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Abstract

We assess the spatial and intertemporal change patterns of farmland prices using per hectare minimum willingness to accept (WTA) sales and rental prices in Malawi. We use three rounds of nationally representative household farm panel data from the Living Standards Measurement Surveys (LSMS), collected in 2010, 2013 and 2016. We study price changes by splitting the sample in quintiles based on distance from the nearest major city, building on the von Thünen theory and urban growth model. Generally, WTA land prices decrease with distance from urban areas. However, WTA land sales prices increased more sharply between 2010 and 2013 in rural areas (+100% vs. +30% in urban proximity). Conversely, by 2016 land sales prices were again, like in 2010, about three times as high in areas near urban centres compared to remote rural areas. Even though sales prices declined in remote rural areas from 2013 to 2016, rental prices remained high. Using farm level population pressure, we show that local population pressure is a driver of WTA land prices, which is an indicator of land scarcity challenges and a growing demand for land. Although a policy focus in the past decade within Africa has been on the new demand for large scale land transfers in rural areas, we see that shadow land prices in smallholder agriculture in Malawi were affected by this sharp increase in demand as well as by increasing population pressure and urbanization. With growing land scarcity, land markets are becoming more important and need to be factored in when formulating development policies that aim to improve access to land and land use efficiency in both peri-urban and rural areas.

Keywords: Farmland prices, Urban sprawl, von Thünen theory, Hedonic Price Model, Malawi

JEL Codes: Q12, Q24

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1. Introduction

African cities are growing rapidly. This urbanisation is driven by population growth and rural-urban migration (Buhaug & Urdal, 2013; Jedwab, Christiaensen, & Gindelsky, 2015). The United Nations (2014) report shows that the proportion of urban to total population in Sub-Saharan Africa (SSA) is expected to increase by 19 percentage points between 2014 and 2050. This increase in urban population has resulted in some African countries reclassifying their urban boundaries through outward expansion into rural space (Manda, 2013). Considering that most land in SSA is under rural agricultural use, the changes in demand for land have contributed to the growth of land markets in Africa (Holden, Otsuka, & Place, 2010). When these markets work well, they contribute to the transfer of land to more efficient producers at prices that make buyers and sellers better off (ibid). However, there are variations in how well these markets work as they depend on the land tenure institutions, political economy factors and shock effects (Holden et al., 2010).

The land markets in SSA have been subject to a fairly new and growing literature with respect to both macro policy factors like the recent "land grab" fears associated with the 2007/08 spike in world energy and food prices, and the micro factors like population pressure and productivity (Chamberlin & Ricker-Gilbert, 2016; Gough & Yankson, 2000; Holden & Otsuka, 2014; Holden et al., 2010). Despite the existing literature, smallholder agriculture land values and prices have not yet been subject to much research in SSA. Coomes, MacDonald, and de Waroux (2018) and Plantinga, Lubowski, and Stavins (2002) indicated that where land price data is available, studying land prices may give valuable insights on land productivity, profitability, changes in demand and supply, urban development, and overall economic growth. However, land markets have not been very active in much of SSA, such as in countries with dominant customary tenure systems or policies that prohibit or restrict land sales (Holden et al., 2010). Coomes et al. (2018) pointed out that where recorded land prices are not available, use of implicit prices is also important for understanding land market forces. We are only aware of two studies in SSA, by Wineman and Jayne (2017) in Tanzania and by Holden and Bezu (2016) in Ethiopia, that used contingent land valuation methods (CVM) to study the spatial and intertemporal variation in land values. We therefore contribute to fill this research gap in the case of Malawi and provide new insights related to macro and micro economic land market forces. We focus on changing demands during the associated recent "land grab" period after the spike in world energy and food prices, and local level population pressure and urbanisation.

In this study, we benefit from the Willingness to Accept (WTA) sale and rental prices for all land parcels of a nationally representative sample of households from the Living Standards Measurement Surveys (LSMS), collected in 2010, 2013 and 2016 in Malawi. We propose that the use of CVM and WTA prices should give a good picture of perceived land values or shadow prices at household level for the years we have the data. This is because of thin land markets in Malawi (Lunduka, Holden, & Øygard, 2009) and that use of few recorded land prices from actual land transfers are unlikely to be a good representation of non-traded land. Therefore, our objective is to assess the effect of changing demands for agricultural land on agricultural shadow land prices (WTA sales and rental prices) across space and over time. Given the thin nature of land markets in Malawi, we propose that household level population pressure may also have an impact on household shadow prices for land in a country dominated by smallholder agriculture, with a high and growing population density, and with an agricultural policy that strongly emphasizes household food security (Chirwa & Dorward, 2013; Government of Malawi, 2016c). We demonstrate that our findings make economic sense and hope that the study can be useful for the thinking around the development of policies that prevent undesirable land use changes in Malawi.

The remainder of the paper is organised in eight sections. Section two present the theoretical framework and state the hypotheses. Section three briefly discusses the Malawi case, its urban centres and population distribution. In section four, we present the survey methods and data while in section five we discuss the estimation method. Section six gives the descriptive statistics. The results are discussed in section seven and we conclude in section eight.

2. Theoretical framework and hypotheses

The von Thünen theory of agricultural investments and economic rent across space (Angelsen, 2007; Sinclair, 1967) and the Capozza and Helsley (1989) stylized urban growth model generally indicates that farmland prices decrease with increasing distance from urban centres because of transportation costs and the better availability of output markets in urban areas. The classical von Thünen theory states that the economic rent or profit from agricultural use is a function of transport cost, with transport cost being a function of distance to a central market place (Sinclair, 1967). This results in spatial variation of economic rent and agricultural land use, where enterprises with high transport cost, like bulky crops (high weight/value ratio), perishable and highly input intensive enterprises yield higher economic rent close to output market places compared to crops with opposite characteristics. The basic assumption of the von Thünen theory was an isolated state with a market located at the city centre and surrounded by flat land on all sides of the market (Angelsen, 2007; Sinclair, 1967). This demarcated the country into high value and low value agricultural land uses. Thus, the von Thünen theory categories agricultural land use in a Nation as a sequence of concentric circles, starting with locating the high return land use enterprise close to the central market and then low return usage allocated far from the market (Sinclair, 1967).

Although the von Thünen theory still defines agricultural land use value in contemporary States, industrialisation and increase in urban population – that can result in urbanisation and urban sprawl, can also influence rural agricultural land use value even before the actual development of urban infrastructure. According to Sinclair (1967), apart from actual development of urban infrastructure, a high probability of converting land use from rural to urban because of high economic and social ties, creates expectations that influence land use value. Thus, it is this increase in probability of spatial expansion of urban areas into rural areas that contribute to the increase in demand for land by both urban dwellers and rural agricultural land users, amidst land laws on compensation, tenure security, macro and micro economic factors. This expected value of agricultural land therefore changes the agricultural land value function from only accounting for economic rent or profit, to include expected future land use values in peri-urban areas (Sinclair, 1967). This increase in land value (from expected future land use) influences holders of agricultural land to either sell their land to developers/urban users; or re-invest in other higher return enterprises like urban farming (poultry, vegetables or flowers); or hold the land by doing nothing[1] (Sinclair, 1967). This effect decreases with distance from urban margins.

Sinclair (1967) fully detailed the theory of urban growth and its effect on agricultural land use value in line with the von Thünen theory. However, it is the Capozza and Helsley (1989) stylized urban growth model that fully integrated valuation of land in urban and rural areas. The model categories the unit land price into urban, peri-urban and rural areas. The price per unit of land in urban areas is mainly valued based on the cost of converting the land use or development cost that captures capital improvements in land; and the value of accessibility to Central Business District (CBD) or transport cost. The unit land price in peri-urban areas is mainly a function of the value of agriculture land or economic rent; and the expected increase in land value built on the trend of spatial expansion of urban areas. Beyond the urban fringe or in rural areas, per unit land prices are only a function of the economic rent, which is a return from farming investments (Anderson, 2012). The development cost of land in urban area makes

[1] However, without regulations, tenure security or further investments, those who hold land by doing nothing are eventually forced out of farming by high urban taxes, zoning practices and nuisances associated with urban life (Sinclair, 1967).

the unit land prices to be higher than in peri-urban areas, while the expected increase in land value in peri-urban areas makes the unit land price to be higher than in rural areas. In general, this shows a decreasing trend of land prices from urban to rural areas. Therefore both macro and micro-economic factors that influence the development cost, expected land use value and the economic rent based on transaction costs in both non-land and land markets can affect land prices in all areas (Plantinga et al., 2002).

