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How Costly is using Livestock as a Saving Device? A Note on Meat Prices during Food Shortages

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Tinbergen Institute Discussion Paper

How Costly is using Livestock as a Saving Device? A Note on Meat Prices during Food Shortages

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How Costly is using Livestock as a Saving Device?

A Note on Meat Prices during Food Shortages

by Wouter Zant

Abstract

We measure if and to what extent livestock sales during food shortages affect the wealth value of livestock. For this purpose we exploit monthly market prices of meat and staple foods in Malawi, for up to 72 locations (towns, villages and markets), for the period from January 1991 to December 2009. The empirical evidence is consistent with increased livestock sales during food shortages, especially small livestock, and especially in the south. Results are robust for different ways to approximate food shortages and various other threats. During food shortages, real meat prices in local markets tend to decrease up to 40%, thereby reducing the wealth value of livestock at the very moment livestock is sold on the market to purchase staple foods. Similar to staple foods, poor agricultural households systematically tend to sell low and buy high. Savings instruments to bridge food shortage periods that do not lose value when liquidated, are needed. Currently popular index insurance, if properly designed to take account of this, or well-functioning safety nets will generate large welfare gains and enhance economic growth.

JEL code: O16, D19

Key words: food security, saving, drought, livestock, subsistence farming, Malawi, Africa

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Introduction and review of the literature

In many sub-Saharan countries farm households protect themselves against crop failure by saving through livestock. The objective of the current paper is to show, in the first place, if market price data on meat markets confirm that households sell livestock during periods of food shortage and employ livestock sales as a risk coping strategy; next, to estimate the size of the price response of such sales, and thereby the adverse impact on the value of livestock and, finally, to assess the welfare implications of using sales of livestock as a saving device and lessons for potential alternative saving instruments used to overcome periods of food shortage.

The literature on saving and risk is huge. Since our investigations are primarily empirical, we discuss a selected number of articles that focus particularly on the role of livestock for poor rural households in developing countries, rather than aiming at an exhaustive review of the literature on saving strategies. The objective of most papers in this area is to assess the extent to which precautionary savings and various coping mechanisms are useful in establishing food security at the household level and effective in smoothing consumption. In a primarily descriptive work Kinsey et al. (1998) investigate the mechanism households employ to cope with the risk of food shortage caused by drought, using panel data of 400 resettlement households in three regions in Zimbabwe, collected with annual surveys from 1983 to 1997. Surveyed households have a substantial herd of livestock, increasing from on average 4 units of cattle in 1983 to 10 in 1995. This contrasts with most African countries, where smallholders typically have much smaller herds. Although the survey does not report household consumption, the key finding is that household's major source to fund food purchases during droughts is livestock sales (between 40% and 50%). This strategy is followed by almost two-third of all households. Non-farm employment (16%-23%) and cash holdings (11%-26%) are other important complementary sources. Claims are not formally tested

but supported by recordings of reasons for sales, ranking of importance of income sources, characterization of risks, and measurements of livestock herds, livestock transactions and livestock prices. Fafchamps et al. (1998) investigate the role of livestock sales during food shortage in the West Africa semi-arid tropics, on the basis of a panel of Burkina Faso farmers, collected between 1981 and 1985, containing a few severe drought years. The available evidence at the time, mainly case studies from anthropologists, argues – without clear formal testing – that livestock sales played a central role in the response of households to drought. According to Fafchamps et al. (1998) livestock sales play a more modest role: they find that livestock transactions compensate for at most 30%, and probably close to 15% of income shortfalls due to village level shocks alone. Kazianga and Udry (2006) follow up on this study, using the same 1981-1985 ICRISAT survey data of around 150 randomly selected rural Burkina Faso households, to examine the degree of consumption smoothing through livestock, grain storage and inter-household transfers. The survey data contain direct recordings of consumption only for the last two survey years, 1984 and 1985: for years before 1984 household consumption is constructed. Kazianga and Udry (2006) show that fluctuations in household consumption closely track fluctuations in household income associated with drought and subsequent recovery, and find no evidence that livestock sales or financial markets serve as an effective coping strategy against these income fluctuations. The limited degree of consumption smoothing observed in the data is due to fluctuations in stocks of grain. Mogues (2011) uses a panel of 448 households from a survey in the south Wollo and Ormiya zones in the eastern Amhara region, in the north-center of Ethiopia, covering differences in agro-ecology, potential production and access to infrastructure, and conducted in seven rounds in the period June 2000 to July 2003, to investigate impacts of weather shocks on asset holdings. The investigation shows that shocks lead to asset drawdown by households and this is more pronounced for covariant

than for idiosyncratic shocks. The impact is also different depending on the type of asset: it is larger for grain stocks than for livestock, and larger for small livestock than for large livestock. It is claimed that the precautionary motive of wealth holding is more prevalent for liquid assets and for less productive forms of wealth (see also Kazianga and Udry, 2006). Several authors record and identify a key role of livestock sales for household under crop failure and food shortages. Among farm households in arid Ouallam District in western Niger, more than two third of livestock sales are made to purchase food, under conditions with a high degree of urgency (Turner and Williams, 2002). Households in semi-arid south-western Madagascar report that around 50% of sales of zebu and close to 80% of the sales of goats is driven by food shortages, while during crop failures on average 56% of food expenditures is funded with livestock sales (Hänke and Barkmann, 2017). Relatively few researchers consider quality of and access to saving instruments, like livestock. In a useful survey on income risk and coping strategies Dercon (2002) highlights a major drawback of (assets like) livestock when used as a saving device: “.... Another problem with holding assets to buffer consumption is that the terms of trade between goods for consumption and assets change as a result of a common shock. If a negative common shock occurs, households would like to sell some of their assets. However, if everyone wants to sell assets at the same time, asset prices will collapse and the amount of consumption that can be purchased will fall”. The empirical estimations in the current paper aim to formally test the importance of this fall in asset prices.

Most work on the impact of livestock sales during food shortages takes the household as the unit of research. This approach has a lot to recommend itself as the key objective is to assess the degree of food security, the degree to which households are capable to buffer fluctuations in income with savings like livestock and to preserve required levels of nutrition. However, rather than adding another household based case study, we take a slightly different route in the current

work. Instead of taking the household perspective, we look at markets¹. We evaluate to what extent markets for livestock, approximated with markets for meat, respond to food shortages. Looking at markets rather than at households allows to assess whether (increased) sales of livestock during food shortages is taking place at the scale of the local market, and in what direction and to what extent this effects meat prices and thereby the value of livestock. Availability of a large number of systematic monthly price data, covering an extensive number of geographical locations, and a long period with several food shortages, makes this evidence an informative complement to household survey based research.

The paper is organised as follows. In Section 1 we supply background information on Malawi and Malawi agriculture, on incidence of poverty, on occurrence of droughts and food shortages, and on livestock rearing by households. In Section 2 we propose a simple conceptual framework and we elaborate the empirical strategy. In Section 3 we show and discuss estimation results and robustness checks. In Section 4 we assess the implications of the estimation results, and in Section 5 we give a summary and conclusion.

1. Livestock, staple food and food shortages in Malawi

Malawi is a relatively small landlocked country in the south of Africa, measuring around 800km from north to south and around 150 km from east to west, bordering in the northwest with Zambia, in the northeast with Tanzania and in the south with Mozambique. A large lake, Lake Malawi, part of the Great Rift Valley, stretches from north to south, along the east border of the country. The Malawi population, which increased during the study period (1991-2009) from close to 9 million

¹ Consequently, we can only highlight the market impacts on households, rather than making claims from the household perspective. However, under a number of assumptions we are able to outline the position of a typical household during a food shortage (see Discussion and implications of outcomes).

to 13-14 million, is mostly rural: only a small fraction (11% to 15%) lives in the cities Lilongwe, Blantyre, Mzuzu and Zomba. Per capita GDP, expressed in purchasing power parity US\$, in 2009 is between 840 and 900 US\$, making Malawi one of the poorest countries in the world, with a ranking in the bottom 14 of all countries². More than 80% of the Malawi population depends for food and income on subsistence farming. The incidence of poverty is high: more than 50% of the population in Malawi is poor (various Integrated Household Surveys) and poverty is extremely high in remote rural districts (e.g. Chitipa in the north: 67.2%; Nsanje and Chikwawa in the south: resp : 76.0% and 65.8%, Integrated Household Survey 2004/2005). In the southern region poverty is at least 10%-points higher relative to the central regions.

The key food crop is maize. Cassava and rice have very modest market shares that are nevertheless increasing and important in a few districts (cassava in Nkhatabay and Nkhotakota, and rice in Karonga and Machinga). Other popular food crops are groundnuts and beans. Tobacco is by far the most important cash crop. Just like the other major cash crops, sugar and tea, tobacco cultivation dates back to the colonial period. Tobacco, however, has become nearly completely smallholder based in the course of the 1990s (see Zant, 2019), while tea and sugar production is (still) mainly on account of estates. Nearly every city, town or larger village has one or more markets for agricultural food crops on a regular basis, often daily or weekly: market price data that we use in the empirical estimations (72 markets) are a limited but representative sample of these markets.

