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Farmland Concentration and Income Productivity Growth: Evidence from Tanzania

by

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EXECUTIVE SUMMARY

This study attempts to evaluate the impact of farmland concentration on rural productivity growth within smallholder households in Tanzania. Conceptually, farmland concentration occurs when relatively few farms have relatively large shares of the arable land resources in a given area. If large farms bring benefits that spillover to surrounding smallholders, then we would expect positive impacts of greater land concentration on growth. If, on the other hand, a small set of large farms dominates production, then growth multipliers may be lower than for areas with more egalitarian land distributions.

To address this question, we assemble a variety of land concentration indicators for rural Tanzania, using data from multiple datasets. We use data on farm household income, demographic characteristics, assets and other household-level controls from the 2009, 2011, and 2012 rounds of the Tanzanian Living Standards Measurement Survey – Integrated Survey of Agriculture (LSMS-ISA). We also assemble a variety of land concentration indicators for rural Tanzania at the regional level, e.g., the Gini coefficient of landholdings, based on the 2009 Agricultural Sample Census, which provides a more comprehensive accounting of farms of all sizes than does the LSMS data.

The question of whether or not the local structure of land ownership matters for rural growth is important for several reasons, particularly within the African context. First, changes in farm structure are occurring rapidly in many Sub-Saharan African countries, with a major trend being one of increasing land concentration driven by medium- and large-scale land acquisitions in customary tenure systems (Jayne et al. 2003, 2014, 2016; Sitko and Chamberlin 2016; Anseeuw et al. 2016). These studies suggest a *de facto* move towards greater concentration, under existing land policies. However, despite these indications, farm household survey data—our standard window into empirical assessments of farm structure—are almost certainly underreporting large farm sizes, and thus obscuring true measures of land concentration (Lowder, Skoet, and Raney 2016; Jayne et al. 2016). If, in fact, land distributions matter for agricultural growth, then we must collectively figure out how to pay better attention to what is happening on the ground.

Key Findings

In this paper, we find evidence that the Tanzanian LSMS-ISA sampling methods appear to systematically miss the largest farms, by comparing LSMS-ISA data with data from the Agricultural Sample Census. Consequently, LSMS-ISA-derived measures of land concentration underestimate the true degree of concentration.

Interestingly, alternative land concentration indicators correlate poorly with one another, suggesting that care should be taken in empirical analysis: the choice of concentration metric influences analytical conclusions based on this choice, at least in magnitude and significance.

Finally, we find evidence that farm land concentration has negative impacts on per-FTE gross income growth. The magnitude of these impacts is somewhat sensitive to land concentration indicator choice, but is otherwise robust to alternative model specifications. These impacts affect income in both farm and non-farm sectors. Furthermore, the negative impacts of land concentration on household income is more pronounced for very small farms than for larger farms.

Conclusion and Recommendations

In this paper, we contend that sampling frames of smallholder-focused surveys, such as the LSMS-ISA surveys, are likely to under-represent the presence of large farms and, consequently, the concentration of landholdings in any given area. We show evidence in support of this contention for Tanzania. Furthermore, we show that alternative empirically derived measures of land concentration differ considerably from one another, a fact which suggests caution is warranted in empirical efforts to understand the impacts of farm structure.

Given these caveats, we estimate a number of regression models which suggest that (a) better measurement of concentration may correct for upward bias in the estimates of impacts on per-FTE gross income; and (b) to the extent that there are positive spillovers, larger farms are better able to capture them.

These results are offered tentatively, pending confirmation from additional data collection exercises which will enable robust identification of land concentration measures at district or even more localized levels. This caveat notwithstanding, we believe the results compiled in this paper are an important contribution to our understanding of how land access, farm structure, and farmland distributions may affect the development trajectories of smallholder-dominated farming systems and rural economies.

Our research underscores the importance of good data on the rural economy in developing countries. The relatively recent bounty of nationally representative data available through such initiatives as the World Bank's LSMS-ISA program is certainly to be applauded. Nonetheless, we would advocate for even greater investments in expanding the sampling frame – both to ensure adequate representation of larger farms (which some research suggests to be the most dynamic component of the rural sector; see Jayne et al. 2014), as well as to enable more spatially disaggregated measures of farm structure and land access.

Although this will require increased investments in data collection, the analytical payoffs are likely to be substantial, particularly in countries where medium- and large-scale land acquisitions are taking place. Because many of these acquisitions are taking place under the radar of traditional data collection mechanisms, and in some cases may be transforming rural farm structure quite rapidly, it is important to plan for such investments now. Unfortunately, discussions of land policy and agricultural policy in SSA remain largely disconnected (Jayne et al. 2016). Ultimately, the scope for African states to rationally guide how land access contributes (or not) to rural development will depend upon how well we are able to monitor and evaluate the changes taking place on the ground.