The review of papers by Byerlee and Deininger (2013), Deininger and Byerlee (2011) and White, Borras Jr, Hall, Scoones, and Wolford (2012) shows that demand for agricultural land increased after 2008, especially in SSA following the sharp increase in world energy and food prices in 2007-2008 period. The authors also indicated that the sharp increase in demand for land has been associated with the recent "land grab" fears in Africa, especially in areas with weak land rights and tenure institutions, and for marginalized groups with weak land rights. However, White et al. (2012) indicated that the policy responses and political discussion[2] around these "land grabs" have challenged agents involved in these large scale land transfers, thereby constraining the supply responses to this demand for agricultural land in SSA. On the other hand, literature on land use and urban proximity indicates that spatial expansion of the city or urban area zones in Africa as a function of population growth, migration, economic development and accessibility to the city, increases demand for land nearer urban centres (Briggs, 1991; Horvath, 1969; Kleemann et al., 2017). In Tanzania, Wineman and Jayne (2017) observed that improved incentives for farming, urbanisation, rising population density and improved tenure security are possible drivers or rising land prices. Therefore, our hypotheses

[2] The policy responses include the World Bank seven principles for responsible agro-investments and the Land Governance Assessment Framework (LGAF) that were implemented in many African countries (Deininger, 2011; Deininger, Hilhorst, & Songwe, 2014) while the political discussions include the civil society movements on land grabs in Africa (Campesina, 2011).

assess the extent to which rural land shadow prices (WTA prices) are isolated from the macro shocks and urban growth in Malawi amidst increasing population pressure.

It is essential to recognize that rural and agricultural based economies such as in Malawi are characterized by high transaction costs; imperfect information; thin, missing, or seasonal factor markets (including land); and specific production relations in agriculture (Binswanger & Rosenzweig, 1986). With increasing population pressure at household level, we hypothesize (H1) that the shadow land prices are responsive to household farm level population pressure in rural as well as peri-urban areas. Second, we hypothesize (H2) that high food and energy prices during the associated "land grab" period (2007-2013) induced higher expected profitability in farming among smallholder farmers even in remote rural areas, thereby increasing WTA land prices, and especially the land sales prices. With falling energy and food prices after that, we hypothesize (H3) that rural land prices have fallen after 2013 and that land prices by 2016 are back to the previous low level in rural areas. Finally, we hypothesize (H4) that land sales prices relative to rental prices are higher in peri-urban areas based on the assumption that the sales market nearer urban centres is more associated with transforming land use from agricultural to non-agricultural purposes with higher potential land use values whereas rental markets primarily transfer land for agricultural purposes only.

3. The case of Malawi

Malawi is of particular interest in this study because of the high population density (average of 185 persons per square Km), population projection that shows that proportion of urban population to total population will double between 2014 and 2050, from both natural increase and rural-urban migration (Government of Malawi, 2019; Kalipeni, 1997; Manda, 2013; United Nations, 2014). The economy is also highly dependent on agriculture, both through exports, employment and food security (Government of Malawi, 2017). The country is also among the SSA countries that experienced a high demand for agricultural land between 2009 and 2013, associated with promotion of large-scale commercial farming under programs like the Greenbelt Initiative for Malawi (Chinsinga, 2017). Although an emerging land market is assisting in market based allocation of land, the land markets remain thin and informal in Malawi (Holden, Kaarhus, & Lunduka, 2006; Lunduka et al., 2009). The country has also recently revised and enacted the land and land related acts (Government of Malawi, 2016a, 2016b) aimed at enhancing land tenure security, land transfers and use, which are yet to be implemented. These issues indicate both the current and future land use and land-scarcity challenges important for understanding the dynamic change effects of demand for agricultural land on land price trends in SSA.

Furthermore, Malawian urbanisation rates have also resulted in reclassification of urban boundaries through horizontal expansion as opposed to vertical growth (Manda, 2013), in a country where share of land to agriculture is 56 percent (Government of Malawi, 2002). This has resulted in increased area under urban-rural space, which is key in understanding the effect of spatial expansion of urban areas on farmland prices. According to Manda (2013), Malawi has four major city zones across the country plus town area zones in most districts. The urban city zones are Lilongwe, Blantyre, Mzuzu[3] and Zomba, listed in order of population size (refer to Figure A1 in Appendix). The 2018 population census ranking of the cities based on population density was Blantyre, Zomba, Lilongwe and Mzuzu (Government of Malawi, 2019). The low density in Lilongwe city is from availability of land that has easily facilitated horizontal expansion of urban area zone into urban-rural space (Kalipeni, 1997). Although city councils consider such settlements as informal, the economic and social integration in the urban-rural space creates expectations on land use value beyond agricultural economic rent/profit. Apart from Lilongwe, Manda (2013) also reported that all other cities and most

[3] Mzuzu city is within Mzimba district

town areas in Malawi are reclassifying their urban boundaries into rural areas. This spatial expansion continues to create a wider rural-urban space in Malawi, which is important for this study.

4. Survey methods and data

To assess the spatial and intertemporal change patterns of land price, we used the national representative survey responses to WTA land sale or rent-out prices and their ratio in Malawi[4]. The ratio of prices should reflect long-term relative to short-term investments decisions among respondent households as well as the impact of converting land from agricultural to non-agricultural sectors near urban centres. Land, being a capital asset, a key production factor and a private good, it should be easier to value than many of the public goods that are valued using the contingent valuation method (Horowitz & McConnell, 2002; Roka & Palmquist, 1997).

Our data is from three panel rounds of the Living Standards Measurement Survey–Integrated Surveys on Agriculture (LSMS-ISA) collected in 2010-11, 2013 and 2016-17 in Malawi (The World Bank Group, 2017). The total number of panel households in 2010, as the baseline year was 1,619. According to the Malawi National Statistics Office (NSO), tracking of households was at individual member which resulted in splitting of households into multiple respondent households. This increased the number of panel households to 1,908 in 2013 and 2,508 in 2016. NSO reported that only 4 percent of the households in 2010 were not identified in the subsequent years.

NSO indicated that farmland area in all years was collected using the global positioning system (GPS) for accurate measurements compared to farmer own estimates. On average, 4 percent of the parcels were not measured and these were dropped. On the minimum WTA farmland prices,

[4] The survey questions were "If you were to sell this (parcel) today, how much could you sell it for" and "If you were to rent out this (parcel) today for 12 months, how much could you rent it for".

the survey design had questions on owned land that excluded rented-in, leased, encroached and borrowed land. In 2016, the questions on minimum WTA sales and rental prices were asked at parcel level compared to plot level in the other years[5]. The WTA prices were in Malawi Kwacha[6] and we deflated these prices using a consumer price index (CPI)[7] with 2010 as base year. For the plot data, we summed up the plot level responses to parcel and did the analysis at household parcel level. The use of parcel level data was to control for parcel specific characteristics. On average, each household had two parcels of land. After data cleaning and keeping household-parcel level data for only owned parcel land, the total number of observations used in this paper was 6,011 household-parcels from 1,131 households in 2010, 1,471 households in 2013 and 1,918 households in 2016.

