integration usually rely on time series data of prices collected in selected markets. Starting from the law of one price, differences in the price of the product in different markets is then used to assess the degree of market interconnectedness. Large intermarket price spreads and persistence of large price margins over time are signs of poor market integration. While earlier models were flawed by not taking into account transaction costs, modern market integration studies do, either by explicitly using information on transfer costs at a single point in time (Baulch, 1997) or by exploiting the discontinuity that transaction costs introduce in the dynamics of the price margin (Van Campenhout, 2007).

While there are now plenty of case studies of market integration of different commodities in difference countries. All these studies investigate how markets are connected to each other. A question that is less often addressed is how farm gate prices are correlated to changes in market centers. This is because empirically modeling price dynamics is done using price series data, which is generally unavailable for farm gate prices. Farm gate prices are generally derived from cross-sectional surveys, and questionnaire modules about commodity marketing often do not provide sufficient detail with respect the number of transactions and precise timings.

In this paper, we combine high frequency wholesale price data collected in market centers in Malawi with farm-gate prices collected in the vicinity of these markets. In particular, using crowd-sourcing, we are able to estimate prices that farmers receive for their crops at a reasonably high interval throughout the maize and soy beam marketing season. This allows us to investigate the size and evolution over time of the price spread between the farmgate.

Market integration, and the ability to measure and diagnose the lack of it, is important for many reasons. As mentioned above, the answer to the question how an initially localized famine is expected to persist will depend on how well markets are integrated into the wider economy (Ravallion, 1986). From a social welfare perspective, poorly integrated markets may convey inaccurate information, leading to sub-optimal commodity movements and trade flows. Policy interventions that uses prices as the main mediator, such as grain reserves, may be much less effective. Also for agricultural technology adoption, price transition is important to avoid technology treadmill effects, whereby a productivity increasing innovation becomes unprofitable as more farmers start using the technology thereby flooding the market with the commodity. This in turn may lead to dis-adoption (Barrett, 2008). Recent research suggests that poorly integrated markets may even have ecological consequences (Lundberg and Abman, 2021)

This paper contributes to the literature in different ways. First, it adds another case study of regional market integration in Malawi for maize and soybean using high frequency data. Second, it studies how farmers are integrated into the regional market system through the use of crowd-sourced data.

This paper is organized as follows.

Analysis

We start by a standard market integration analysis using simple error correction models, abstracting from transaction costs for now. Define p_t^R as the price of a homogenous commodity in the reference market at time t, and p_t as the price of that same commodity in a random market. Define the price margin at time t to be:

$$m_t = p_t^R - p_t \tag{1}$$

The focus then is on how this price margin evolves through time. In its most simplest form, this can be expressed in the following autoregressive model:

$$\triangle m_t = \rho . m_{t-1} + \varepsilon_t \tag{2}$$

where $\triangle m_t = m_t - m_{t-1}$ measures the change in the price margin between two periods and $\varepsilon_t$is a normally distributed error term. This equation states that the change in the price margin is a function of the price margin in the previous period. If markets are connected by trade, one would expect that if the price margin is large, it would reduce over time. In other words, $\rho < 0$.[1],[2]

[1] Strictly speaking, the price margin will reduce if $-2 < \rho < 0$. If $\rho = -1$, the price difference is completely corrected within one period. If $\rho < -2$, there will be overcorrection. If $\rho = 0$ the price margin remains constant and if $\rho > 0$ the price margin increases over time.

[2] Time series of prices are usually non-stationary in nature. However, if prices are

When price series data at the farm-gate level would be available, the same analysis can be run to look at adjustment of farm gate prices to.

Model 2 does not consider the existence of transaction costs. A non-zero transaction cost would result in a price band where there is no adjustment. Only when the price difference between the two locations exceeds the transaction cost, trading becomes profitable and so only then prices will start moving towards each other. A popular model that incorporates transaction costs is the Threshold Auto-Regressive (TAR) model. We will estimate the simple model in equation 3.[3]

$$\triangle m_t = \begin{cases} \rho . m_{t-1} + \varepsilon_t & \text{if } |m_{t-1}| > T_{t-1} \\ \varepsilon_t & \text{otherwise} \end{cases} \tag{3}$$

Equation 3 states that the price difference for the commodity between two spatially separated markets reduces over time as long as the price difference in the previous period is larger (in absolute values) than the transaction cost T_{t-1}. Note that this model allows for reversal of trade flows and assumes transaction costs as well as adjustment are the same regardless of the direction of trade.