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ACRONYMS

ASC	Tanzanian Agricultural Sample Survey
CIMMYT	International Maize and Wheat Improvement Center
FAO	Food and Agriculture Organization of the United Nations
FTE	Full-time equivalent
LSMS-ISA	Living Standards Measurement Survey-Integrated Survey on Agriculture
MC	Mundlak-Chamberlain
NPS	Tanzanian National Panel Survey (aka the Tanzanian LSMS-ISA)
TSh	Tanzanian Shillings
US$	United States Dollar

1. INTRODUCTION

This study attempts to evaluate the impact of farmland concentration on rural productivity growth within smallholder households in Tanzania. Conceptually, farmland concentration occurs when relatively few farms have relatively large shares of the arable land resources in a given area. A priori, we have two competing hypotheses: on the one hand, if large farms bring benefits that spillover to surrounding smallholders, then land concentration may facilitate growth across all households in a shared location. On the other hand, if productivity gains are concentrated within relatively few households (as might be the case in areas where a few large farms have a disproportionate share of land and production), then growth multipliers from agricultural surplus may be more limited, as compared with more egalitarian land distributions.

To answer this question, we assemble data from the 2009 Agricultural Sample Census, as well as the 2009, 2011, and 2012 rounds of the Tanzanian Living Standards Measurement Survey – Integrated Survey of Agriculture (LSMS-ISA). We assemble a variety of land concentration indicators for rural Tanzania, using multiple datasets. Interestingly, alternative growth indicators correlate poorly with one another, suggesting that care should be taken in empirical analysis. Furthermore, the source of data matters: we find that standard sampling methods for smallholder-focused rural household surveys appear to systematically miss the largest farms. Finally, we find some evidence that farmland concentration has negative impacts on per-Full-time Equivalent (FTE) gross income growth. However, these results are sensitive to land concentration indicator choice, as well as model specifications.

This question—whether or not the local structure of land ownership matters for rural growth—is important for several reasons, particularly within the African context. First, changes in farm structure are occurring rapidly in many Sub-Saharan African countries, with a major trend being one of increasing land concentration driven by medium- and large-scale land acquisitions in customary tenure systems (Jayne et al. 2003, 2014, 2016; Sitko and Chamberlin 2016; Anseeuw et al. 2016). These studies suggest a *de facto* move towards greater concentration, under existing land policies. However, despite these indications, farm household survey data—our standard window into empirical assessments of farm structure—are almost certainly underreporting large farm sizes, and thus obscuring true measures of land concentration (Lowder, Skoet, and Raney 2016; Jayne et al. 2016). If, in fact, land distributions matter for agricultural growth, then we must collectively figure out how to pay better attention to what is happening on the ground.

The remainder of the paper is structured as follows: Section 2 expands on the theoretical mechanisms linking land concentration and growth outcomes in rural households. Section 3 describes the data we use in this study, and Section 4 discusses the challenges of empirically addressing our research question. Descriptive and econometric results are presented in Sections 5 and 6, respectively, followed by conclusions in Section 7.

2. CONCEPTUAL FRAMEWORK

2.1. Core Theoretical Perspectives

There are two competing ways in which we might think about the relationship between land concentration and growth. The first of these is rooted in the seminal work of Johnston and Kilby (1975) and Mellor (1976), who emphasized the importance of growth multipliers as drivers of rural development. The core idea is that because the propensity to spend additional income on local goods and services is greatest for small households, then virtuous cycles are engendered by broad-based agricultural growth in which income gains by smallholders are cycled through local farm and non-farm economies. Broad-based agricultural growth tends to generate greater second-round expenditures in support of local non-tradable goods and services in rural areas and towns. If, however, agricultural productivity gains are concentrated within relatively few households (as might be the case in areas where a few large farms have a disproportionate share of land and production), then growth multipliers from agricultural surplus may be more limited, as compared with more egalitarian land distributions. Empirical work by Deininger and Squire (1998) and Vollrath (2007) support this idea, providing some evidence (at the national level) that relatively egalitarian land distribution patterns are associated with more broadly based growth, and higher rates of growth, than more concentrated land distributions.