Maize in Malawi dominates both in agricultural production and in consumption of households. It is the major staple food in Malawi, accounting for 52% to 65% of the total per capita

² Malawi per capita GDP in purchasing power parity US\$ according to IMF, 2009: 881 US\$ (ranking: 170 in a total of 181 countries), according to the World Bank, 2008: 837 US\$ (rank: 156 in a total of 166 countries) and according to CIA, 2009: 900 US\$ (rank: 180 in a total of 193 countries).

calorie intake (FAO, 1990, 2002). Due to its high population density the largest market for maize is the southern part of the country. Also, nearly all households grow maize. Production of maize in Malawi is undertaken by households primarily for home consumption. The quantity of marketed maize is, hence, limited: estimates of the marketed share of production range from 5 to 25% of domestic production (Jayne et al., 2008). The main maize crop in Malawi is planted in October and November and harvested from April to May. Variation in rainfall and occasional droughts cause large fluctuations in production of maize. Apart from a distinct geographical variation, especially 1991/92 shows up as a year with an extreme drought, almost throughout Malawi (see Appendix, Table A1). Country-wide crop failures of maize occurred in crop season 1991/92, 1994/95, 2000/2002 and 2004/2005³. Periods with food shortages are clearly identified by extremely high staple food prices, in particular maize (see Appendix, Figures A2). However, this does not apply to the large staple food price increases in 2008 which were caused by other factors. We may also assess food shortages by measuring to what extent production meets requirements (see Appendix, Figure A4). Similar to the rainfall data, the food shortages in 1992/93 and 1994/95 are much larger than one is tempted to think on the basis of (real) maize prices.

Just like prices of all agricultural products and common for sub-Sahara agriculture (see Kaminski et al., 2016), there is a distinct seasonal pattern in Malawi maize prices. This pattern shows highs at the end of the marketing season, just before harvesting, during the months of January, February and March and lows after harvesting during the months May, June and July. In general, maize price movements in Malawi are large in view of the importance of maize as a staple food for households in Malawi and in view of the claim of expenditure on maize on household budgets for most households.

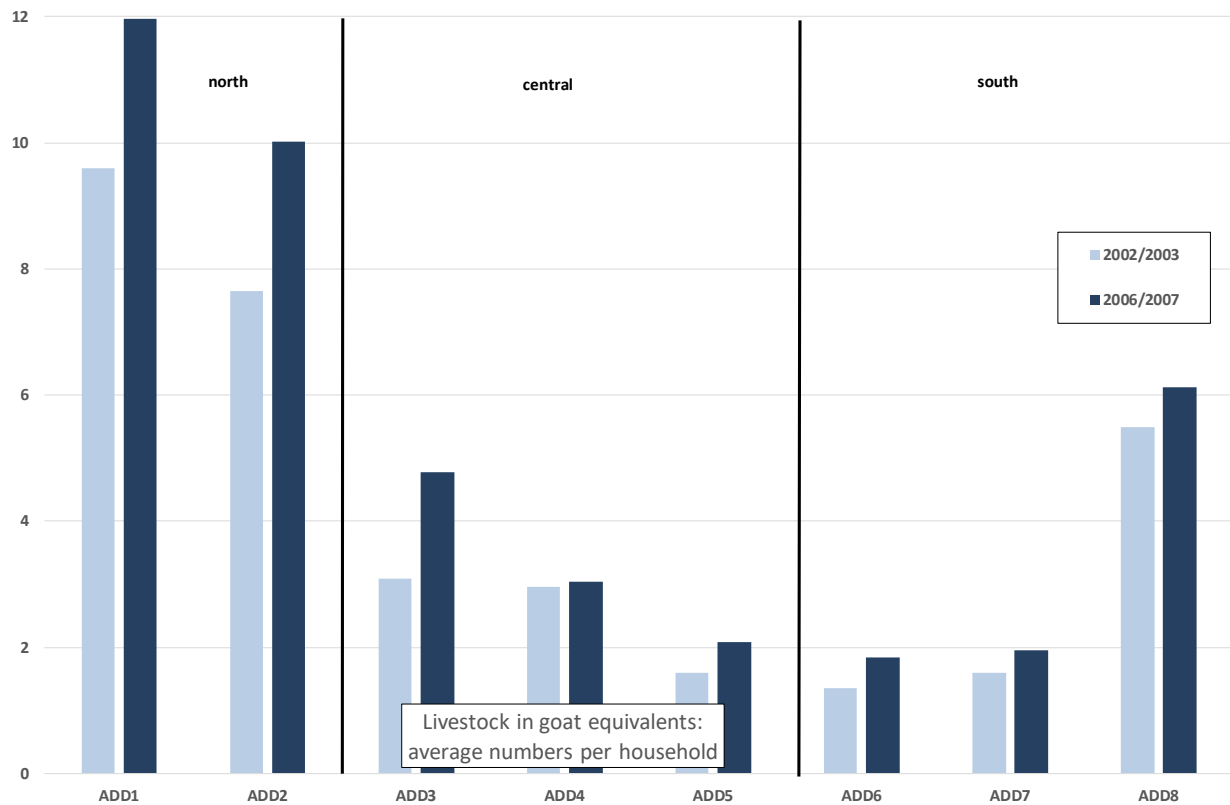
³ Note that the associated food shortage occurs in the marketing year following the year of the crop failure.

There is virtually no systematic information on the size of livestock, by type of livestock, by location and year, and on livestock transactions. Data on monthly meat prices for a substantial number of markets and for nearly two decades, are, from this perspective, the most complete and systematic source of information. There are, nevertheless, two publications that document on the results of a census among farmers including a module on livestock and various other details (National Census of Agriculture and Livestock (NACAL), Malawi 2006/2007 and Core Welfare Indicators Questionnaire 2002). On the basis of these two source and combined with population data, we find that livestock rearing per household especially takes place in the northern and southern districts (see Appendix, Figure A1)⁴. Overall, the number of goats per household is the largest, but there are regional variations: in the northern district cattle is more prevalent, while in the southern districts goats are more prevalent. To obtain a clearer picture on the combination of different types of livestock, we have converted all types of livestock to “goat equivalents” using weights for tropical livestock units. The result of this calculation, plotted in Figure 1, shows relatively large number of goat equivalent units in the northern and southern districts (Chitipa, Karonga and Mzimba in the north, and Chikwawa and Nsanje in the south) and very modest numbers for households in the central region (districts of Lilongwe and Blantyre). In fact, the absolute number of livestock units per household in the central region is so low (see, for example, Kinsey et al. 1998) that it is difficult to attribute a serious role for livestock in terms of precautionary saving, in these areas. Households in the outer north and the outer south, with larger herds of livestock, may resort to livestock because they have few alternative options to protect against crop failures. Conversely, households in the central region, where the Malawi cities are

⁴ The numbers are averages by Agricultural Development Division. The within ADD distribution of livestock over households is, without doubt, skewed, with only a small proportion of households with livestock and the larger proportion of households with no livestock. A major reason for limited access to livestock savings is asset lumpiness (see Dercon, 2002).

located, have easier access to temporary urban wage jobs and other non-farm employment opportunities – a common technique to deal with income shortfalls arising from crop failure or drought – and easier access to food-aid in case emergency arises. Dercon (1998, 2002) also indicates off-farm activities as a rational choice for low-income households in case of credit constraints and agricultural risk. Finally, the correspondence between the regional pattern of poverty incidence and the per household number of livestock units is striking.

Figure 1 Livestock in goat equivalents: average number of units per household by ADD



Note to Figure: Conversion weights for tropical livestock units: 1 cow = 5 goats; 1 pig = 1.5 goats; 1 sheep = 1 goat; 1 chicken = 0.2 goat.

2. Conceptual framework, data and data sources, and empirical strategy

Conceptual framework

We approximate livestock markets with markets for meat⁵. For the meat markets we assume that ordinary demand and supply analysis applies. Hence, meat prices are to a large extent determined by geographically specified local conditions and by time related developments that are similar to all markets. The exception that we elaborate on in the current paper is the exogenous shock that arises out of droughts and subsequent food shortages: we hypothesize that such shocks lead to increased sales of livestock. The increased sales of livestock will subsequently increase the supply of meat which exerts a downward pressure on meat prices.

Data, data sources and variable construction

The core data for the empirical estimations are monthly market prices for goat meat, steak & bone, pork, maize, rice and cassava, for a total of 72 markets, all sourced from the Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi. We have chosen the price of goat meat, steak & bone and pork as meat prices. These prices correspond with the major livestock categories reared by Malawi households (see Appendix, Figure 1). For some predominantly Islamic districts (Machinga) there is no (or only a limited) market for pork. We have chosen for staple food prices, the price of maize, rice and cassava. These staple foods are the major staple foods grown and consumed by Malawi households. From the description of Malawi agriculture it is clear that maize dominates both in production and consumption, in all districts of Malawi. Cassava is a popular crop in the northern districts that border lake Malawi (Nkhatabay,

⁵ We are aware that livestock markets are not the same as meat markets. However, there is a one-to-one relationship between prices on these markets. Moreover, livestock markets tend to be thin leading to extreme and unreliable market prices and missing observations in the data, while meat markets are more regular with sufficient volume on both sides of the market and market price data which are reasonably complete.

Nkhotakota, and Karonga), while rice is especially grown in Karonga in the north, and Machinga and Zomba in the south.