For the spatial variables, NSO collected the distance to the nearest major city at community level through focus group discussions. Composition of the community groups had representation of different age and gender group members, local leaders/chiefs, skilled and unskilled workers. There was no indication of group incentives to bias the estimate hence a proper estimate of distance. We used this measure of distance in kilometre (km) for each Enumeration Areas (EAs) listed in ascending order from the city zone to peri-urban to rural areas for our analysis. The EAs within the city zone had a zero distance, with largest distance representing more remote rural areas. The sample had 102 EAs in 2013 and 2016 but 98 EAs in 2010. We maintained the 102 EAs for our analysis. Within each EA, the number of household-parcel observations varied.

5. Estimation method

[5] Parcel is a continuous piece of land that is not separated by river or path wide enough to allow movement of an ox-cart or vehicle (The World Bank Group, 2017). A parcel can include several plots of different crops under different crop management systems.

[6] One US dollar to Malawi Kwacha (MK) was on average MK156.53 in 2011; MK369.18 in 2013 and MK726.04 in 2017 (Government of Malawi, 2015) and www.rbm.mw.

[7] The data on CPI was obtained from IMF website (International Monetary Fund, 2016)

Since the introduction of value in exchange (Ricardo, 1891), three main estimation methods have been developed to estimate land prices. These are Demand and Supply method; the Net Present Value (NPV) method and Hedonic Price Method (HPM) (Choumert & Phélinas, 2015). Following Rosen (1974), hedonic pricing refers to implicit prices of differentiated products based on their attributes revealed by economic agents. HPM implies that the price of a heterogeneous good consisting of group of distinguishable attributes $\mathbf{Z} = (z_1, z_2, \ldots\ldots, z_k)$, is a function of all these attributes – both intrinsic and extrinsic (Choumert & Phélinas, 2015; Huang, Miller, Sherrick, & Gomez, 2006). At market equilibrium, the price function for the heterogeneous good is $P(\boldsymbol{Z})$, an aggregate of implicit attribute prices $p_j(\boldsymbol{z})$ or Willingness to Accept (WTA) a trade, which is equal to the marginal market prices or Willingness to Pay (WTP) for the attributes of the good, by individual households supplying and demanding the good (Choumert & Phélinas, 2015).

In line with Palmquist (1989), agricultural land or farmland is a heterogonous good where the market equilibrium price $P(\boldsymbol{Z})$ is an aggregate of implicit prices $p_j(\boldsymbol{z})$ based on land attributes. The WTA prices are the implicit or shadow land prices $p_j(\boldsymbol{z})$ for individual households based on their land attributes. Maddison (2000) groups these attributes into non-produced and structural variables. The non-produced variables include the less dynamic attributes like soil quality and climate while the structural attributes include gradually changing variables like population, development of infrastructure and other land uses. Palmquist and Danielson (1989) indicated that changes in any of these attributes changes the implicit price $p_j(\boldsymbol{z})$ of farmland. Thereby changing the individual household bid value or WTA farmland price, subject to productivity factors and household characteristics. This is on the assumption that households are informed about the different attributes of their land and there exist a unified land market

(Maddison, 2000)[8]. Maddison (2000) further indicated that a change in any of the land attributes can have a different impact on land sales and rental prices. Thus, we separately analysed the rate of change in per hectare land sales and rental prices, and their ratio.

To estimate using hedonic price method, Maddison (2000) and Parsons (1990) indicated that this is an empirical issue. However, the function should be additively separable in terms of structural attributes of land and that prices should be independent of quantity. We used a log-linear function specified in equations 1 and 2 for land prices and their ratio, and the per hectare land prices to control for total parcel area.

$$logWTA_{ijkl}^{S/R_o} = \alpha_0 + \beta_1 D_{ikl} + \gamma_t + \sum_{n=2}^{N} \beta_n X_{ijkl} + \sum_{m=N+1}^{M} \beta_m Q_{ijkl} + c_{ij} + \varepsilon_{ijkl} \quad (1)$$

$$logRatioWTA_{ijkl} = \alpha_0 + \beta_1 D_{ikl} + \gamma_t + \sum_{n=2}^{N} \beta_n X_{ijkl} + \sum_{m=N+1}^{M} \beta_m Q_{ijkl} + c_{ij} + \varepsilon_{ijkl} \quad (2)$$

We specify $logWTA_{ijkl}^{S/R}$ as the log of per hectare minimum land prices a household is willing to accept in land sales (S) or rent-out (R_o) markets. $logRatioWTA_{ijkl}$ is the log of the ratio per hectare land prices. After deflating the prices and diving by parcel farmland area (ha) we observed four and seven variables in sales and rental prices respectively, that were below MK1/ha but positive. These were from different households. At the same time, four households only reported sales prices and zero rental prices per parcel. We did not drop these observations and used the Inverse Hyperbolic Sine (IHS)[9] to log transform all land prices (Burbidge, Magee, & Robb, 1988; Friedline, Masa, & Chowa, 2015). To assess the associated micro and macro effects, we used D_{ikl} for household size to land ratio (number of persons per ha) as an indicator

[8] These assumptions hold on farmland because most agriculture households are constantly working on their land and are able to observe both less dynamic and rapidly changing farmland attributes. Most households also trade their agricultural crops on national markets that integrate land markets (Maddison, 2000).

[9] The STATA command is "ihstrans" and the formula for transformation is log(x+sqrt(x^2+1)). This is similar to the log transformation, except that its domain is the entire real line and therefore it is defined at zero. The interpretation of the transformed variable remain percent change without adjustment.

of farm level population pressure and γ_t for year dummy variables to capture the changing trends in line with macro-economic factors.

The household, community and land attribute control variables included; X_{ijkl} for less dynamic and Q_{ijkl} for gradually changing variables. In line with Holden et al. (2010) and Maddison (2000), we consider factors that are less dynamic and separable at household level to include parcel area (GPS measured area); sex of household head; distance to a baseline dwelling location to control for household re-allocating between survey period; soil type (sandy, loam, clay, other types); and one-year lagged drought/irregular rains experience for weather shock effect. At community, the *X* variable was the distance to major weekly markets in line with von Thünen theory. The Q_{ijkl} include age and education of household head; and total livestock units for wealth. We also included a one-year lag of total livestock units per household to account for changes in stock levels. The Appendix Table A1 provide full description of the variables included in the model. The error term is ε_{ijkl} and all the variables are for household-parcel *i*-*j*, from community *k*, and in region *l*. The estimated coefficients are α_0 , β_1 to β_M and the c_{ij} is for household-land-parcel time invariant unobserved heterogeneity.

To facilitate assessment of the dynamic change patterns in per hectare minimum WTA land sales and rental prices, we estimated the rate of change in land prices between 2010, 2013 and 2016 using linear fixed effects estimator. We compared these patterns across five quintiles of distance to an Enumeration Area (EA) from the nearest major city. Specifically, the distance from the city ranged from 0 to 379 km. The 102 EAs were grouped into five categories of 20 EAs each except for the first group that has 22 EAs because we observed that EAs 1 to 26 were within the 0-2 km radius from the city zone area. This was to ensure our analysis focus on land price changes from the peri-urban to rural areas. The quintiles were (1) 1-22 EA within 0-0 km; (2) 23-42 EA within 0-37 km; (3) 43-62 EA within 40-80 km; (4) 63-82 EA within 80-140 km and (5) 83-102 EA within 161-379 km. The use of quintiles was mainly to capture the radial distribution of land prices.

6. Descriptive statistics

We present the summary statistics for the changes in WTA land prices in Figures 1, 2, and 3 and Table 1 in order to clarify price patterns in complementary way. The figures and the table report median prices in each quintile of distance to a nearest major city as opposed to mean values that are subject to outlier influence in contingent valuation methods (Holden & Bezu, 2016). Following the urban growth theory, land prices in the city mainly respond to development cost compared to areas from peri-urban to rural places as discussed above. Thus, our focus is from the peri-urban to rural areas. Figure 1 illustrates that WTA land sales prices from peri-urban to rural areas made close to a parallel shift from 2010 to 2013 while the tendency of higher sales price increase near urban areas become stronger again in 2016. Table 1 below also illustrates this, with land sales prices being about three times as high close to urban areas as compared to remote rural areas.