There are other ways of thinking about how land concentration may limit smallholder productivity, which posit different channels, but which are consistent with the above framework. For example, Berry and Cline (1979), using national-level data, found that the relative underutilization of agricultural land increases with the degree of inequality in land distribution. Sitko and Jayne (2014) describe similar findings for farm-level data from Zambia: larger holdings were less utilized (i.e., had lower shares of land being used for cropping or other intensive productive activities) than smaller holdings. This is consistent with the idea that areas with higher land concentrations have fewer farmers, and fewer farm activities, available for peer-to-peer learning, which is one avenue by which productivity gains may be realized.

Also at the country-level, Binswanger and Deininger (1997), Engerman and Sokoloff (1997), and Sokoloff and Engerman (2000) all discuss ways in which land inequality may be associated with institutional control. In particular, land concentration (inequality) is often associated with an elite class of rural landholders, which wields important political power; this power often translates to limited ability by non-elites to participate in political systems, as well as other institutions (such as public educational systems) that may condition per-FTE gross income. While the logic of this argument is most clearly conceived at the national or regional levels, it may also play out in more localized ways. For example, if large farms dominate in a particular area, they may influence the nature of local supply chains, such that input providers, output dealers and other service providers are more oriented towards supporting larger farms in ways that are less accessible to smaller producers.

On the other hand, a countervailing hypothesis is that large farms (at least under some conditions) may generate important spillover benefits for smallholders operating in their vicinity. Commercially oriented larger farms may infuse capital into rural areas, and may attract state investment in infrastructure development, both of which would benefit all farms in an area (von Braun and Meinzen-Dick 2009). Additionally, large commercially oriented farm investments may provide the economies of scale required for the development of services markets, e.g., in logistics, finance, input supply and output marketing services (Collier and Dercon 2014). Such markets should be beneficial to smallholders who can access them. Introduction of new production technologies may facilitate technological spill-overs, via knowledge transfers and increased access to agricultural technologies (Kleemann et al. 2013; Rakotoarisoa 2011).[1] Direct linkages between large and small farmers may also exist, e.g., out-grower schemes, contract farming arrangements, and the generation of wage employment opportunities. Where such arrangements are in place, knowledge transfer may be particularly strong (De Schutter 2011; Munjenja and Wonani 2012). As a final point, large farm production may also help to stabilize food prices, which should reduce risk and uncertainty facing smallholder producers.[2] To the extent to which such positive spillovers exist, then land concentration may facilitate growth across all households in a shared location.

As it stands, however, the empirical evidence base for either positive or negative impacts of large farm spillovers on nearby smallholders remains weak. Sipangule and Lay (2015) find some evidence for localized positive productivity spillovers of large agricultural investments to nearby smallholders in Zambia.[3] Most other studies seeking evidence of impacts rely on regional case study approaches (e.g., Cotula et al. 2009; Anseeuw et al. 2012).

In principle, positive impacts of e.g., technology spillovers, or positive externalities from capital investments, may coexist with negative impacts of concentrated wealth and diminished growth linkages. Our empirical question, therefore, may best be framed in terms of which effect is dominant, as inferred by the growth outcomes associated with alternative concentration measures.

2.2. Model of per-FTE Gross Income Determinants

We may generalize the above ideas as follows. Let us start with a farm-level production function:

$$Y_{i,j,t} = \boldsymbol{\beta X}_{i,j,t} + \boldsymbol{C_j} + \theta G_{j,t-1} + \boldsymbol{\epsilon}_{i,j,t} \tag{1}$$

where Y is per-FTE gross income for farmer *i* in community *j* at time *t*; **X** is a vector of household-level characteristics, C is a vector of geographic context characteristics, G is a measure of access to local public and private capital in community j, and ε is an idiosyncratic error term. If we accept that (unobservable) access to local public and private capital stocks is conditioned by the (observable) localized distribution of land control, i.e.,

$$G_{j,t} = f(I_{j,t}, Z_{j,t}) \tag{2}$$

where I is a measure of land inequality in community j at time t, and Z is a vector of other factors that influence G, then we may rewrite an estimable production function as:

$$Y_{i,j,t} = \boldsymbol{\beta X}_{i,j,t} + \delta I_{j,t-1} + \gamma Z_{j,t-1} + \boldsymbol{\epsilon}_{i,j,t} \tag{3}$$

[1] Such knowledge transfer from large to small farmers may take place directly, e.g., via technical assistance, formal and informal training and/or service provision, or indirectly, e.g., via learning-by-doing.

[2] This argument was made by von Braun and Meinzen-Dick (2009) for global food prices, but in principle could also be made for regional or even local food prices.