For the construction of a variable reflecting maize *abundance-scarcity* by district we have used census based population data by district (Rural Development Project) from the National Statistical Office – dated 1987, 1998 and 2008 – that are interpolated for intermediate months, and annual maize production data, also sourced from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi. Rainfall data, used to instrument staple food prices, are from the Department of Climate Change and Meteorological Service in Zomba, and are available for 31 locations⁶. Monthly rainfall observations, aggregated by season – where the season runs from April to March – are first attributed to Extension Planning Areas (EPAs, 102 in total) and subsequently averaged by district (Rural Development Project). For descriptive purposes we have shown real prices of meat and staple food, calculated by using the Malawi consumer price index for deflation, which is sourced from the International Financial Statistics from the IMF. Malawi has a total of 26 districts (Rural Development Project (RDPs)), eight Agricultural Development Divisions (ADDs) and three regions (north, central and south): Appendix, Table R2 shows how the 72 markets for which we have price data, RDPs, ADDs and regions are related.

We formalize maize required for basic nutrition per person as follows: $\text{requirement}_i = \text{maize kcal share in diet}_i * \text{kcal needs per person}_i$. Unfortunately we only have country averages for the latter two variables based on case studies, and population by month and district. Hence, we

⁶ We are aware that much more detailed and sophisticated remote sensing climate data are available. However, we are satisfied with the rainfall data at hand: they clearly identify years and locations of drought (see Appendix, Table A1) and they behave well in estimations, generating significant coefficients with the right sign and with a straightforward interpretation.

calculate maize required for basic nutrition, in district j and date t as follows: $\text{requirement}_{jt} = \text{population}_{jt} * \text{average maize kcal share in diet} * \text{average kcal needs per person}$. For the average maize kcal share we use 0.5 and 0.65 and for average kcal needs per person (per day) we use 2100kcal and 2300kcal. The per kg kcal content of maize is 3570 (see also Zant, 2012), which completes the construction of maize requirements. Finally, we construct our measure of relative local *abundance-scarcity* by dividing last season maize production by district with current season maize requirements by district: a value larger than 1 indicates relative abundance, while a value below 1 indicates a food shortage.

Empirical strategy

We postulate that (spatial) meat prices are empirically determined by local supply and demand conditions, and by food shortages. We assume that the influence of local supply and demand conditions on spatial meat prices is sufficiently captured by location and time fixed effects. We start with the following standard Difference in Difference specification:

$$p^{meat}_{jt} = \eta_0 + \eta_1 \text{food shortage}_{jt} + \varphi_j + \psi_t + \varepsilon_{jt} \quad (1)$$

where p^{meat}_{jt} is the price of meat in location j at time t , and $\text{food shortage}_{jt}$ is a variable that indicates if location j at time t experiences a food shortage. Parameters φ_j represent market fixed effects and ψ_t (country wide) time fixed effects, and ε_{jt} is an error term with zero mean. If households sell livestock during food shortages, we expect that a food shortage has a negative impact of meat prices and hence $\eta_1 < 0$. Next, we propose to approximate food shortages, in the first place, with prices of staple foods. Food shortage are directly linked to previous season crop failures and prices of staple foods – by far the largest component in the diet of the Malawi population – quickly and sharply increase in the marketing season following a crop failure. Under this assumption we have:

$$p^{meat}_{jt} = \eta_0 + \eta_1 p^{staple\ food}_{jt} + \varphi_j + \psi_t + \varepsilon_{jt} \quad (2)$$

where $p^{staple\ food}_{jt}$ is the price of a staple food in location j at time t .

One may argue that staple food prices are not a good approximation of food shortages because these prices also vary for other reasons. For example, the 2008 increases in staple food prices were caused by development on the world market, rather than by domestic supply and demand conditions. As nearly all agriculture in Malawi is rain-fed, we accommodate for this issue, by instrumenting staple food prices with last season rainfall and seasonality: only the fluctuations in staple food prices that are due to the climate are fluctuations that reflect food shortages. Potential reverse causality – that meat prices impact on staple food prices – is also addressed in this way.

Hence, we estimate:

$$p^{meat}_{jt} = \eta_0 + \eta_1 \widehat{p^{staple\ food}_{jt}} + \varphi_j + \psi_t + \varepsilon_{jt} \quad (3)$$

and

$$p^{staple\ food}_{jt} = \theta_0 + \theta_1 \text{last season rainfall}_{jt} + \theta_2 \text{seasonality}_{jt} + \varphi_j + \psi_t + \varepsilon_{jt} \quad (4)$$

Instead of staple food prices we may also use a more physical approximation of food shortages. For this purpose, we exploit the dominance of maize in the diet of Malawi population, and construct the requirement of maize by district, as a linear transformation of population⁷. We assume that actual previous season maize production relative to current season maize requirements is a sensible (ex-post) approximation of food shortages: values lower than 1 characterize a food shortage. We propose the following specification:

$$p^{meat}_{jt} = \eta_0 + \eta_1 [\text{maize production}_{j, \text{last season}} / \text{maize requirements}_{jt}] + \varphi_j + \psi_t + \varepsilon_{jt} \quad (5)$$

Due to its definition, we now test the hypothesis $\eta_1 > 0$: relative scarcity of maize – a food shortage – will than have a negative impact on meat prices. There is no need to instrument the abundance-scarcity variable or apply any other adjustment (for omitted variables, reverse causality,

⁷ See *Data, data sources and variable construction* for the construction of the maize requirement variable.

endogeneity, etc): production of maize is last season production and thereby predetermined, and population by district develops only gradually over time, without major shifts and shocks, and is also largely predetermined (and likely to take over part of the fixed effect).

An attractive feature of including time fixed effects in the estimations is that prices are automatically deflated and made comparable over time⁸. The time fixed effects additionally capture other common time fixed effects, on top of the country-wide fluctuations in the general price level. It is, however, unlikely that the implicit deflation properly reflects the general price level at all times and all locations. In the light of the difficulty of proper deflation, we do, however, have an interesting alternative to estimate: rather than using meat prices as dependent variable, we propose to estimate the terms of trade between meat and staple foods. Hence, we have:

$$p^{meat}_{jt}/p^{staple\ food}_{jt} = \eta_0 + \eta_1 [maize\ production_{j,lastseason}/maize\ requirements_{jt}] + \varphi_j + \psi_t + \varepsilon_{jt} \quad (6)$$

Since households value their livestock in terms of the quantity of staple food that can be purchased, such an estimation is informative. Since we have staple food prices for a large number of markets (strictly the same number of markets as in case of meat prices), using the terms of trade is likely to generate a more complete and more accurate picture. Again, the coefficient of interest is η_1 and we expect, as in the previous specification that $\eta_1 > 0$, with a slightly adjusted interpretation: relative scarcity in the maize market leads to a deterioration of the meat-maize terms of trade.

3. Estimations and robustness checks

We first estimate specification (3), using IV-2SLS where staple food prices are instrumented with climate variables. The instrumenting is likely to generate a more accurate approximation of food

⁸ Converting prices to real prices using the standard (national) consumer price index for deflating, adds little because the time fixed effects absorb all effects that are constant between locations, including those of the national consumer price index (and the conversion into real prices).

shortages. The availability of price data increases drastically after January 2004: from this date onwards observations increase, for all series, from less than 30% to nearly 80% of all locations (see Appendix, Figure A2). For this reason, we estimate, as a start, with the observations from January 2004 to October 2009, a total of 70 months, also including the 2005-06 food shortage.

Table 1 Meat Prices and Staple Food Prices (Jan 2004 – Oct 2009, IV-2SLS)

dependent variable: ln(goat meat price)	(1)	(2)	(3)
explanatory variable	ln(maize price)	ln(rice price)	ln(cassava price)
	-0.078*** (0.023)	-0.085** (0.043)	-0.071** (0.031)
Centered R ²	0.951	0.952	0.949
Uncentered R ²	0.999	0.999	0.999
Kleibergen-Paap rk LM statistic	262.5	194.0	80.0
Cragg-Donald Wald F statistic	5.9	2.9	1.0
Hansen J statistic	127.8	133.0	131.3
no. of observations	3685	3527	3164
dependent variable: ln(steak&bone price)	(1)	(2)	(3)
explanatory variable	ln(maize price)	ln(rice price)	ln(cassava price)
	-0.117*** (0.020)	-0.088*** (0.033)	-0.075*** (0.029)
Centered R ²	0.951	0.952	0.951
Uncentered R ²	0.999	0.999	0.999
Kleibergen-Paap rk LM statistic	311.8	273.1	94.9
Cragg-Donald Wald F statistic	7.1	4.4	1.5
Hansen J statistic	100.4	156.3	139.1
no. of observations	3329	3142	2798
dependent variable: ln(pork price)	(1)	(2)	(3)
explanatory variable	ln(maize price)	ln(rice price)	ln(cassava price)
	-0.016 (0.029)	0.031 (0.045)	0.001 (0.034)
Centered R ²	0.944	0.947	0.949
Uncentered R ²	0.999	0.999	0.999
Kleibergen-Paap rk LM statistic	233.6	184.9	81.9
Cragg-Donald Wald F statistic	4.8	2.7	1.0
Hansen J statistic	89.0	106.0	101.8
no. of observations	3429	3256	2954

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with IV-2SLS. Instruments for staple food prices are last season rainfall by district and within year seasonality by Agricultural Development Division (ADD). Additionally maize prizes are included as instrument for rice prices and cassava prices. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Kleibergen-Paap rk LM statistic: under-identification test; Cragg-Donald Wald F statistic: weak identification test; Hansen J statistic: over-identification test of all instruments.