Equation 3 suggests that there are two dimensions to market integration: transaction costs and the speed of adjustment. Both of these properties need to be considered together when assessing the degree of market integration. Clearly, well integrated markets will have low transaction costs ($T_{t-1} \to 0$), and when the price difference exceeds the transaction cost, price adjustment will be fast ($|\rho| \to 1$).

Data

One reason why we find larger adjustment speed between farm gate prices and retail prices is because the former are more likely to be prone to measurement

related to each other by some long run relationship like the law of one price, a linear combination of the price such as equation 1 will be stationary, in which case equation 2 is normally referred to as the error-correction representation that describes short run dynamics consistent with the long run equilibrium.

[3] More general TAR models often allow for some arbitrary price adjustment within the price band formed by the transaction cost. Exploiting theory of the law of one price, we imposes unit root behaviour within the price band formed by the transaction costs to increase efficiency in the estimate of model parameters.

error. Error correction models, by definition, will have higher adjustment for noisier data. However, this does not mean that we can can not use the data. It just depends on what comparisons we make. For instance, if we while it would be incorrect to conclude that the inter-market arbitrage is less efficient than the arbitrage between markets and the farm gate, we may still be able to compare market-farmgate linkages in the North to market-farmgate linkages in the South assuming they are prices are affected by the same measurement error patterns.

Results

We start with a conventional market integration analysis focusing on arbitrage between market centers. With an eye on the analysis of the margin between regional markets and supply areas around these markets, we will subdivide Malawi in three regions: The north where we take Mzuzu as the reference market, the center where we take Lilongwe to be the reference market, and the south where Zomba is the leading consumer center.

For Mzuzu, we look at the integration of 5 markets with Mzuzu (Chitipa, Karonga, Rumphi, Mzimba and Jenda). From these market pairs, Mzuzu-Chitipa is the furthest distance apart (about 310 km), while the shortest distance is between Mzuzu and Rumphi (65 km). These three markets are plotted in Figure 1. In the top panel, nominal price series are shown in malawian kwatcha per kg. Prices in Chitipa are generally lower than prices in Mzuzu, especially in 2018. The reverse seems to be the case for Rumphi, where prices seem to be higher than in Mzuzu, also particularly during the 2018. The bottom panel shows that price margins sometimes switch signs. For instance, in the first half of 2020, the price difference between Mzuzu and Rumphi switches signs eight times. This may indicate that trade flows between the two markets reversed several times.

In Table 1, we report parameter estimates for the adjustment parameters of the simple model of Equation 2. For the Mzuzu-Karonga trade link, while these markets are far apart, the adjustment seems to be pretty fast. This is probably because these markets are both connected by the main motorway of Malawi (M1) and runs through low laying areas. Other markets such as Mzimba or Jenda are off the main north-south road connection.

The market system around Lilongwe seems to be less well integrated. While distances between market pairs are generally lower than distance be-