[3] Empirical evidence is somewhat limited. Some literature uses firm level data (Javorcik 2004; Görg and Greenaway 2004), and does not focus on agriculture. At least two studies have provided evidence in support of large-scale land-based investments contributing to infrastructural improvements in the investment locations (Mujenja and Wonani 2012; FAO 2012).

where δ is an estimable coefficient on observable land quality. If growth-linkages dominate the relationship between land concentration and productivity changes, then $\delta<0$. If positive spillovers dominate the relationship, then $\delta>0$.

3. DATA USED IN THIS STUDY

Data in this analysis come from two main sources. Data on household per-FTE gross income measures were constructed from the Tanzanian National Panel Survey (NPS), available for three waves (2009, 2011, and 2013).[4] This survey is nationally representative, and contains data on households in both rural and urban areas (per census definitions at the enumeration area level). Given the nature of our research question, we keep only households in rural areas. After dropping observations without data for the variables of interest, we have 6,704 observations across the three waves.[5]

We constructed indicators of land concentration from the observations within the NPS, at the regional level. However, because we suspect that the NPS sample may have failed to capture the extent to which large farms are present within any region, we also constructed such measures from the Tanzanian Agricultural Sample Census (ASC) for 2009.[6] The ASC collected data on 52,635 rural agricultural households (most of whom were smallholders), as well as all 1,006 large-scale farms known to exist in the country at the time.[7]

Unfortunately, data on large farms were only made available with regional level identifiers. Thus, we were only able to construct comparable land concentration measures between the NPS and ASC at the regional level.

[4] ASC data are available here: http://opendata.go.tz/dataset/tanzania-utafiti-wa-sampluli-sensa-ya-kilimo-2007-2008.

[5] This includes 1204 households which reported one or more cropped plots which had no corresponding production information.

[6] NPS data are available here: http://go.worldbank.org/OOLZL0UIR0.

[7] Large scale farms were defined on the basis of landholdings (>20 hectares) as well as a number of other criteria, which allowed some smaller holdings to be included (e.g., operating at least 0.5 ha of intensive greenhouse horticultural production). See NBS (2012: p11) for more details.

4. IMPLEMENTATION CHALLENGES

There are several important challenges in empirically estimating our model of interest. These include data quality constraints, sampling frame limitations, an inherent arbitrariness in defining measures of land concentration, and endogeneity issues in ascertaining impacts of land concentration on growth outcomes.

4.1. Data Quality Issues

The Tanzanian National Panel Survey data, described above, have a number of limitations in how information on per-FTE gross income was collected. First, for wage income, the amount worked by an individual over the previous 12 months was only calculated for the last two waves. Furthermore, while the second and third waves asked about primary and secondary jobs, the first wave only asked about the primary job. Thus, we were not able to use the first wave of the NPS in this analysis.

Another limitation is that data on individual time allocations for non-wage work (e.g., time spent on farming activities) was limited: while the third round did ask about time allocations over the previous 12 months, the first two rounds only asked about the number of hours worked in the past week. This constrained our ability to construct a per-FTE gross income measure for agriculture with a well-defined denominator if we also want to use more than a single round of data.

Finally, even though total time worked for wage income over the previous year was nominally recorded (via three questions: "During the last 12 months, for how many months did you work in this job?"; "During the last 12 months, how many weeks per month do you usually work in this job?"; and "During the last 12 months, how many hours per week do you usually work in this job?"), the informal nature of much wage employment in Tanzania (perhaps particularly in rural areas) implies a high degree of variability, which may not easily filter through such averaging questions. The upshot of this is that our income data are very noisy, as are our measures of per-FTE gross income based thereon.

4.2. Sampling Frame Limitations

There are very likely limitations of existing survey sampling frames for adequately assessing land concentration. A priori, we might expect systematic under-observation of larger holdings in rural household surveys for several reasons: larger holdings may less readily resolve into associated household units; owners of larger holdings may not be locally resident (i.e., operate via local managers) or, even if locally resident, may be more likely to travel and thus fail to show up in the sample.

Another sampling frame limitation is the level of aggregation at which inference is designed to be made. The NPS is designed to make inference at the regional level. However, regions are quite large, and mask much variation within regional units. Unfortunately, this constraint is fixed at present, but we return to this point in the conclusions, advocating for investments in larger farm survey samples that would enable measures of land concentration (and other summary statistics) to be generated at the district level.