The first stage estimations of the IV-2SLS (not shown) behave well: staple food prices are negatively correlated with last season rainfall and the seasonality dummies generate the expected

pattern of low prices just in the months after harvest and high prices in the months before harvest. The estimation outcome of equation (3), reported in Table 1, support a highly significant negative impact of food shortages on meat prices, in the case of goat meat and steak & bone. Coefficients are also substantially and consistently larger compared to corresponding OLS estimations (not shown, available from the author). This indicates that the size of the response is larger if fluctuations in maize prices are restricted to those effectively associated with drought. However, no significant impact is found for pork prices. Possibly this is caused by geographical variation in the rearing of pigs and the lack of a market for pork (on religious grounds) in parts of the country.

Employing staple food prices to approximate food shortages is certainly a useful strategy to assess impact of food shortages on meat prices. An alternative way is to use a measure of scarcity-abundance of staple food in the local market. Geographical variation in crop outcomes and population density, jointly with high transaction costs create sufficient variation and make locations spatially independent to a sufficient degree, to make this an attractive robustness check for previous estimations. We have constructed an abundance-scarcity variable by exploiting the dominance of maize in the diet of Malawi population: actual previous year local maize production versus the households requirement of maize for consumption, both by district. Values lower than 1 of the abundance-scarcity variable characterize a food shortage. Applied to the data the scarcity clearly confirms food shortages (location-year) that are documented as such (see Appendix, Figure A4). The plots of the maize abundance-scarcity variable indicate a larger intensity of food shortages in the years 1992-93 and 1994-95, relative to the food shortage in 2005-06, also if we compare these developments with the development of staple food prices during these food shortages.

Estimation results based on equation (5), reported in Table 2, confirm a highly statistically significant impact of food shortages – now approximated with the maize scarcity-abundance variable – on meat prices. Note that given the way the variable is constructed, we now expect a positive sign. The impact is significant for all meat prices, the coefficient is the largest for goat meat and the smallest for pork. Using the complete sample period – including the 1992-93 and the 1994-95 food shortage – increases all coefficients. To answer the questions formulated in the introduction: estimation results are consistent with increased livestock sales during food shortages, and thereby further confirm previous results.

Table 2 Meat Prices and Maize Abundance-Scarcity (OLS)

dependent variable: ln(goat meat price)		ln(previous season maize production / current season maize requirements)	
explanatory variable		Jan 1991 – Oct 2009	Jan 2004 – Oct 2009
		0.090*** (0.006)	0.054*** (0.007)
R ²		0.992	0.952
no. of observations		5542	3865
dependent variable: ln(steak&bone price)		ln(previous season maize production / current season maize requirements)	
explanatory variable		Jan 1991 – Oct 2009	Jan 2004 – Oct 2009
		0.065*** (0.005)	0.045*** (0.007)
R ²		0.995	0.952
no. of observations		5926	3512
dependent variable: ln(pork price)		ln(previous season maize production / current season maize requirements)	
explanatory variable		Jan 1991 – Oct 2009	Jan 2004 – Oct 2009
		0.031*** (0.006)	0.024*** (0.007)
R ²		0.992	0.944
no. of observations		4999	3585

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Since prices of consumer goods and budget compositions of households fluctuate tremendously between years and between locations and, most importantly, within the season, it is notoriously difficult (and virtually impossible) to find adequate consumer price indices in developing country agricultural settings, for converting local prices into real prices. The available national consumer price index simply fails to capture these fluctuations. An alternative for the current exercise that partly meets these requirements – to control for within season fluctuations of prices by location – is to convert meat prices into the meat-staple food terms of trade. In fact, since detailed data for both prices for meat and staple foods are available, this alternative is particularly suitable for the current exercise. Hence, we next investigate if food shortages lead to a deterioration of the meat-maize terms of trade.

The results of estimating equation (6), reported in Table 3a and Table 3b, further confirm previous assessments: the impact of food shortages on meat-maize terms of trade is statistically significant with the expected sign for all meat prices. Terms of trade vis-a-vis maize generate results that fits the data best and impacts are reasonably stable over time. The size of the coefficient is largest for goat meat and smallest for pork. Also the response to maize is larger relative to rice and cassava. Terms of trade vis-a-vis cassava increase substantially if the 2004-2009 sample is used. The data also support a distinct geographical pattern with systematically larger impacts for the southern region (see Appendix, Table A3 and Table A4a and A4b). Further geographical disaggregation by Agricultural Development Division shows even stronger geographical variation (not shown, available from the author)

**Table 3a Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), Jan 1991 – Oct 2009**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.147*** (0.013)	0.084*** (0.012)	0.084*** (0.021)
R ²	0.808	0.682	0.480
no. of observations	5121	5199	4802
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.111*** (0.011)	0.053*** (0.009)	0.034** (0.012)
R ²	0.793	0.713	0.476
no. of observations	5443	5519	5115
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.113*** (0.013)	0.019* (0.011)	0.000 (0.019)
R ²	0.808	0.711	0.524
no. of observations	4779	4719	4386

Table 3b Terms of Trade between Meat Prices and Staple Food Prices versus Maize Abundance-Scarcity (OLS), Jan 2004 – Oct 2009

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.135*** (0.019)	0.111*** (0.017)	0.183*** (0.032)
R ²	0.807	0.655	0.514
no. of observations	3685	3642	3300
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.131*** (0.019)	0.091*** (0.016)	0.218*** (0.034)
R ²	0.800	0.652	0.477
no. of observations	3371	3290	2980
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.113*** (0.019)	0.071*** (0.017)	0.147*** (0.034)
R ²	0.806	0.664	0.533
no. of observations	3428	3365	3079

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The evidence, documented in the previous estimations, supports the hypotheses that that livestock prices during food shortages have decreased, which is consistent with increased livestock sales. Size and significance of impact varies by region and by type of livestock and staple food: increased livestock sales are supported in the southern districts, and estimated impacts are largest for goats and the smallest, and occasionally zero, for pigs. Responses are systematically larger and more significant if maize is used to approximate shortages, which reflects the dominant role of maize in the Malawi staple food markets.

**Table 4 Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), around the 2005-2006 food shortage**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.162*** (0.023)	0.102*** (0.021)	0.224*** (0.039)
R ²	0.831	0.648	0.570
no. of observations	1836	1800	1708
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.148*** (0.023)	0.059*** (0.019)	0.258*** (0.041)
R ²	0.826	0.646	0.532
no. of observations	1684	1635	1564
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.122*** (0.023)	0.053** (0.021)	0.210*** (0.040)
R ²	0.826	0.677	0.592
no. of observations	1737	1691	1616

With estimation results varying by region, by type of livestock and staple food, and also by sample period, it may be insightful to focus on specific periods. We therefore re-estimate with observations restricted to the period of the 2005-2006 food shortage, from February-March 2005 to February-March 2006. Estimations for this period, documented in Table 4, show significant impacts for all types of livestock, with the largest coefficients with cassava prices and the smallest with rice prices. The large coefficients that arise if cassava prices are used, suggests increased integration of cassava in the Malawi diet. The other specifications (equation (3): meat prices dependent variable and staple food prices instrumented; equation (5), meat prices dependent variable and maize abundance-scarcity explanatory variable) have similar outcomes (not shown, available from the author). During the 2005-2006 shortage the median maize price increase, from

February-March 2005 to February-March 2006 is around 250%. Using the estimates of the above table we find that real meat prices decreased around 25% (pork, steak and bone) to 40% (goat meat). Estimation results focusing on other food shortage periods (1992-1993; 1995-1996 and 2001-2003) generate comparable results, though less significant coefficients with cassava prices. The estimations for other food shortage periods suffer from too few observations and therefore have limited statistical power (see Appendix, Table A5 and Table A6).

Another interesting period is the period from early 2008 to late 2009. During this period food prices in Malawi increased substantially (see Appendix, Figure A2). However, this price increase originated from the world market and had no relation with the domestic agricultural outcome in Malawi. In the domestic market staple food supply was available in very reasonable quantities. We can verify our results by exploiting this 2008-2009 price increase: If the hypothesis holds that accumulated savings in the form of livestock are especially liquidated (sold on the market) during food shortages, we should observe that during this period meat prices respond much less to the relative abundance-scarcity of maize (what is produced vis-a-vis what is needed domestically). The evidence supports such a much weaker response during this period (results not reported, available from the author).

4. Discussion and implications of outcomes

Strictly, the estimations are simply describing a decrease of real meat prices during food shortages: with complementarity of food items one would expect meat price to increase jointly with other food prices and that this does not happen is virtually the only extraordinary issue. If we can identify food shortage locations, we may as well inspect the terms of trade of meat prices vis-à-vis staple food prices in a specific location. Using price data for the 2005-2006 season we observe that the terms of

trade for goat meat versus maize deteriorated from February 2005 to February 2006 with a factor 4. We can exploit the deterioration in terms of trade over the season, observed in food shortage locations, to figure out the share of maize requirements households can cover with sales of livestock. With a number of assumptions, we calculate that a typical household⁹ that grows maize for home consumption requires around 700kg of maize for a whole year¹⁰, or around 60kg per month, to adequately feed all household members. With a few additional assumptions on goats¹¹, we calculate the market value of selling goats by this household in terms of maize. With a complete crop failure and assuming that households fully anticipate maize prices and household maize needs in the remaining marketing season, the household sells its two goats directly after harvesting time and – also directly after harvesting time – purchases maize. Under these conditions the household is able to cover around 33% of its maize needed till the next harvest. However, it is not difficult to envisage circumstances that are (even) less favorable. For example, a smaller livestock, delayed or sequential sale of goats, unfavorable farm gate versus market prices (for sale of livestock and for purchase of maize) or limited maize storage capacity are likely to further decrease this contribution. These numbers – the share of household consumption that can be covered with livestock sales during in case of crop failure – come close to what is found elsewhere in the literature (see for example Fafchamps et al., 1998; Kazianga and Udry, 2006). In conclusion, only a limited share of consumption needs can be covered with livestock sales. The large deterioration of the meat-maize terms of trade in the course of a food-shortage further decreases this share substantially.