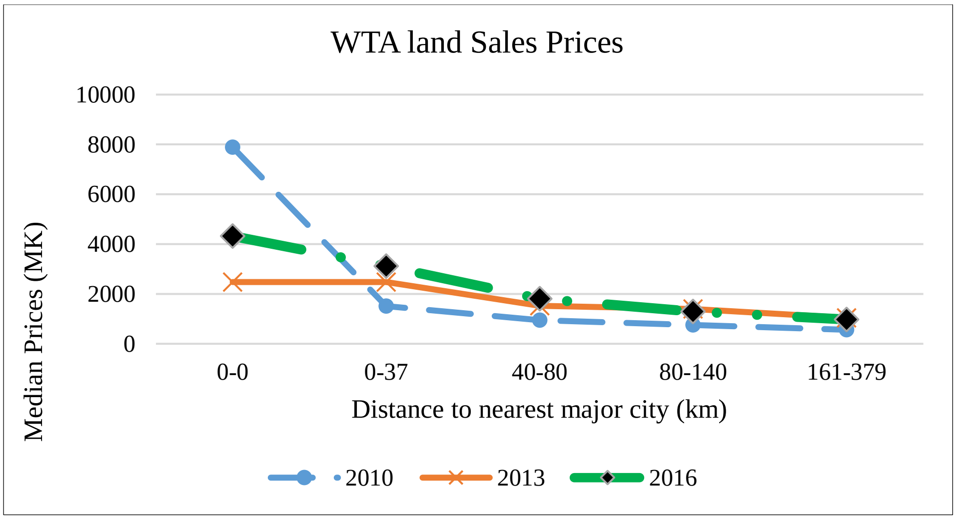

Figure 1: WTA land sales prices over space and time

Table 1: Median deflated WTA land prices over space and time

Variable	Statistic	EA id (number)	Distant range to city (km)	2010	2013	2016
CPI deflated WTA Prices (2000 base year)						
Deflated WTA sale price (MK)/Ha	Median	EA No. 1 – 22	D: 0 – 0	7886	2478	4321
		EA No. 23 – 42	D: 0 – 37	1513	2478	3116
		EA No. 43 – 62	D: 40 – 80	950	1528	1800
		EA No. 63 – 82	D: 80 – 140	751	1394	1299
		EA No. 82 – 102	D: 161 – 379	562	1041	976
Deflated WTA rent-out price (MK)/Ha	Median	EA No. 1 – 22	D: 0 – 0	124	149	158
		EA No. 23 – 42	D: 0 – 37	102	137	144
		EA No. 43 – 62	D: 40 – 80	94	110	122
		EA No. 63 – 82	D: 80 – 140	76	108	107
		EA No. 82 – 102	D: 161 – 379	62	87	96
Deflated WTA ratio-sales/rental price/Ha	Median	EA No. 1 – 22	D: 0 – 0	36	20	20
		EA No. 23 – 42	D: 0 – 37	15	19	20
		EA No. 43 – 62	D: 40 – 80	10	16	14
		EA No. 63 – 82	D: 80 – 140	10	12	11
		EA No. 82 – 102	D: 161 – 379	10	11	10

We observe an almost similar parallel upward shift in rental prices from 2010 to 2013 in Figure 2 and that the change from 2013 to 2016 is minimal across the quintiles. From 2013 to 2016, the rental prices remain relatively higher compared to the sales prices that appeared to have declined to some degree beyond 80 km distance. Table 1 shows that the land rental prices respond much less to urban proximity than land sales prices. While land sales prices were on average 63 percent high in near urban areas as compared to remote rural areas across the years, rental prices were on average only 36 percent higher near urban areas. We also observe this ratio from Figure 3 and Table 1 that present the ratio of WTA land sales and rental prices as per the household responses. It appears that this ratio is on the increase near urban areas but that the increasing ratio has expanded from the near urban areas from 2010 to 2013 and 2016. We suggest that it was the macro-economic changes like high food and energy prices that triggered speculative demands for land and that this also affected smallholder households' WTA selling (shadow) prices for land from 2010 to 2013.

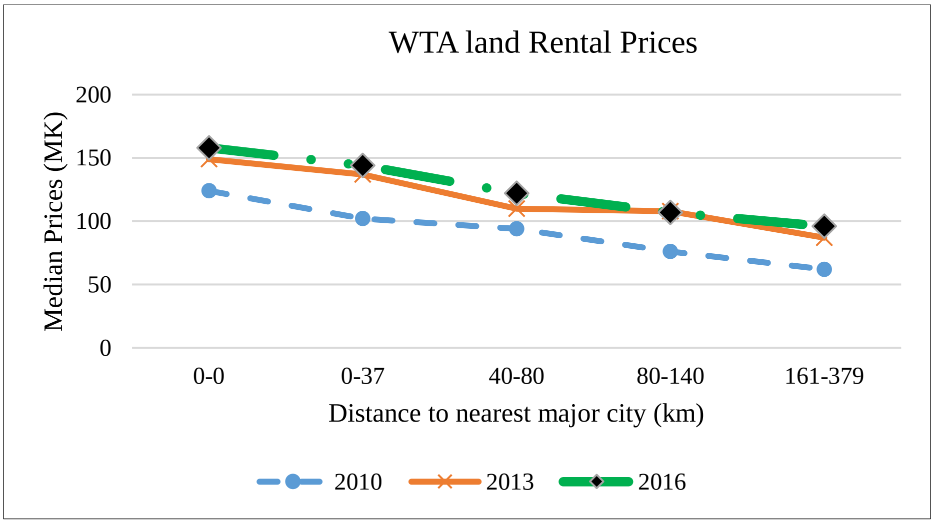

Figure 2: WTA land rental prices over space and time

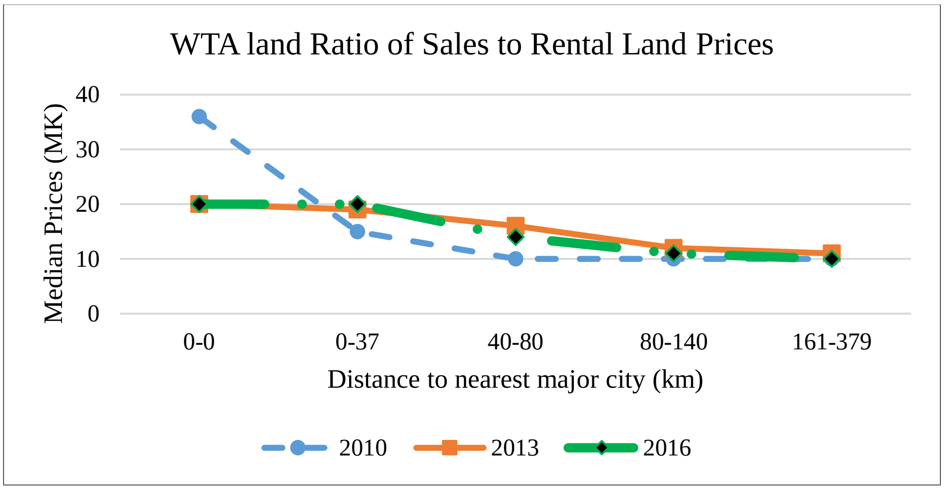

Figure 3. Ratio of WTA land sales to rental prices over space and time

The summary statistics for all the explanatory variables are presented in Appendix Table A2 in order to accommodate quintile statistics. As an indicator of farm level population pressure, Table A2 shows that the mean household size to owned land ratio ranged from 8 to 17 persons per ha with an overall higher ratio within the 37 km radius or in peri-urban areas. However, there were variations across the space and over time as observed from the standard deviations for the mean values. Among the control variables, the mean parcel land holding size across the quintiles ranged from 0.3 to 0.5 ha with higher parcel area in more remote or rural areas across the years. Overall representation of female-headed households was between 17 and 32 percent across the quintiles. On average the households that were tracked in 2013 and 2016 had moved within 2 to 6 km distance from their 2010 baseline location.