4.3. Conceptualization and Measurement of Land Concentration

The conceptual core of our notion of land concentration—how much farmland is concentrated under relatively few large farmers—is relatively clear. However, translating this

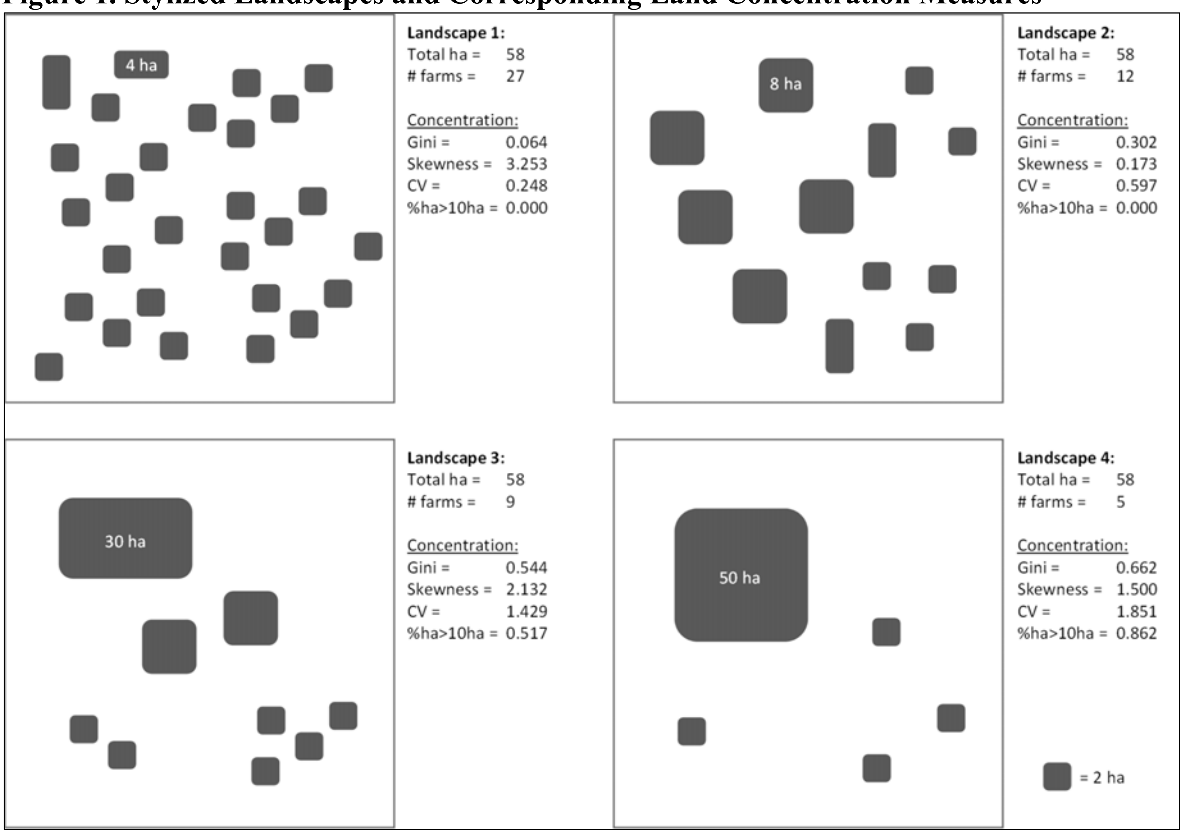
Table 1. Alternative Indicators of Land Concentration

	Land Concentration Measure
1.	Gini coefficient
2.	Skewness (3rd standardized moment)
3.	Coefficient of variation (standard deviation / mean)
4.	% land under largest 10% of farms

notion to a measurable index involves some fundamentally arbitrary decisions. There are manifold measures available, some of which are shown in Table 1. In principle, we would expect these measures to correlate well with one another if they are converging on the same idea, although this is not a foregone conclusion mathematically. We address this question empirically in Section 5.

Figure 1 shows stylized landscapes, which represent alternative farm size configurations of a constant total area. Concentration metrics are calculated for each, and shown in the figure. For the most part, these correspond with an intuitive understanding of concentration in that, as we progress from the upper left, through the upper right, lower left and lower right, we have generally increasing values in most metrics.

Figure 1. Stylized Landscapes and Corresponding Land Concentration Measures



Source: Authors.

4.4. Endogeneity Concerns

Finally, in estimating our model of interest, there are several endogeneity concerns. The first of these is that land concentration and per-FTE gross income are jointly driven by unobserved factors. For example, if land concentration is associated with commercially oriented investments that target preferentially located areas, we may get upwardly biased coefficient estimates. To control for this, we include a range of other geographical controls in our regression models (described below). Furthermore, we use land concentration measures constructed for 2009, while our household level productivity measures and other controls are defined for 2011 and 2013.