⁹ A typical household is assumed to have 6 persons: 2 adults, 2 teen-agers, and 2 children below 10 years of age.

¹⁰ The annual quantity of maize, required to feed a households is calculated as follows: $[2 \text{ (adults)} \times 2300 \text{ (daily kcal requirement of adults)} + 2 \text{ (teenagers)} \times 1800 + 2 \text{ (children)} \times 1200] \times 60\% \text{ (maize calorie share in household diet)} \times 365 \text{ (number of days per year)} / 3570 \text{ (per kg kcal content of maize)}$.

¹¹ Specifically we assume that the number of goats per household is 2, the weight of goat is 30kg and the meat content of a goat is 25kg.

A saving device that drastically decreases in value when needed is a poor characteristic of a saving device. The empirical estimations support such a drastic decrease in livestock value during food shortages, and highlight a major drawback of using livestock sales to overcome crop failures. The more general story is that poor agricultural households in developing countries suffer from extreme seasonality: they tend to sell their agricultural output when relative prices are low (livestock during food shortage, but also, staple food crops directly after harvest) and purchase when relative prices are high (staple food in the lean season, or during food shortages). The dynamics in seasonality of staple food prices underlying the terms of trade deterioration explains the limited extent that livestock sales cover consumption needs. Likewise it also explains the observed preference for using grain stocks to bridge periods of lack staple food: this is not an issue of liquidity (Kazianga and Udry, 2006; Mogue, 2011), but rather absence of a terms of trade deterioration.

The deterioration in the terms of trade of the livestock saving device spells out requirements for an effective saving device: such a device should not lose value at the very moment when it is liquidated. The design of currently popular index insurance schemes – schemes which reduce the problems of standard insurance: moral hazard, selection of risks and high administration costs – but also the arrangements underlying social safety nets, should therefore define claims in real terms. Hence, indemnity claims of index insurance, but also claims on support from safety nets, need to be formulated in physical terms, for example in kg of maize, corresponding with the loss of maize harvest, or its money equivalent at the moment the claims are made. Saving instruments that meet these requirements are likely to reduce (ex-ante) risk and encourage growth; In case of credit constraint and risky agriculture, Dercon (1998, 2002) shows that low income households tend to choose low return-low risk activities. If a savings instrument is available that adequately

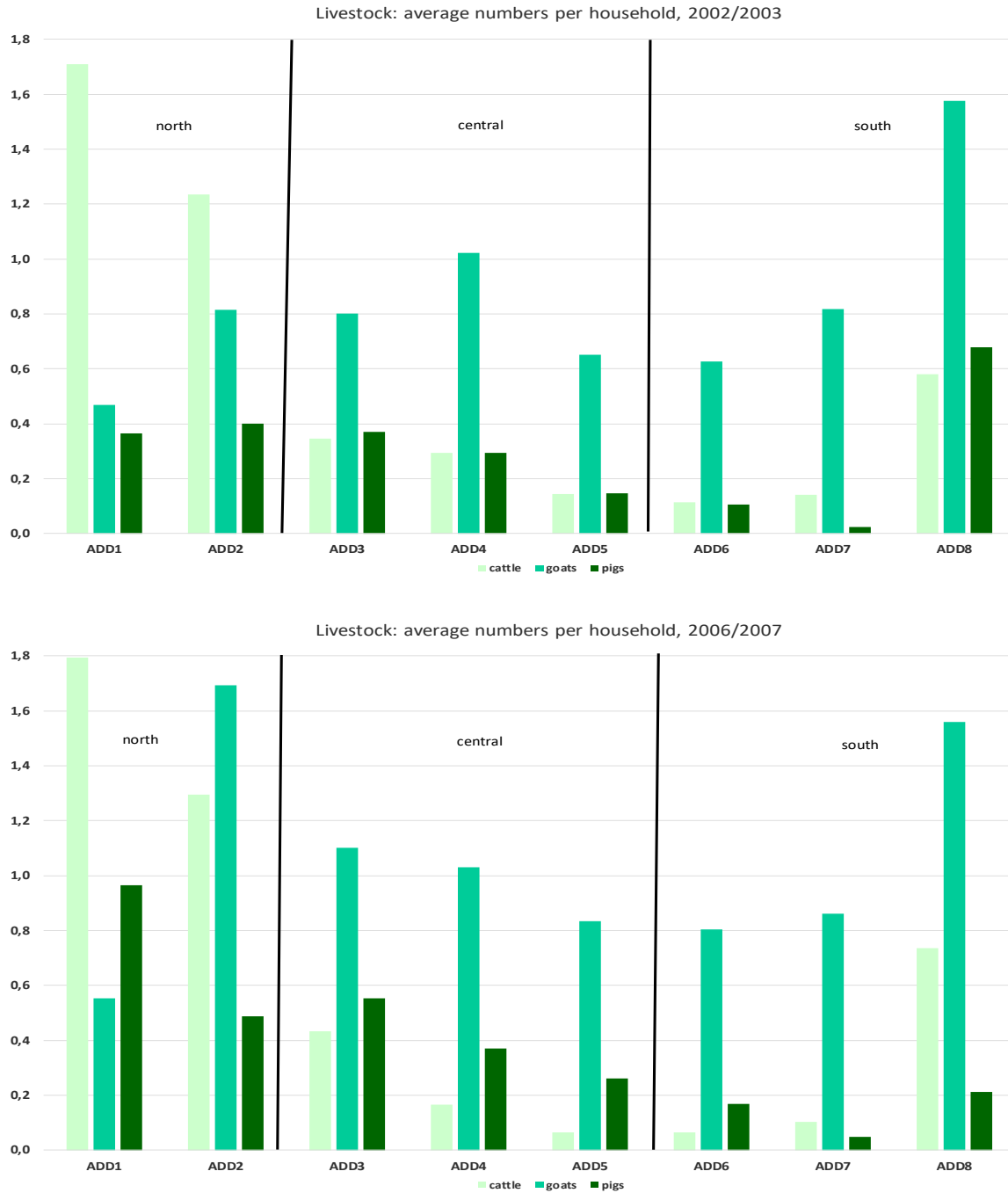
protects against contingencies like income shortfalls or food shortages, households have better opportunities to take up high return-high risk activities (like cattle rearing). The long run effects on welfare and growth if ex-ante risk is eliminated are large (see Elbers et al 2007).

5. Summary and conclusion

We measure if and to what extent livestock sales during food shortages affect the wealth value of livestock. For this purpose we exploit monthly market prices of meat and staple foods in Malawi, for up to 72 locations (towns, villages and markets), for the period from January 1991 to December 2009. We find empirical support for increased livestock sales during food shortages, particularly for small livestock, specifically in the north or the south. During food shortages, real meat prices in local markets tend to decrease up to 40%, thereby reducing the wealth value of livestock at the very moment livestock is sold on the market to purchase staple foods. Results are robust for endogeneity of staple food prices and different ways to approximate food shortages. Similar to staple foods, poor households systematically tend to sell low and buy high. Alternative saving devices to bridge food shortage periods that do not lose value when needed, like adequately designed index insurance or well-functioning social safety nets, therefore will generate large welfare gains and enhance economic growth.