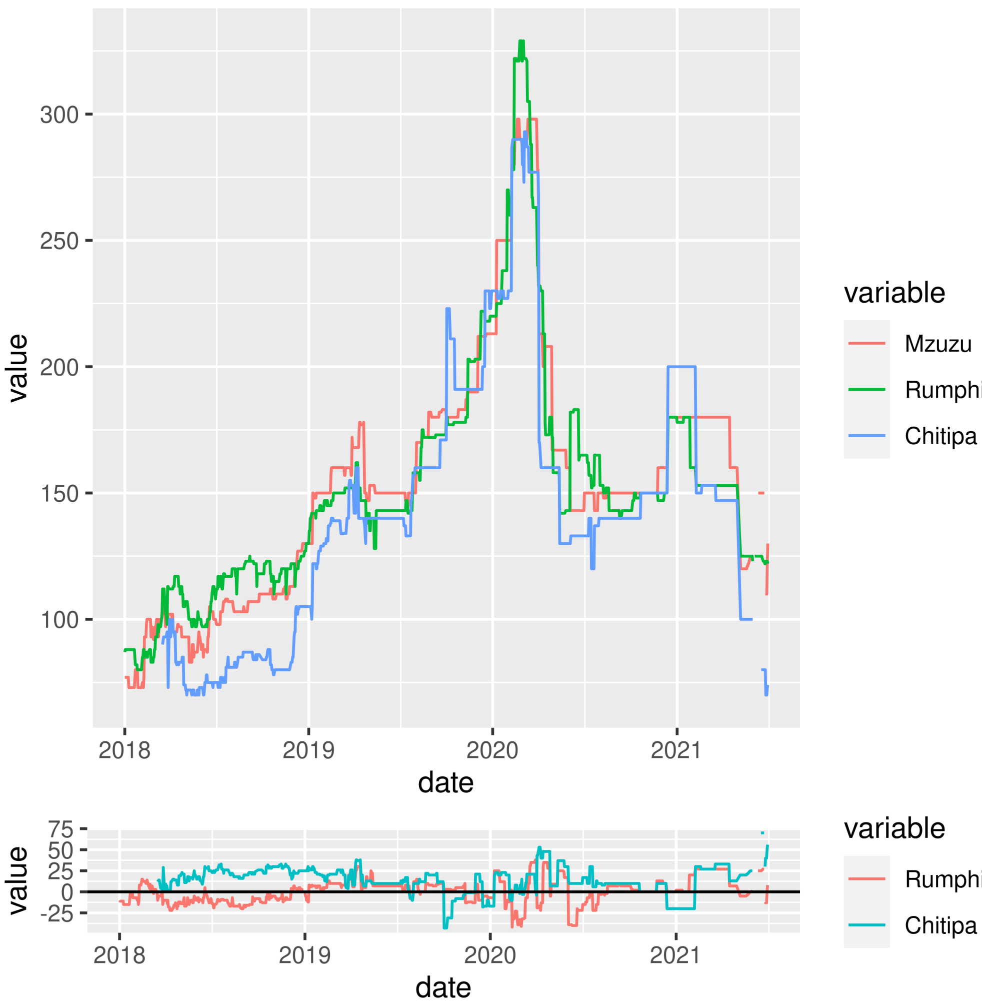

Figure 1: Maize prices (levels and margins) in Mzuzu, Chipita and Rumpi

	distance	estimate	half-life	nobs
Mzuzu - Rumphi	65 km	-0.056**	12 days	1065
Mzuzu - Mzimba	106 km	-0.047**	15 days	1065
Mzuzu - Jenda	148 km	-0.049**	14 days	636
Mzuzu - Karonga	218 km	-0.054**	13 days	1065
Mzuzu - Chitipa	310 km	-0.025**	27 days	996
Lilongwe - Mitundu	40 km	-0.051**	13 days	642
Lilongwe - Chimbiya	71 km	-0.033**	21 days	644
Lilongwe - Salima	99 km	-0.031**	22 days	635
Lilongwe - Mchinji	111 km	-0.028**	24 days	644
Blantyre - Lunzu	14 km	-0.069**	10 days	640
Blantyre - Chikwawa	53 km	-0.049**	14 days	646
Blantyre - Luchenza	63 km	-0.046**	15 days	638
Blantyre - Zomba	67 km	-0.057**	12 days	638
Blantyre - Mulanje	70 km	-0.060**	11 days	632
Blantyre - Ngabu	101 km	-0.048**	14 days	644
Blantyre - Chiringa	105 km	-0.035**	19 days	638
Blantyre - Bangula	134 km	-0.031**	22 days	646
Blantyre - Nsanje	182 km	-0.071**	9 days	637

Table 1: Adjustment parameters

tween markets in the north, adjustment is markedly slower. Market integration in the south seems to be more in line with market adjustment in the north. Overall, results are according to expectation where adjustment of a shock to half its initial value takes about 10 days in the market pair that is closest (Blantyre - Lunzu at a 14km distance apart) and up to 27 days in the market pair that is furthest apart (Mzuzu - Chitipa at 310 km distance apart). One notable exception is the trade link between Blantyre and Nsanje that seems to be extremely well integrated.

Adjustment is slower than one would suggest. For instance, in the north, it seems unreasonable that it takes 12 market days for a margin to be cut in half for two markets that are only 65 km apart. The reason why this is the case may be related to the fact that transaction costs are neglected in these models and so the estimated adjustment parameter also includes part of the regime where not adjustment is expected leading to a downward bias.

We therefore re-estimate bilateral market adjustment after taking transaction costs into account.

Conclusion

We find that markets are fairly competitive with traders able to charge only minimal markups and these markups disappear as the season progresses.

Appendix

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