A second concern is that unobserved farm-level heterogeneity would affect per-FTE gross income measures, thus biasing all coefficient estimates in the model. To address this, we take advantage of our panel to incorporate the Mundlak-Chamberlain (MC) device (Mundlak 1978; Chamberlain 1984) into our models, giving us an estimator that Wooldridge (2010) refers to as the Correlated Random Effects model. The MC device employs household-level averages of all time-varying components of the model in order to control for unobserved time-constant heterogeneity, under the assumption that such heterogeneity is correlated with the time-averages.

A third concern is the possible bias arising from attrition. We test for this and generally find that our models are affected by attrition. We therefore define and implement attrition weights in all of the regression models, following the methods described in Baulch and Quisumbing (2011).

A final concern is with bias arising from unobserved factors that may influence whether or not a household engages in income generating activities under any of the sub-groupings we consider in our analysis (farm, non-farm, off-farm agricultural wage income, or total income). If the factors governing the choice of productive engagement also affect outcomes (i.e., per-FTE income), then models estimated only on households with income (for any given sub-category) will be biased. To address this, we implement a Heckman selection model, in which the first stage (participation in the income activity being evaluated) is conditioned by the factors used in our main model as well as additional regressors: binary indicators of household experiencing drought within previous 2-years, experiencing pest and/or disease within previous 2-years, experiencing a death in the household within previous 2-years, or being landless. Model results generally support the two-stage approach (i.e., show positive correlation between the error terms of the selection and outcome stages), although second stage results differ little from the OLS model results. Nonetheless, the results we report in section 6 are all from the second stage of the Heckman specifications.

5. DESCRIPTIVE RESULTS

5.1. Farm Size Structure

The Tanzanian farm sector is dominated by smallholdings, as elsewhere in the region. However, measures of farm structure are sensitive to choice of dataset. Table 2 shows distributions of holding sizes across the country, using the NPS and ASC for 2009. While the median and mean farm sizes are firmly within the smallholding range, they differ substantially from one another. The mean holding size under the ASC is 3 times that of the NPS, suggesting that the sampling frame of the NPS may be under-representative of holdings at the upper end of the spectrum. (Note that this is also true when we exclude data from the large-scale farm component of the data, as shown in the bottom row of the table.)

5.2. Productivity Levels and Growth, by Farm Size Category

Table 3 below shows changes over time in the rate of production and productivity growth by farm size category. If we find that it is only large farms that are experiencing productivity growth, then we would expect this to influence our findings about what category of farm size is most beneficial to per-FTE gross income growth. However, we fail to see a pronounced pattern.

5.3. Land Concentration Measures

We construct and compare land concentration measures at the national level from both the NPS and ASC for 2009 (Table 4 below). Comparing measures constructed using the small farm component of the ASC with measures from the NPS, we find that while the Gini coefficient is similar, some other measures (skewness, CV and Timmer's measure) suggest higher concentration in the NPS sample, while others (the percentage of land under farms of 10+ hectares) indicate greater concentration in the ASC. However, when including the large scale farm component of the ASC, all resulting concentration measures indicate higher degrees of concentration than the NPS sample (except for Timmer's measure, which is now similar in magnitude in both datasets).

We draw two conclusions from these results. First, the choice of land concentration measure seems to matter in such comparisons. Second, inclusion of the large-scale farms clearly shifts all measures in ways that unambiguously signal higher concentration of holdings.

Table 2. Farm Structure in Tanzania

	Percentile								
	5th	10th	25th	50th	75th	90th	95th	99th	mean
Cultivated land (NPS)	0.0	0.2	0.4	1.2	2.0	4.0	5.7	12.5	2.0
Controlled land (NPS)	0.2	0.4	0.6	1.3	2.4	4.5	6.7	15.2	2.3
Controlled land (ASC)	1.0	1.0	2.0	4.0	7.0	12.0	20.0	50.0	6.5
Controlled land (ASC: large scale farms excluded)	1.0	1.0	2.0	4.0	7.0	12.0	20.0	49.0	6.3

Note: NPS data for 2008/2009; ASC data for 2009. Landless households are not included.