Appendix

Figure A1 Livestock and households by region



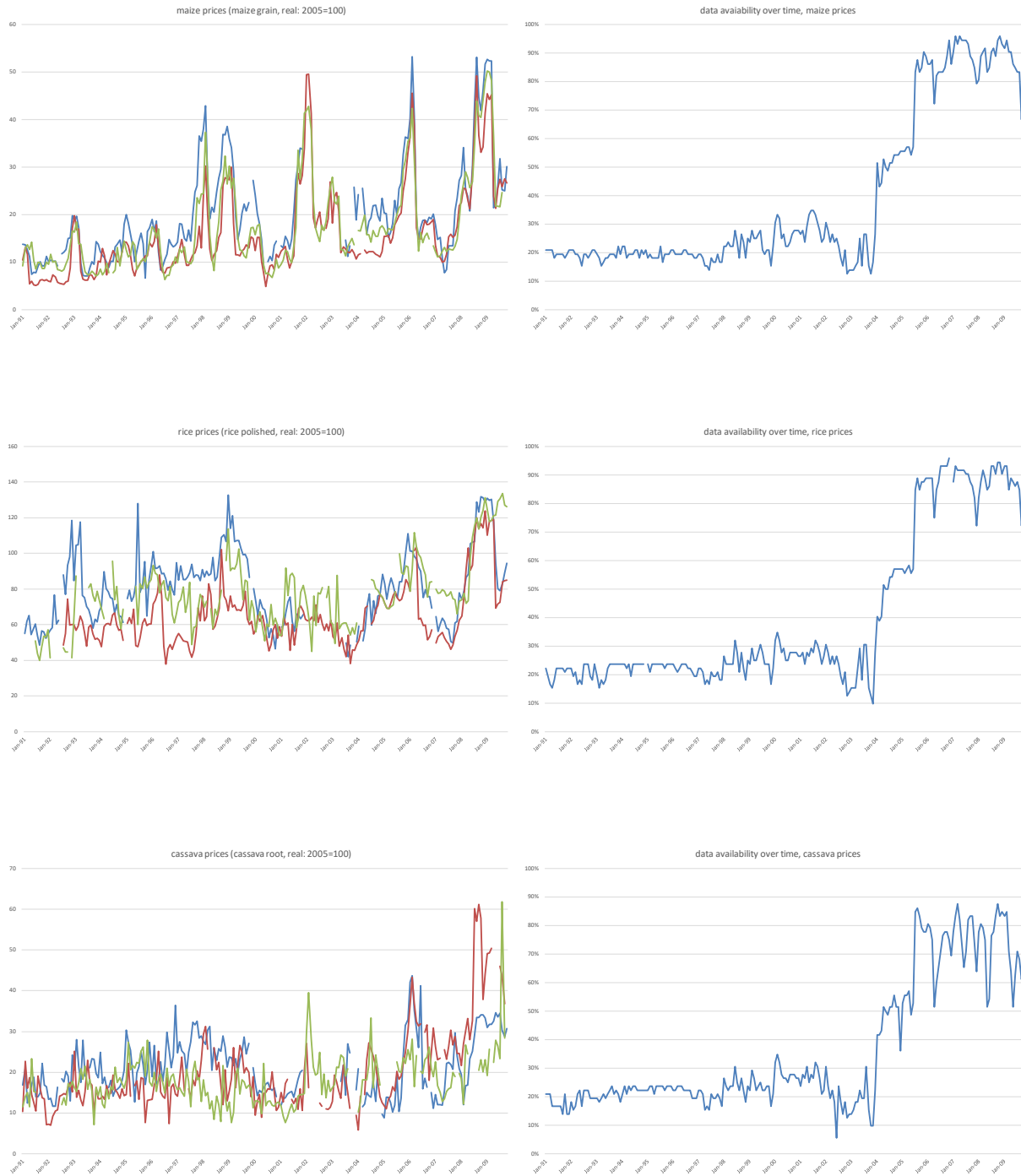
Districts of Agricultural Development Divisions (ADD) are: ADD1, Karonga: Chitipa, Karonga; ADD2, Mzuzu: Rumphi, Nkhatabay, Mzimba; ADD3, Kasungu: Kasungu, Ntchisi, Dowa, Mchinji; ADD4, Lilongwe: Lilongwe, Dedza, Ntcheu; ADD5, Salima: Nkhotakota, Salima; ADD6, Blantyre: Mwanza, Blantyre, Chiradzulu, Phalombe, Mulanje, Thyolo; ADD7, Machinga: Mangochi, Machinga, Balaka, Zomba; ADD8: Shire Valley: Chikwawa and Nsanje.

Figure A2 Price development and price data availability



Note to figures: Staple food and meat prices are 2005 constant prices, deflated with the national consumer price index, for three selected markets for which many observations are available. Data availability shows the share of locations / markets (72 in total) for which price data are available. Source: Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi.

Figure A2 Price development and price data availability (continued)



Note to figures: Staple food and meat prices are 2005 constant prices, deflated with the national consumer price index, for three selected markets for which many observations are available. Data availability shows the share of locations / markets (72 in total) for which price data are available. Source: Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi.

Figure A3 Within-season return for maize, rice and cassava

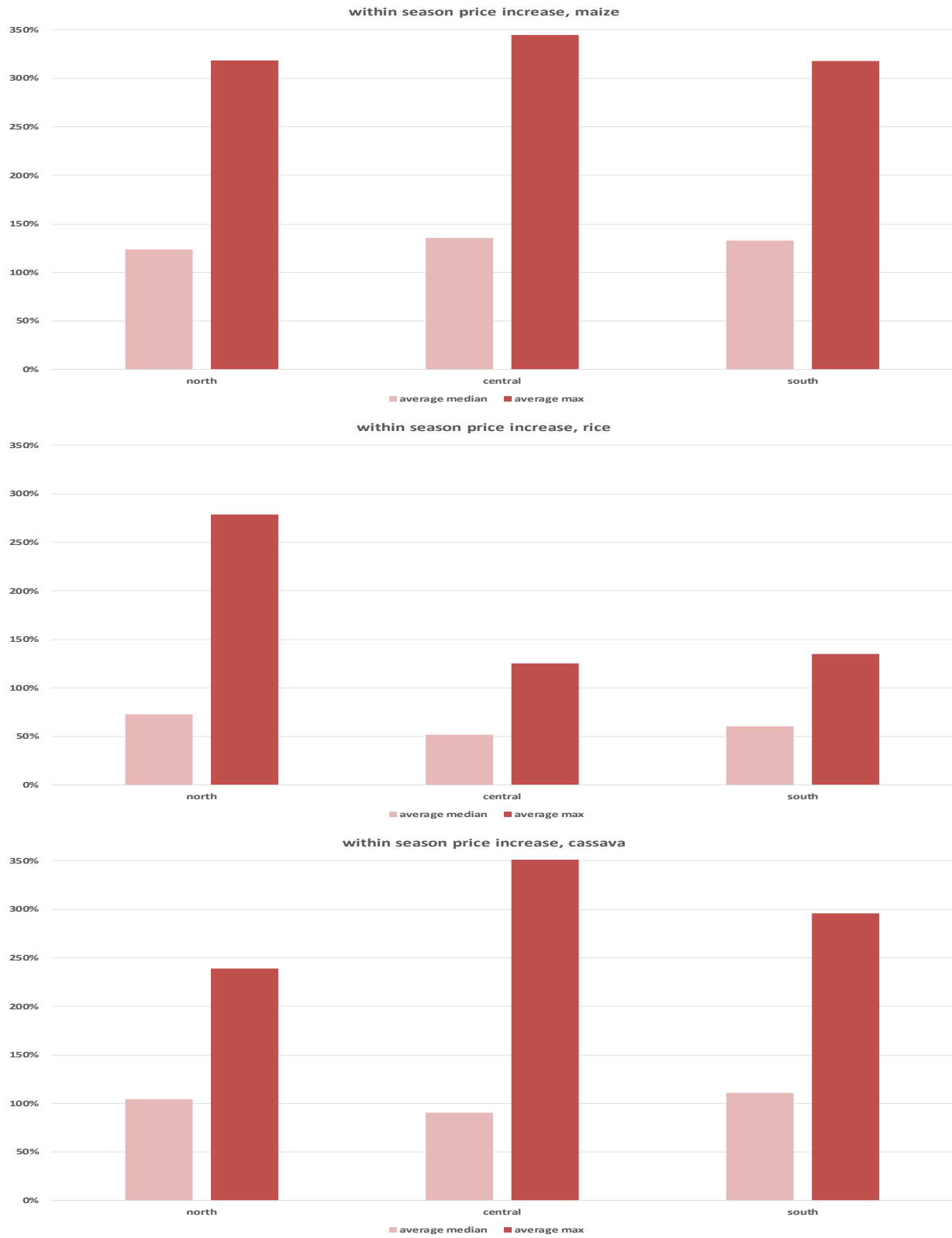
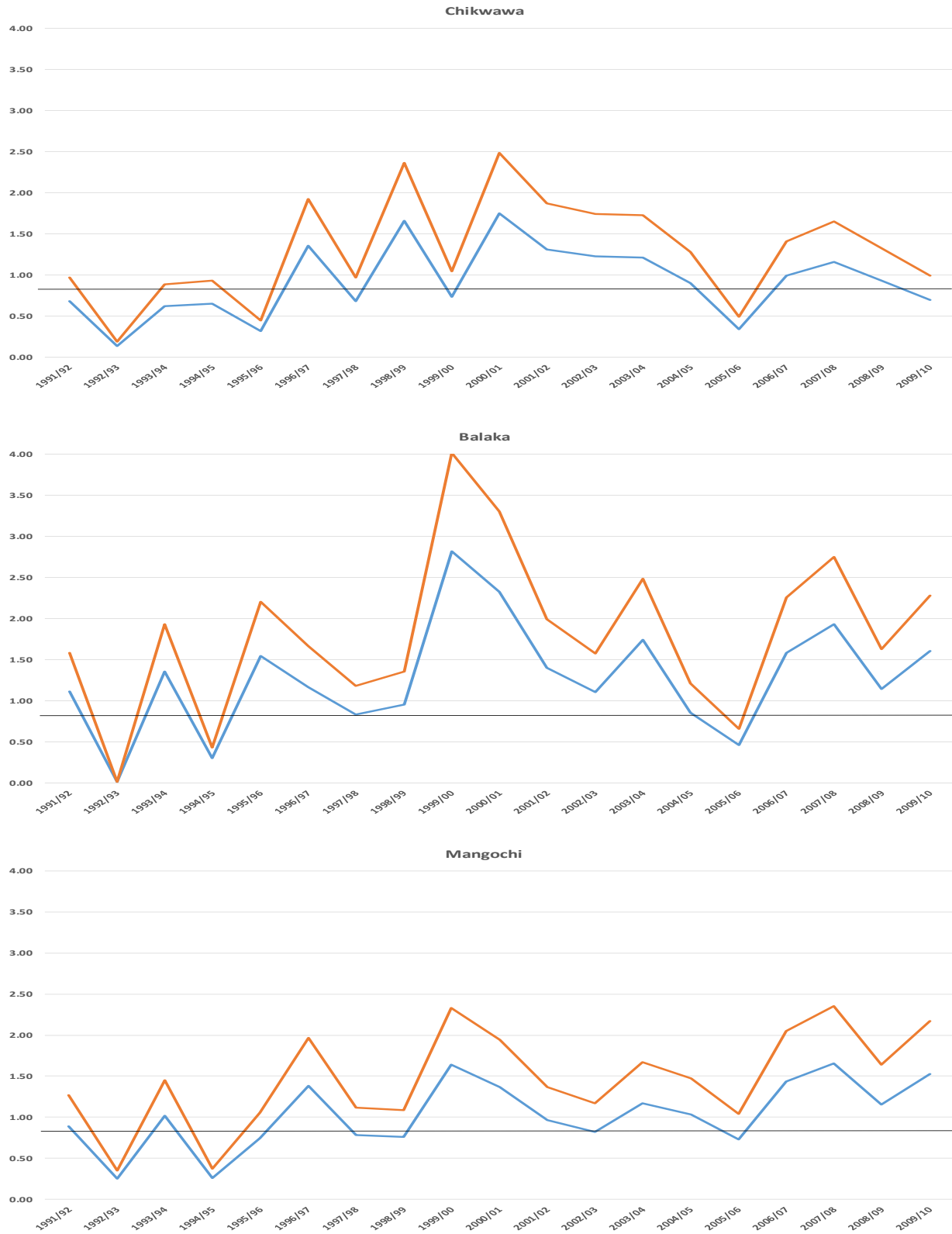