7. Results and discussion

Table 2 below presents the main regression results in form of key variables associated with the spatial and intertemporal land prices. The full model results are presented in the Appendix Tables A3, A4 and A5. We assess our hypotheses based on the key regression results presented in Table 2.

Our first hypothesis (H1) was that farmland shadow prices are responsive to household farm level population pressure in rural as well as peri-urban areas. The results show that both land sales and rental shadow prices are positively correlated with farm level population pressure. For a one unit increase in household size to land ratio (number of persons per ha), the increase in WTA prices or land shadow prices range between 0.3 to 0.9 percent across the quintiles. The percent change in both sales and rental markets is relatively higher within the city area zone and the intermediate quintile compared to more remote areas. This may signify the importance of agriculture for own food production even in near urban areas, as it is an important policy objective for households to be self-sufficient in staple food (maize) production in Malawi (Chirwa & Dorward, 2013). Thus, we cannot reject hypothesis H1 and conclude that farmland prices are increasing across the peri-urban and rural areas and that own agricultural production is still important for food security and a driver of land shadow prices in Malawi.

Secondly, we hypothesized (H2) that high food and energy prices during the associated "land grab" period (2007-2013) induced higher expected profitability in farming also among smallholder farmers even in remote rural areas, thereby increasing WTA land prices, and especially the land sales prices. Figures 1-2 and Table 1 in section 6 together with time dummy variables in Table 2 provide relevant evidence. Between 2010 and 2013, the increase in land sales prices is significant from peri-urban to rural area quintiles but not within the city zone. This effect is higher at a distance above 80 km radius compared to areas close the city. This seems to indicate that the macro-economic price increase and sharp increase in investor demand for land penetrated also the smallholder agricultural sector all the way into distant rural areas in Malawi. It is possible that the significant increase in the ratio between land sales and rental prices also is a result of this macro shock which may have affected land sales values more strongly in areas not too far from urban centres. Thus we cannot reject hypothesis H2 and conclude that WTA or shadow land prices among smallholder farmers also in remote rural areas in Malawi responded to changing demands in the period associated with "land grabs" in Africa.

Thirdly, with falling energy and food prices we hypothesized (H3) that rural land prices have fallen after 2013 and that land prices by 2016 are back to the previous low level in rural areas. Figure 1 and the calculated change from 2013 to 2016 in Table 2 demonstrate that land sales prices have remained fairly stable or showed a slight decline in the more remote rural areas compared to peri-urban areas. For the rental prices, we observed a general increase from 2013 to 2016 from peri-urban to rural areas but mainly within the intermediate quintiles. We therefore have to reject our H3 hypothesis. The persistent high or increasing land prices indicate that, despite the fall of world prices and policies that constrained supply of land in rural areas of SSA, there are other upward push factors that have prevented the land sales and rental prices from having fallen back to earlier levels. This shows the competing and growing demand for agricultural land in both peri-urban and rural areas. We controlled for one of the upward push factors in form of the farm level population pressure that we observed to be increasing farmland shadow prices in peri-urban and rural areas of Malawi in this study.

Table 2: Dynamic changes in deflated minimum WTA land prices (IHS transformed prices)

Variable (2010 base year)	EA and distance quintiles				
Number of EA	**1 - 22**	**23 - 42**	**43 - 62**	**63 - 82**	**83 - 102**
Distant range to the city (km)	**0-0 km**	**0-37 km**	**40-80 km**	**80-140 km**	**161-379 km**
Sales model					
Household size to land ratio	0.008****	0.008**	0.009***	0.003*	0.005****
(Number of persons per ha)	(0.0009)	(0.0029)	(0.0028)	(0.0019)	(0.0010)
2013 year	-0.292	0.390****	0.347***	0.634****	0.346***
	(0.2913)	(0.0860)	(0.1077)	(0.0907)	(0.1043)
2016 year	-0.047	0.730****	0.453****	0.495****	0.433****
	(0.2535)	(0.0774)	(0.0976)	(0.1029)	(0.0940)
Other Controls	Yes	Yes	Yes	Yes	Yes
Constant	8.610****	7.860****	7.888****	7.750****	6.772****
	(0.5892)	(0.2559)	(0.1668)	(0.4223)	(0.1239)
Observations	388	1,070	1,847	1,600	1,574
R-squared	0.218	0.125	0.159	0.128	0.158
Number of EA id	22	20	20	20	20
Calculated change: 2013 to 2016	0.245	0.340***	0.106	-0.139	0.087
	(0.3862)	(0.1157)	(0.1454)	(0.1372)	(0.1404)
Rental model					
Household size to land ratio	0.009****	0.006**	0.008****	0.005****	0.004***
(Number of persons per ha)	(0.0015)	(0.0026)	(0.0014)	(0.0010)	(0.0012)
2013 year	0.151	0.103	0.084	0.339***	0.271***
	(0.1091)	(0.0991)	(0.0751)	(0.1001)	(0.0895)
2016 year	0.110	0.266**	0.298****	0.455****	0.450****
	(0.1410)	(0.0953)	(0.0684)	(0.0890)	(0.0637)
Other Controls	Yes	Yes	Yes	Yes	Yes
Constant	5.082****	5.640****	5.668****	5.478****	4.773****
	(0.2707)	(0.1613)	(0.0967)	(0.1806)	(0.1617)
Observations	389	1,076	1,847	1,602	1,575
R-squared	0.303	0.201	0.249	0.237	0.234
Number of EA id	22	20	20	20	20
Calculated change: 2013 to 2016	-0.041	0.157	0.214**	0.116	0.179
	(0.1782)	(0.1375)	(0.1056)	(0.1339)	(0.1099)
Land sales/rental price ratio model					
Household size to land ratio	-0.000	0.001	0.002*	-0.001	0.001***
(Number of persons per ha)	(0.0008)	(0.0008)	(0.0011)	(0.0008)	(0.0003)
2013 year	-0.314	0.318***	0.305***	0.315***	0.086
	(0.3027)	(0.0828)	(0.0850)	(0.1072)	(0.1214)
2016 year	-0.045	0.406****	0.197*	0.066	0.022
	(0.2699)	(0.1016)	(0.1055)	(0.1037)	(0.0862)
Other Controls	Yes	Yes	Yes	Yes	Yes
Constant	3.990****	2.995****	2.909****	3.114****	2.709****
	(0.5567)	(0.1697)	(0.1439)	(0.2942)	(0.1045)
Observations	388	1,062	1,841	1,587	1,565
R-squared	0.081	0.052	0.048	0.030	0.039
Number of EA id	22	20	20	20	20
Calculated change: 2013 to 2016	0.269	0.088	-0.108	-0.249*	-0.640
	(0.4056)	(0.1311)	(0.1355)	(0.1491)	(0.1489)

Note: Robust standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. We calculated the change from 2013 to 2016 by comparing the computed mean differences after the regression results. We used t-test to assess the significance level of the mean difference compared to zero.

Our final hypothesis (H4) was that land sales prices relative to rental prices are higher in areas nearer urban centres. We noted that the rise in the ratio of the sales and rental prices between 2010 and 2013 expanded further into rural areas. By 2016, this trend had been partly reversed. Land sales markets near urban centres may be more associated with transforming land use from agricultural to non-agricultural purposes or new investment in agriculture for urban farming (like poultry, vegetable and flower farms). Such demand may explain the higher and increasing gap between sales and rental prices as we do not think the ratio would have changed if the purpose remained for agricultural use only, and without new investments.

8. Conclusion and Policy Implications

Land markets in Africa are thin and land prices have until recently not been subject to much research. The use of the Contingent Valuation Method (CVM) to study shadow prices for land can nevertheless be useful to assess how the "heat" from market forces is affecting the valuation of land, mainly for non-traded land. We utilize three rounds of nationally representative household-parcel level data (LSMS-ISA) from Malawi where land owners were asked about their minimum WTA selling and rent out prices for their land. Building on the von Thünen theory and urban growth model, we study shadow land sales and rental price trends in peri-urban and rural areas.