Table 3. Productivity Increases by Farm Size Category

Productivity Measure	Landholding size category	2009	2011	2013	Average annual growth	Sample size in 2013
		Values in 1000s of real 2013 TSh				
Agricultural per-FTE gross income	landless	363	371	871	35%	104
	0<2 ha	591	530	812	9%	853
	2-5 ha	2,610	975	2,471	-1%	550
	> 5 ha	1,665	2,289	2,679	15%	97
Off-farm, non-agric. per-FTE gross income	landless	2,830	5,420	5,121	20%	420
	0<2 ha	2,750	2,586	1,999	-7%	822
	2-5 ha	2,561	3,326	2,746	2%	404
	> 5 ha	3,764	2,687	6,485	18%	61
Off-farm agric. per-FTE gross income	landless	858	2,221	1,296	13%	73
	0<2 ha	2,905	2,503	1,453	-12%	380
	2-5 ha	3,219	2,731	2,180	-8%	194
	> 5 ha	5,900	2,746	2,844	-13%	24
Total per-FTE gross income	landless	2,003	4,920	4,630	33%	463
	0<2 ha	1,406	1,460	1,260	-3%	1,078
	2-5 ha	1,670	1,727	2,721	16%	617
	> 5 ha	2,044	2,328	4,651	32%	104

Source: NPS. Top 1% of values excluded as outliers. Calculations based on real 2010 values. Households in urban areas are not included.

Table 4. National Measures of Land Concentration from Alternative Data Sources

	dataset		
Measure of land concentration	NPS (2009)	ASC (2009; sm. only)	ASC (2009; sm. + lg.)
Gini	0.57	0.54	0.89
Skewness	28.59	16.71	49.74
Coefficient of variation	2.97	1.83	19.09
(75pct - 25pct) / median	1.50	1.14	1.36
% of land held by farms > 10 ha	0.22	0.52	0.89

To further explore the correlation across alternative concentration measures, we construct correlation matrices for alternative indicators at the regional level. These are shown in Table 5 below. We find that alternative indicators correlate very imperfectly with one another, suggesting that any empirical analysis of the impacts of land concentration include multiple concentration indicators to evaluate robustness of analytical conclusions.

Table 5. Correlation Matrix of Land Concentration Measures Defined at the Regional Level

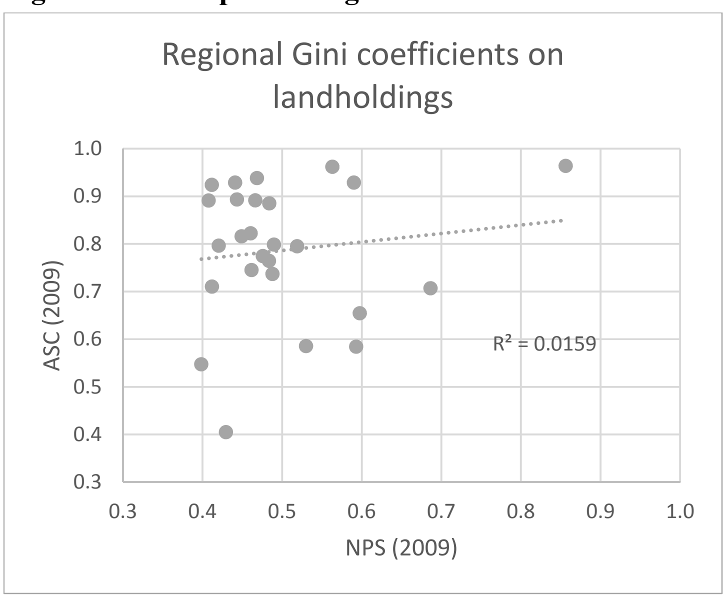
	Gini	Skewness	CV	Landless % of HHs	% land in farms < 2 ha	% land in farms 2-5 ha
Gini	1					
Skewness	0.3566	1				
CV	0.7425	0.8294	1			
Landless % of HHs	0.1438	0.0364	-0.0331	1		
% land in farms < 2 ha	-0.5613	-0.4390	-0.5652	0.2416	1	
% land in farms 2-5 ha	-0.8910	-0.3379	-0.6405	-0.0341	0.8021	1
% land in farms > 5 ha	0.8421	0.3764	0.6461	-0.0341	-0.8829	-0.9886

Source: ASC.

Comparing regional Gini coefficients for the NPS and ASC (including large scale farm component), we see in Figure 2 that despite some regional variation, measures tend to be higher across the set of regions.

For these reasons, in our econometric analysis below, we use land concentration measures defined at the regional level from the ASC.