Figure A4 Last season maize production relative to current season maize requirements



Note to figures: the upper and lower line refer to differences in the construction of requirements (2100-2300kcal pppd; maize share in diet: 50%-60%).

Table A1 Annual rainfall from April to March, by district (Rural Development Project)

region	ADD	district		1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
north	Karonga	Chitipa	1	1166.3	862.7	1005.9	783.9	611.9	907.6	1010.7	863.8	1362.9	847.6	646.6	976.6	878.7	939.3	938.7	1079.0	969.9	1021.1	808.8	898.2	1018.0
north	Karonga	Karonga	2	779.5	828.6	908.0	872.4	481.9	740.1	1047.1	484.1	1332.5	889.2	745.4	1168.8	1269.0	918.8	1189.2	1081.0	1083.5	819.1	898.1	1029.4	922.6
north	Mzuzu	Rumphi	3	720.5	612.2	334.6	676.9	487.3	609.7	744.0	677.3	595.1	589.2	471.7	660.3	793.5	729.3	755.0	689.3	524.3	781.0	748.0	768.3	820.3
north	Mzuzu	Mzimba	4	1004.4	825.4	670.7	749.9	721.3	790.3	931.1	683.4	806.3	952.9	701.8	1026.4	916.5	874.9	940.3	891.8	668.8	940.8	801.9	787.6	775.2
north	Mzuzu	Nkhataba	5	1666.2	1552.3	991.1	1253.8	1083.8	1404.9	1724.0	1181.9	1590.9	2066.3	1154.0	1520.8	1652.4	1562.3	1604.9	1062.7	1386.3	1338.4	1441.4	1328.3	1485.1
central	Kasungu	Kasungu	6	919.3	803.7	554.1	880.2	836.9	537.1	938.7	885.7	915.3	869.3	612.2	936.5	669.5	1061.0	835.6	918.3	611.5	1135.1	657.6	720.6	773.8
central	Kasungu	Mchinji	11	1051.0	765.7	673.0	1115.0	806.1	539.0	862.6	851.7	1338.6	1433.2	825.4	1705.4	869.5	1173.3	840.3	691.1	1454.7	1219.8	1129.0	1183.4	1019.8
central	Kasungu	Ntchisi	8	851.9	714.7	582.3	837.5	595.1	655.7	916.8	748.3	1199.9	893.7	674.6	1452.0	743.4	1004.7	688.1	781.9	734.8	1034.7	917.8	706.5	1113.5
central	Kasungu	Dowa	9	851.6	728.1	622.6	885.0	581.4	658.1	975.9	782.5	1136.8	923.5	682.1	1305.1	861.4	1037.2	666.6	797.9	768.8	924.4	989.1	740.5	1004.1
central	Salima	Salima	10	1036.3	1042.1	1002.8	1297.7	828.7	490.5	1124.9	1196.0	1621.5	1194.2	762.6	1386.8	1467.6	1566.9	1059.3	883.9	1570.8	1313.3	1236.9	1235.7	967.5
central	Salima	Nkhotako	7	1438.3	1305.4	992.7	2052.8	1001.6	1042.8	1198.3	1301.8	1658.7	1246.1	1558.7	1697.8	1387.4	1190.0	1277.4	1261.6	1332.9	1287.3	1520.4	2049.7	884.3
central	Lilongwe	Lilongwe	12	1025.0	708.6	652.4	940.1	625.1	536.0	1048.1	837.0	1078.4	1171.4	678.0	979.7	882.4	1077.1	737.9	811.2	780.3	924.7	979.6	830.3	725.3
central	Lilongwe	Dedza	13	924.0	930.8	857.8	1203.2	843.0	697.5	897.1	1118.1	902.5	872.9	802.4	861.4	844.1	1264.2	707.2	724.0	914.6	895.8	1025.7	962.1	979.2
central	Lilongwe	Ntcheu	15	812.9	1019.2	519.9	971.8	790.8	917.1	922.5	1285.0	971.5	920.5	861.3	888.4	960.1	1323.6	741.9	846.2	1051.0	1029.8	1050.4	984.9	912.4
south	Machinga	Mangochi	14	762.2	912.9	585.3	883.4	414.7	422.7	873.0	1306.1	721.6	707.9	766.9	1236.1	854.1	1109.5	561.3	744.4	900.9	1086.7	928.5	880.9	851.0
south	Machinga	Machinga	16	841.1	979.9	641.5	956.5	542.9	614.0	1029.8	1541.5	870.4	931.3	769.0	1325.2	896.8	1076.9	791.9	739.9	1040.6	1123.6	936.5	862.7	796.8
south	Machinga	Balaka	17	706.0	933.5	357.3	772.4	675.0	871.0	738.2	1350.3	722.2	1099.4	803.0	927.5	907.9	689.9	969.0	487.9	1047.8	941.6	676.4	667.0	464.1
south	Machinga	Zomba	18	947.3	992.4	684.4	979.2	637.7	695.3	1126.7	1399.3	1058.5	1158.8	840.3	1420.3	931.4	1048.5	813.9	781.1	1189.1	1091.8	1072.1	965.1	932.9
south	Blantyre	Phalombe	24	1300.4	1236.4	849.1	1316.0	882.1	997.4	1378.7	1526.3	1374.9	1547.9	1044.8	1663.7	1223.4	1346.5	937.3	1018.9	1419.2	1266.2	1184.0	1266.0	1123.0
south	Blantyre	Mwanza	19	973.5	802.3	469.8	878.9	1204.5	1315.7	675.2	1478.9	1316.0	1114.1	829.9	1241.3	1062.1	988.5	632.8	792.4	1063.9	805.8	839.0	657.0	616.0
south	Blantyre	Neno	20	924.7	810.1	515.5	845.1	1077.3	1123.3	748.7	1467.0	1233.6	1074.3	814.0	1207.7	1010.8	940.0	626.2	724.6	1068.4	847.8	857.3	702.0	671.8
south	Blantyre	Blantyre	21	821.4	851.4	589.4	932.9	760.7	677.4	1015.9	1414.7	1065.6	1179.5	860.4	1304.1	953.3	875.3	690.8	595.4	1164.5	1068.1	951.5	913.9	940.3
south	Blantyre	Chiradzulu	22	748.3	826.8	387.2	836.1	762.0	794.1	968.6	1296.4	1073.1	1219.6	862.3	1379.2	859.9	827.8	643.4	529.8	1178.6	1048.0	873.0	832.0	933.0
south	Blantyre	Mulanje	23	1197.3	1059.1	666.8	1372.5	999.8	1133.2	1436.1	1576.7	1580.0	1927.2	1175.8	1811.2	1635.2	1295.9	938.8	983.6	1495.9	1365.4	1276.9	1324.6	1252.3
south	Blantyre	Thyolo	25	1045.1	904.9	716.6	1224.3	759.2	908.8	1355.1	1609.1	1370.7	1727.4	1085.4	1453.4	1580.6	1085.6	834.0	989.7	1346.4	1258.3	1267.3	1145.8	1108.1
south	Shire Valli	Chikwawa	26	747.3	727.4	450.1	902.7	664.9	737.0	1101.5	1324.3	974.4	1140.0	898.8	1143.9	905.4	884.6	664.4	611.7	925.2	1161.8	1046.7	754.4	659.8
south	Shire Valli	Nsanje	27	948.7	749.1	423.6	984.2	716.7	787.6	1232.1	1202.0	1157.3	1541.6	1011.9	1707.8	930.1	799.1	882.7	618.0	863.6	1053.8	1168.5	842.7	800.0

Note to Table: the darker shades indicate increasingly lower rainfall levels relative to minimum rainfall levels required for vegetative growth (around 700mm per season).