The sharp increase in world energy and food prices in the 2007-2008 period is associated with the recent "land grabs" and increased demand for agricultural land in Africa. Our study indicates that this macro policy shock has penetrated into the smallholder sector and affected shadow land prices even in remote rural areas. However, this investor demand for agricultural land has been constrained by the falling energy and food prices after 2013, policy responses and political discussions around these "land grabs" in Africa. Our study demonstrates that other factors, i.e. population pressure at household farm level, urbanisation and urban sprawl contributed to maintaining high shadow land prices from 2013 to 2016.

While much of the land policy focus in the past decade has been on recent large scale land transfers within the agricultural sector in Africa, we see that land shadow prices in smallholder agriculture in Malawi are also affected by the grinding effects of population growth and urbanization. With growing land scarcity, Malawi needs to factor in the emerging land markets when formulating rural and urban development policies. Policy considerations can be on whether land markets can help to improve land use efficiency and whether they can be an affordable avenue for accessing land by land scarce households and the youth.

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Appendix

Map of Malawi

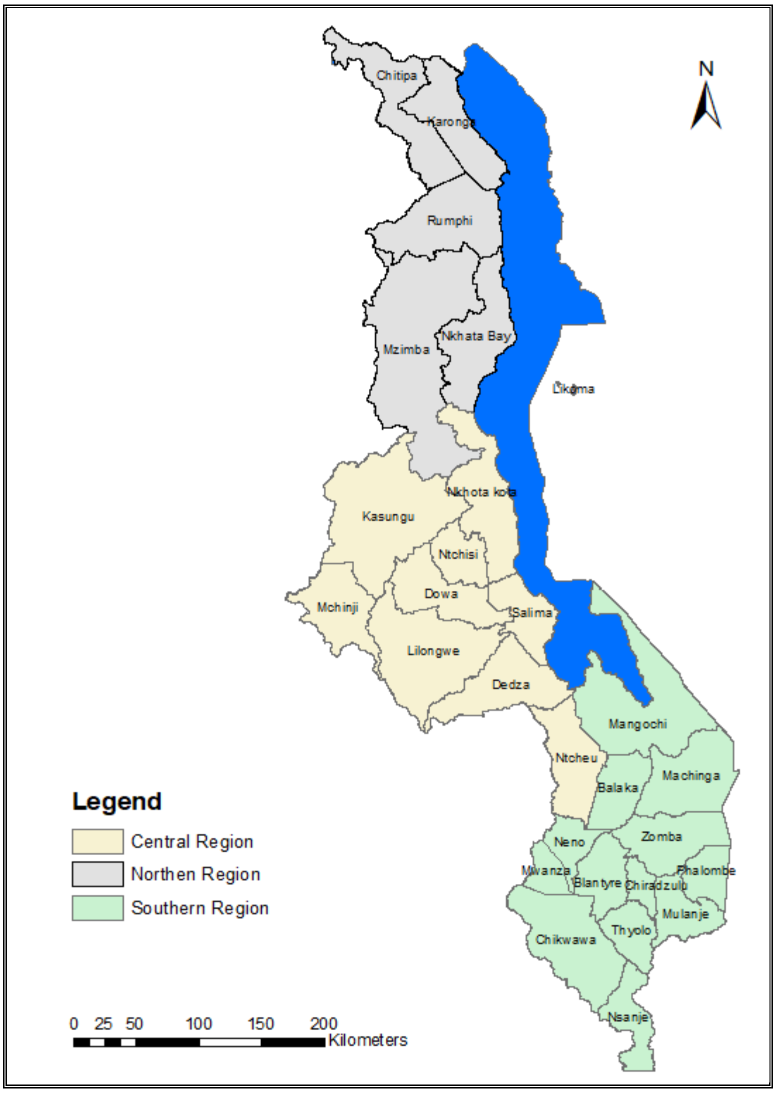

Figure A1: Map of Malawi showing districts

Table A1: Description of variables

Variable	**Descriptions**	**Unit**
Deflated WTA sale price (MK)/Ha	CPI deflated WTA land sales price for each parcel at household level.	MK/ha
Deflated WTA rent-out price (MK)/Ha	CPI deflated WTA land rent out price for each parcel at household level	MK/ha

Deflated WTA ratio-sales/rental price/Ha	CPI deflated WTA land sales to rent out price ratio for each parcel at household level	MK/ha
Distance (KM) to nearest major city)	Distance from a nearest major city in Malawi (Blantyre, Lilongwe, Zomba and Mzuzu) to an Enumeration Area (EA). This was collected through focus group discussion and it is a group estimate. We used this variable to define the quintile (five groups) from city to rural areas. Different units were used to measure distant at EA and we converted them to km.	KM
Distance from 2010 household dwelling (KM)	The NSO reported that 54 percent of households tracked in 2016 had moved from the baseline house location in 2010. The variable shows the distance between the house locations in 2010 compared to 2013 or 2016, mainly for those who were tracked. This is provided in the data in km	KM
Household size to land ratio (number of persons per ha)	An indicator of household farm level population pressure. That is, the number of households members divided by total owned farm size measure in hectares. Although the data was at household parcel, we summed up the parcel area and used total owned farm size for this variable.	Number/ha
GPS measured farmland parcel area (Ha)	Individual parcel area owned by the household. Each parcel was measured with GPS	Ha
One year lagged household drought/irregular experience (1=Yes)	Households were asked if they were experienced drought or irregular rains in the previous rainy season that affected them. The response was a binary with 1=Yes	Dummy

Sex of Household Head (1=Female)	Household member identified as heading the family with 1=Female	Dummy
Education of Household Head (Years)	Number of schooling years attained by the household head (continuous variable)	Years
Age of household head	Age of household head as a continues variable	Years
Distance to Weekly market (KM)	Distance to weekly markets where households can either buy inputs or sell their produce in a week. This distance was estimated through focus group discussions at Enumeration Area and we converted all unit measures into km	KM
Total Livestock Units	A sum of all livestock units based on Livestock units conversion figures for different types of animals	Number
One year lagged Total Livestock Units	Livestock units owned by a household 12 months prior to survey period	Number
Soil type	Categories of soil per parcel into sandy, loamy, clay and other types.	Categorical

Table A2: Summary statistics over space and time

Variable	Statistic	Distance (km)	2010	2013	2016	Variable	Statistics	Distance (km)	2010	2013	2016
CPI deflated WTA Prices (2000 base year)						**Control Variables**					
Deflated WTA sale price (MK)/Ha	Median	D: 0 – 0	7886	2478	4321	Sex of Household Head (1=Female)	Percent	D: 0 – 0	9.57	14.03	19.17
		D: 0 – 37	1513	2478	3116			D: 0 – 37	19.39	24.48	32.03
		D: 40 – 80	950	1528	1800			D: 40 – 80	27.00	28.27	30.71
		D: 80 – 140	751	1394	1299			D: 80 – 140	20.96	16.92	19.18
		D: 161 – 379	562	1041	976			D: 161 – 379	19.70	23.88	30.55
Deflated WTA rent-out price (MK)/Ha	Median	D: 0 – 0	124	149	158	Age of household head	Mean	D: 0 – 0	39	44	48
		D: 0 – 37	102	137	144			D: 0 – 37	44	46	47
		D: 40 – 80	94	110	122			D: 40 – 80	47	48	49
		D: 80 – 140	76	108	107			D: 80 – 140	43	45	47
		D: 161 – 379	62	87	96			D: 161 – 379	44	45	46
Deflated WTA ratio-sales/rental price/Ha	Median	D: 0 – 0	36	20	20	Education of Household Head (Years)	Mean	D: 0 – 0	7.21	7.76	6.73
		D: 0 – 37	15	19	20			D: 0 – 37	5.12	5.34	5.34
		D: 40 – 80	10	16	14			D: 40 – 80	4.31	4.76	4.54
		D: 80 – 140	10	12	11			D: 80 – 140	4.88	5.20	5.18
		D: 161 – 379	10	11	10			D: 161 – 379	4.96	4.71	4.96
Key Explanatory Variables											
Household size to land ratio (number of persons per ha)	Mean (std. dev.)	D: 0 – 0	18.45 (20.2)	20.37 (63.5)	16.22 (18.7)	Total Livestock Units	Mean (Std. dev.)	D: 0 – 0	0.19 (0.43)	0.31 (0.51)	0.60 (1.80)
		D: 0 – 37	12.78 (16.6)	16.34 (40.1)	14.31 (21.0)			D: 0 – 37	0.35 (0.85)	0.33 (0.79)	0.33 (0.85)
		D: 40 – 80	8.20 (7.6)	11.55 (29.3)	9.85 (12.9)			D: 40 – 80	0.34 (0.70)	0.36 (0.88)	0.35 (0.88)
		D: 80 – 140	10.05 (29.8)	16.60 (69.6)	8.58 (20.3)			D: 80 – 140	0.34 (0.69)	0.73 (3.68)	0.89 (6.36)
		D: 161 – 379	11.39 (36.7)	10.69 (10.3)	9.82 (11.7)			D: 161 – 379	0.47 (0.99)	0.49 (1.08)	0.52 (1.19)
Control Variables											
	Mean	D: 0 – 0	0.39 (0.25)	0.41 (0.41)	0.45 (0.48)	Lag Total Livestock Units	Mean	D: 0 – 0	0.24 (0.40)	0.14 (0.26)	0.32 (0.64)

	(Std. dev.)	D: 0 – 37	0.39	0.30	0.31		(Std. dev.)	D: 0 – 37	0.24	0.19	0.25
			(0.36)	(0.23)	(0.32)				(0.51)	(0.41)	(5.17)
GPS measured farmland parcel area (Ha)		D: 40 – 80	0.38	0.35	0.37			D: 40 – 80	0.31	0.28	0.31
			(0.29)	(0.32)	(0.37)				(0.54)	(0.45)	(0.46)
		D: 80 – 140	0.41	0.43	0.53			D: 80 – 140	0.28	0.15	0.35
			(0.34)	(0.38)	(0.46)				(0.47)	(0.40)	(1.12)
		D: 161 – 379	0.44	0.43	0.46			D: 161 – 379	0.38	0.20	0.29
			(0.40)	(0.39)	(0.42)				(0.70)	(0.51)	(0.84)
Distance to Weekly market (KM)	Mean	D: 0 – 0	6.23	13.46	4.21	One year lagged household drought/irregular experience (1=Yes)	Percent	D: 0 – 0	20.53	14.06	27.22
		D: 0 – 37	2.72	2.14	6.18			D: 0 – 37	51.58	37.23	55.53
		D: 40 – 80	4.39	4.57	5.67			D: 40 – 80	47.93	36.11	40.97
		D: 80 – 140	3.58	3.80	3.37			D: 80 – 140	55.86	31.71	50.11
		D: 161 – 379	5.25	4.58	5.50			D: 161 – 379	54.89	29.73	41.96
Distance (KM) to nearest major city)	Mean	D: 0 – 0	0.00	0.00	0.00	Distance from 2010 household dwelling (KM)	Mean	D: 0 – 0	-	32.33	52.24
		D: 0 – 37	27.31	27.75	27.25			D: 0 – 37	-	4.72	5.24
		D: 40 – 80	61.31	60.08	60.09			D: 40 – 80	-	4.86	4.95
		D: 80 – 140	109.76	109.67	110.00			D: 80 – 140	-	3.12	5.83
		D: 161 – 379	229.34	222.82	217.56			D: 161 – 379	-	4.22	2.43
Sample Size	N	D: 0 – 0	53	147	195						
		D: 0 – 37	237	359	487						
		D: 40 – 80	484	624	763						
		D: 80 – 140	419	571	626						
		D: 161 – 379	407	544	633						

Note: The number of EAs in each distance quintile is **(1)** 1 to 22 EAs for 0 – 0 km; **(2)** 23 to 42 EAs for 0 – 37 km; **(3)** 43 to 62 EAs for 40 – 80 km; **(4)** 63 to 82EAs for 80 – 140 km; **(5)** 83 to 102 EAs for 161 – 379 km.

Table A3: Dynamic changes in deflated minimum WTA land prices (IHS transformed prices)–Hedonic Price Model with linear fixed effect estimator

Number of EA	**Model A: 0 < EA No. <= 22**			**Model B: 22 < EA No. <= 42**		
Distance to nearest major city (km)	**0 to 0 km**			**0 to 37 km**		
VARIABLES	**1a: Sales Prices**	**2a: Rental Prices**	**3a: Ratio Prices**	**1b: Sales Prices**	**2b:Rental Prices**	**3b:Ratio Prices**
Household size to land ratio	**0.008******	**0.009******	-0.000	**0.008****	**0.006****	0.001
(Number of persons per ha)	**(0.0009)**	**(0.0015)**	(0.0008)	**(0.0029)**	**(0.0026)**	(0.0008)
weekly market distance (KM)	0.003	**-0.014***	0.011	0.003	-0.003	**0.013****
	(0.0119)	**(0.0079)**	(0.0080)	(0.0046)	(0.0034)	**(0.0051)**
Farmland parcel area (Hectares)	**-0.574*****	**-0.530*****	-0.059	**-0.665*****	**-0.914******	0.129
	(0.1731)	**(0.1743)**	(0.0877)	**(0.1840)**	**(0.1386)**	(0.0852)
distance to IHS3location (KM)	**-0.003*****	-0.001	**-0.002****	-0.005	-0.001	-0.004
	(0.0009)	(0.0004)	**(0.0009)**	(0.0032)	(0.0014)	(0.0025)
Total Livestock Units	0.000	0.018	-0.002	0.010	0.017	-0.034
	(0.0244)	(0.0210)	(0.0221)	(0.0412)	(0.0194)	(0.0245)
Lag-total livestock units	0.015	-0.057	0.086	0.002	**0.002***	0.001
	(0.1427)	(0.0742)	(0.0908)	(0.0017)	**(0.0008)**	(0.0010)
Household head sex (1=Female)	0.020	0.167	-0.008	**-0.141****	**-0.124***	-0.068
	(0.1697)	(0.1172)	(0.1346)	**(0.0520)**	**(0.0668)**	(0.0773)
Household head age	0.004	0.006	-0.002	0.003	0.001	0.001
	(0.0059)	(0.0035)	(0.0068)	(0.0030)	(0.0016)	(0.0021)
Household head education (Years)	-0.006	**0.030***	-0.015	0.006	0.001	0.008
	(0.0229)	**(0.0166)**	(0.0169)	(0.0136)	(0.0077)	(0.0136)
One year lagged household drought/irregular	-0.205	-0.089	-0.111	**-0.165***	-0.056	-0.082
experience (1=Yes)	(0.1815)	(0.1092)	(0.1817)	**(0.0870)**	(0.0581)	(0.0765)
Soil Type - Compared to sandy soil						
Loam soil	0.056	0.176	-0.116	0.073	-0.071	0.120
	(0.1995)	(0.1382)	(0.1367)	(0.0965)	(0.0612)	(0.0897)
Clay soil	-0.062	0.149	-0.256	0.157	-0.060	**0.230****
	(0.2715)	(0.1232)	(0.2399)	(0.1184)	(0.0696)	**(0.1017)**
Others types	0.313	0.136	0.127	0.072	**-0.280****	**0.393****
	(0.5106)	(0.2817)	(0.3522)	(0.1832)	**(0.1120)**	**(0.1693)**
Region (Compared to Central region)						