Table A2 Regions, ADDs, RDP and markets

Region	ADD	RDP	Market	region	ADD	RDP	market
North	Karonga	Chitipa	Chitipa	central	Lilongwe	Lilongwe	Nkhoma
North	Karonga	Chitipa	Misuku	central	Lilongwe	Lilongwe	Nsundwe
North	Karonga	Chitipa	Nthalire	central	Lilongwe	Ntcheu	Lizulu
North	Karonga	Karonga	Chilumba	central	Lilongwe	Ntcheu	Ntcheu
North	Karonga	Karonga	Karonga	central	Lilongwe	Ntcheu	Sharpevalley
North	Mzuzu	Mzimba	Embangweni	central	Lilongwe	Ntcheu	Tsangano_To
North	Mzuzu	Mzimba	Jenda	central	Salima	Nkhotakota	Dwangwa
North	Mzuzu	Mzimba	Mzimba	central	Salima	Nkhotakota	Mwansambo
North	Mzuzu	Mzimba	Mzuzu	central	Salima	Nkhotakota	Nkhotakota
North	Mzuzu	NkhataBay	Chintheche	central	Salima	Salima	Salima
North	Mzuzu	NkhataBay	Mpamba	south	Blantyre	Blantyre	Limbe
North	Mzuzu	NkhataBay	Nkhatabay	south	Blantyre	Blantyre	Lunzu
North	Mzuzu	Rumphi	Hewe	south	Blantyre	Blantyre	Ntonda
North	Mzuzu	Rumphi	Rumphi	south	Blantyre	Chiradzulu	Chiradzulu
Central	Kasungu	Dowa	Bowe	south	Blantyre	Mulanje	Muloza
Central	Kasungu	Dowa	Dowa	south	Blantyre	Mwanza	Mwanza
Central	Kasungu	Dowa	Madisi	south	Blantyre	Mwanza	Neno
Central	Kasungu	Dowa	Mponela	south	Blantyre	Phalombe	Migowi
Central	Kasungu	Kasungu	Chamama	south	Blantyre	Phalombe	Phalombe
Central	Kasungu	Kasungu	Chatoloma	south	Blantyre	Thyolo	Bvumbwe
Central	Kasungu	Kasungu	Kasungu	south	Blantyre	Thyolo	Luchenza
Central	Kasungu	Kasungu	Nkhamenya	south	Machinga	Balaka	Balaka
Central	Kasungu	Kasungu	Santhe	south	Machinga	Machinga	Liwonde
Central	Kasungu	Mchinji	Mchinji	south	Machinga	Machinga	Ntaja
Central	Kasungu	Mchinji	Mkanda	south	Machinga	Mangochi	Mangochi
Central	Kasungu	Ntchisi	Malomo	south	Machinga	Mangochi	Monkeybay
Central	Kasungu	Ntchisi	Ntchisi	south	Machinga	Mangochi	Namwera
Central	Lilongwe	Dedza	Bembeke	south	Machinga	Zomba	Jali
Central	Lilongwe	Dedza	Mtakataka	south	Machinga	Zomba	Mayaka
Central	Lilongwe	Dedza	Thete	south	Machinga	Zomba	Thondwe
Central	Lilongwe	Lilongwe	Chimbiya	south	Machinga	Zomba	Zomba
Central	Lilongwe	Lilongwe	Kasiya	south	ShireValley	Chikwawa	Chikwawa
Central	Lilongwe	Lilongwe	Lilongwe	south	ShireValley	Chikwawa	Nchalo
Central	Lilongwe	Lilongwe	Mitundu	south	ShireValley	Chikwawa	Ngabu
Central	Lilongwe	Lilongwe	Nanjiri	south	ShireValley	Nsanje	Bangula
Central	Lilongwe	Lilongwe	Nambuma	south	ShireValley	Nsanje	Nsanje

Additional estimation output

Table A3 Meat Prices and Maize Abundance-Scarcity (OLS), by region

dependent variable: ln(goat meat price)		ln(previous season maize production / current season maize requirements)	
explanatory variable	Jan 1991 – Oct 2009	Jan 2004 – Oct 2009	
North	0.029*** (0.008)	-0.042*** (0.010)	
Central	0.096*** (0.009)	0.046*** (0.009)	
South	0.103*** (0.006)	0.074*** (0.007)	
R ²	0.992	0.954	
no. of observations	5542	3865	
dependent variable: ln(steak&bone price)		ln(previous season maize production / current season maize requirements)	
explanatory variable	Jan 1991 – Oct 2009	Jan 2004 – Oct 2009	
North	0.023*** (0.006)	-0.010 (0.010)	
Central	0.068*** (0.008)	0.033*** (0.009)	
South	0.075*** (0.005)	0.057*** (0.007)	
R ²	0.995	0.953	
no. of observations	5926	3512	
dependent variable: ln(pork price)		ln(previous season maize production / current season maize requirements)	
explanatory variable	Jan 1991 – Oct 2009	Jan 2004 – Oct 2009	
North	0.008 (0.008)	-0.058*** (0.010)	
Central	0.038*** (0.009)	0.005 (0.010)	
South	0.044*** (0.008)	0.043*** (0.008)	
R ²	0.992	0.946	
no. of observations	4999	3585	

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table A4a Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), Jan 1991 – Oct 2009, by region**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	0.043** (0.020)	-0.023 (0.017)	0.028 (0.027)
Central	0.161*** (0.019)	0.089*** (0.018)	0.221*** (0.030)
South	0.186*** (0.015)	0.124*** (0.013)	0.073*** (0.023)
R ²	0.810	0.687	0.485
no. of observations	5121	5199	4802
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	0.069*** (0.014)	-0.013 (0.014)	-0.020 (0.020)
Central	0.108*** (0.017)	0.043*** (0.015)	0.164*** (0.025)
South	0.133*** (0.014)	0.083*** (0.010)	0.029 (0.019)
R ²	0.794	0.716	0.481
no. of observations	5443	5519	5115
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	0.066*** (0.016)	-0.046*** (0.015)	-0.050** (0.022)
Central	0.127*** (0.018)	0.018 (0.017)	0.135*** (0.029)
South	0.144*** (0.016)	0.062*** (0.012)	-0.004 (0.025)
R ²	0.809	0.714	0.529
no. of observations	4779	4719	4386

**Table A4b Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), Jan 2004 – Oct 2009, by region**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	-0.075*** (0.027)	-0.086*** (0.024)	0.109** (0.043)
Central	0.094*** (0.024)	0.090*** (0.022)	0.294*** (0.043)
South	0.188*** (0.018)	0.154*** (0.016)	0.173*** (0.033)
R ²	0.815	0.669	0.518
no. of observations	3685	3642	3300
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	-0.033 (0.027)	-0.033 (0.023)	0.188*** (0.045)
Central	0.075*** (0.025)	0.075*** (0.022)	0.331*** (0.045)
South	0.174*** (0.019)	0.116*** (0.015)	0.202*** (0.035)
R ²	0.806	0.659	0.480
no. of observations	3371	3290	2980
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
North	-0.071*** (0.027)	-0.111*** (0.025)	0.087** (0.044)
Central	0.066** (0.026)	0.032 (0.023)	0.238*** (0.045)
South	0.160*** (0.019)	0.111*** (0.017)	0.140*** (0.035)
R ²	0.812	0.676	0.536
no. of observations	3428	3365	3079

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table A5 Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), around the 1992-1993 food shortage**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.376*	0.570***	-0.163
	(0.223)	(0.214)	(0.230)
R ²	0.832	0.757	0.608
no. of observations	91	115	113
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.224***	0.127	0.109
	(0.066)	(0.084)	(0.076)
R ²	0.738	0.588	0.457
no. of observations	272	284	269
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.110	0.242*	-0.026
	(0.134)	(0.144)	(0.141)
R ²	0.788	0.685	0.742
no. of observations	116	101	87

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table A6 Terms of Trade between Meat Prices and Staple Food Prices
versus Maize Abundance-Scarcity (OLS), around the 1994-1995 food shortage**

	(1)	(2)	(3)
dependent variable: ln(goat meat price)	ln(goat meat price/maize price)	ln(goat meat price/rice price)	ln(goat meat price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.182*** (0.056)	0.133** (0.052)	0.106 (0.078)
R ²	0.706	0.687	0.521
no. of observations	128	158	164
	(1)	(2)	(3)
dependent variable:	ln(steam&bone price/maize price)	ln(steam&bone price/rice price)	ln(steam&bone price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.159*** (0.040)	0.041 (0.027)	0.057 (0.046)
R ²	0.599	0.735	(0.592)
no. of observations	313	354	359
	(1)	(2)	(3)
dependent variable:	ln(pork price/maize price)	ln(pork price/rice price)	ln(pork price/cassava price)
explanatory variable	ln(previous season maize production / current season maize requirements)		
	0.234*** (0.081)	-0.044 (0.071)	-0.013 (0.088)
R ²	0.763	0.743	0.686
no. of observations	143	139	147

Note: The source data are monthly market price observations for 72 locations (markets, villages and towns), from January 1991 to October 2009, taken from Agro-Economic Survey, Ministry of Agriculture and Food Security, Government of Malawi (see data section for further details). Equations are estimated with OLS. All estimations include location (market) and time fixed effects. Robust standard errors are reported in brackets below the coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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