Northern region	0.627	0.027	0.518	**2.328*** **	**2.642***** **	-0.326
	(0.5705)	(0.2545)	(0.3863)	**(0.6412)**	**(0.3092)**	(0.4951)
Southern region	**1.166** **	-0.002	**1.184*** **			
	(0.4274)	(0.1742)	**(0.3547)**			
2013.year	-0.292	0.151	-0.314	**0.390***** **	0.103	**0.318*** **
	(0.2913)	(0.1091)	(0.3027)	**(0.0860)**	(0.0991)	**(0.0828)**
2016.year	-0.047	0.110	-0.045	**0.730***** **	**0.266** **	**0.406***** **
	(0.2535)	(0.1410)	(0.2699)	**(0.0774)**	**(0.0953)**	**(0.1016)**
Constant	8.610****	5.082****	3.990****	7.860****	5.640****	2.995****
	(0.5892)	(0.2707)	(0.5567)	(0.2559)	(0.1613)	(0.1697)
Observations	388	389	388	1,070	1,076	1,062
R-squared	0.218	0.303	0.081	0.125	0.201	0.052
Number of EA id	22	22	22	20	20	20

Note: Robust standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Dynamic changes in deflated minimum WTA land prices (IHS transformed prices)–Hedonic Price Model with linear fixed effect estimator

Number of EA	**Model C: 42 < EA No. <= 62**			**Model D: 62 < EA No. <= 82**		
Distance to nearest major city (km)	**40 to 80 km**			**80 to 140 km**		
VARIABLES	**1c: Sales Prices**	**2c: Rental Prices**	**3c: Ratio Prices**	**1d: Sales Prices**	**2d:Rental Prices**	**3d:Ratio Prices**
Household size to land ratio	**0.009*** **	**0.008***** **	**0.002***	**0.003***	**0.005***** **	-0.001
(Number of persons per ha)	**(0.0028)**	**(0.0014)**	**(0.0011)**	**(0.0019)**	**(0.0010)**	(0.0008)
weekly market distance (KM)	0.012	-0.018	**0.031***	-0.006	-0.008	0.004
	(0.0205)	(0.0222)	**(0.0170)**	(0.0111)	(0.0111)	(0.0119)
Farmland parcel area (Hectares)	**-0.958***** **	**-1.033***** **	0.093	**-0.708***** **	**-0.861***** **	**0.140** **
	(0.0864)	**(0.0952)**	(0.0722)	**(0.1249)**	**(0.1044)**	**(0.0634)**
distance to IHS3location (KM)	0.002	-0.000	0.002	0.001	0.001	0.000
	(0.0017)	(0.0009)	(0.0013)	(0.0031)	(0.0012)	(0.0020)
Total Livestock Units	-0.001	**-0.058*** **	0.027	-0.002	0.003	-0.006
	(0.0396)	**(0.0190)**	(0.0368)	(0.0044)	(0.0033)	(0.0054)
Lag-total livestock units	0.022	**0.055***	0.019	0.053	-0.008	0.082

	(0.0507)	**(0.0284)**	(0.0606)	(0.0747)	(0.0521)	(0.0799)
Household head sex (1=Female)	**-0.240*** **	-0.039	**-0.154** **	0.025	-0.041	0.076
	(0.0794)	(0.0708)	**(0.0590)**	(0.0812)	(0.0530)	(0.0470)
Household head age	-0.002	-0.002	-0.000	-0.000	**-0.003***	0.002
	(0.0021)	(0.0018)	(0.0017)	(0.0022)	**(0.0014)**	(0.0019)
Household head education (Years)	**0.028** **	0.006	**0.023** **	0.011	0.005	0.006
	(0.0120)	(0.0072)	**(0.0100)**	(0.0072)	(0.0051)	(0.0069)
One year lagged household drought/irregular	-0.070	**-0.111** **	0.049	0.142	0.078	0.083
experience (1=Yes)	(0.0761)	**(0.0475)**	(0.0866)	(0.0906)	(0.0475)	(0.0788)
Soil Type - Compared to sandy soil						
Loam soil	**0.177*** **	**0.129***	-0.005	0.028	0.074	-0.055
	(0.0581)	**(0.0740)**	(0.0918)	(0.0993)	(0.0831)	(0.0725)
Clay soil	0.065	0.022	-0.006	0.051	0.038	-0.026
	(0.0608)	(0.0878)	(0.0907)	(0.1125)	(0.1047)	(0.0625)
Others types	0.171	0.152	-0.038	**0.197***	0.034	0.143
	(0.1171)	(0.0949)	(0.1688)	**(0.1132)**	(0.1484)	(0.1971)
Regional (Compared to central region)						
Northern region	**-1.141** **	**1.145**** **	**-2.201**** **			
	(0.5256)	**(0.2942)**	**(0.4060)**			
Southern region				-0.505	-0.142	-0.579
				(0.7387)	(0.3040)	(0.4697)
2013.year	**0.347*** **	0.084	**0.305*** **	**0.634**** **	**0.339*** **	**0.315*** **
	(0.1077)	(0.0751)	**(0.0850)**	**(0.0907)**	**(0.1001)**	**(0.1072)**
2016.year	**0.453**** **	**0.298**** **	**0.197***	**0.495**** **	**0.455**** **	0.066
	(0.0976)	**(0.0684)**	**(0.1055)**	**(0.1029)**	**(0.0890)**	(0.1037)
Constant	7.888****	5.668****	2.909****	7.750****	5.478****	3.114****
	(0.1668)	(0.0967)	(0.1439)	(0.4223)	(0.1806)	(0.2942)
Observations	1,847	1,847	1,841	1,600	1,602	1,587
R-squared	0.159	0.249	0.048	0.128	0.237	0.030
Number of EA id	20	20	20	20	20	20

Note: Robust standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1

Table A5: Dynamic changes in deflated minimum WTA land prices (IHS transformed prices)–Hedonic Price Model with linear fixed effect estimator

Number of EA		**Model E: 82 < EA No. <= 102**	
Distance to nearest major city (km)		**161 to 379 km**	
VARIABLES	**Model 1e - Sales Values**	**Model 2e - Rental Values**	**Model 3e - Ratio Value**
Household size to land ratio (Number of persons per ha)	**0.005******	**0.004*****	**0.001*****
	(0.0010)	**(0.0012)**	**(0.0003)**
weekly market distance (KM)	**-0.020***	-0.001	**-0.019***
	(0.0101)	(0.0086)	**(0.0093)**
Farmland parcel area (Hectares)	**-0.814******	**-0.844******	-0.018
	(0.1393)	**(0.1400)**	(0.0494)
distance to IHS3location (KM)	0.001	-0.003	0.004
	(0.0021)	(0.0019)	(0.0022)
Total Livestock Units	**0.087****	**0.041*****	0.039
	(0.0339)	**(0.0134)**	(0.0269)
Lag-total livestock units	0.110	**0.063***	0.061
	(0.0807)	**(0.0330)**	(0.0697)
Household head sex (1=Female)	0.001	-0.055	0.046
	(0.0860)	(0.0553)	(0.0718)
Household head age	**0.004****	-0.001	**0.005*****
	(0.0015)	(0.0016)	**(0.0015)**
Household head education (Years)	0.016	0.003	0.011
	(0.0104)	(0.0063)	(0.0085)
One year lagged household drought/irregular experience (1=Yes)	-0.028	0.022	-0.042
	(0.0753)	(0.0550)	(0.0582)
Soil Type - Compared to sandy soil			
Loam soil	0.066	-0.052	**0.133****
	(0.0832)	(0.0739)	**(0.0538)**
Clay soil	0.036	-0.061	0.074
	(0.1001)	(0.1083)	(0.0652)
Others types	**-0.202***	0.061	-0.202
	(0.1130)	(0.1016)	(0.1680)
Regional Dummies			

Southern region	**1.793********	**1.737********	0.128
	(0.2557)	**(0.2407)**	(0.2701)
2013.year	**0.346*******	**0.271*******	0.086
	(0.1043)	**(0.0895)**	(0.1214)
2016.year	**0.433********	**0.450********	0.022
	(0.0940)	**(0.0637)**	(0.0862)
Constant	6.772****	4.773****	2.709****
	(0.1239)	(0.1617)	(0.1045)
Observations	1,574	1,575	1,565
R-squared	0.158	0.234	0.039
Number of EA id	20	20	20

Note: Robust standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1