Figure 2. Scatterplot of Regional Gini Coefficients on Landholdings from ASC and NPS



6. ECONOMETRIC ANALYSIS

6.1. Baseline Specification

Coefficient estimates for land concentration measures from our baseline regression specifications are shown in Table 6 (the full set of results are shown in the appendix). There are four dependent variables: (i) agricultural per-FTE gross income; (ii) non-agricultural per-FTE gross income; (iii) off-farm agricultural per-FTE gross income; and (iv) total per-FTE gross income. All of these dependent variables are log transformed. For each of these dependent variables, the specifications differ only in the choice of land concentration measure: (a) Gini coefficient, (b) skewness, (c) coefficient of variation, and (d) share of land under farms of >10 hectares.

The main conclusion is as follows: while impacts on any particular income type are highly dependent upon which concentration measure is used, the overall impacts on both farm, non-farm and total per-FTE gross income is negative. This result is robust to whether or not the MC device is included.

Given the predominance of gendered differences in land access in Sub-Saharan Africa (Doss et al. 2013), we considered the possibility that land concentration may be correlated with poorer access to land by women (in which case gendered land access would constitute an omitted variable that is correlated with and biasing the coefficient on land concentration. To address this concern, we first note that in all specifications (including all the baseline specifications shown in the appendix), the female-head dummy is not significant. Furthermore, when we specify a model that interacts the female-head dummy with the land concentration measures, the coefficient estimate for the interaction term is not significantly different from that of the non-interacted term. This provides some reassurance that a gendered access story is not driving our results.

When estimating the same models with NPS-derived land concentration measures—which we have shown to be likely to underestimate the prevalence of large farms—we find that coefficient estimates for land concentration impacts are generally positive for total income, in contrast with the results shown above. Given the likelihood of under-inclusion of larger farms in the NPS data, this result is provocative, as it suggests that incomplete accounting of larger farms may generate inaccurate analytical conclusions.

6.2. Interacting Concentration with Farm-size Dummies

Table 7 shows results from model specifications that interact regional land concentration measures with household-specific farm size measures. (Full estimation results are shown in Appendix A4.) Impact estimates vary across both dependent variables as well as land concentration measures, as before. However, the interaction terms show a consistent pattern: for impacts on farm per-FTE gross income (first four columns) and total per-FTE gross income (last four columns), it is the smaller farms that suffer larger negative impacts of concentration.

One interpretation of the size-related impacts on farm and total productivity is that spillover effects from land concentration are not equally accessible to all farms within an area. This might be the case, for example, if the key spillover is better financial services markets, which are most easily accessed by larger farms or wealthier households with sufficient resources (e.g., collateral, human capital). Unfortunately, our data do not allow us to do more than surmise what specific channels of spillover may be taking place. (Note: these results are very similar to results of models that use household asset categories in place of farm size categories, which is not surprising given the high correlation between asset wealth and land holding size.)

Table 6. Selected Coefficients from Baseline Regression Models

	Dependent variable: farm per-FTE gross income				Dependent variable: non-farm per-FTE gross income			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Land concentration								
Gini	-1.4190 (0.000)***				-0.7949 (0.000)***			
skewness		-0.0073 (0.004)***				0.0030 (0.161)		
CV			-0.0264 (0.000)***				-0.0030 (0.458)	
share under farms >10 ha				-1.0124 (0.000)***				-0.8068 (0.000)***

	Dependent variable: average wage per-FTE gross income				Dependent variable: total per-FTE gross income			
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Land concentration								
Gini	-0.5051 (0.115)				-1.3441 (0.000)***			
skewness		0.0015 (0.619)				-0.0037 (0.058)*		
CV			0.0011 (0.855)				-0.0193 (0.000)***	
share under farms >10 ha				-0.7239 (0.067)*				-1.0216 (0.000)***

Notes: Dependent variables are inverse hyperbolic sine transformed per-FTE gross income measured in 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Full model results shown in Appendix A3. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Selected Coefficients from Regression Models Including Interaction Terms between Land Concentration and Farm Size

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE gross income				Dep var: non-farm per-FTE gross income			
Gini	-1.3567 (0.000)***				-0.8141 (0.000)***			
Gini * farm >10 ha	0.2363 (0.025)**				0.1761 (0.100)			
skewness		-0.0042 (0.031)**				0.0026 (0.225)		
skewness * farm >10 ha		0.0074 (0.004)***				0.0050 (0.063)*		
CV			-0.0208 (0.000)***				-0.0043 (0.299)	
CV * farm >10 ha			0.0126 (0.024)**				0.0105 (0.079)*	
land in farms of >10 ha				-1.0474 (0.000)***				-0.8317 (0.000)***
land in farms of >10 ha * farm size >10 ha				0.2556 (0.010)***				0.1752 (0.081)*

Table 7 cont. Selected Coefficients from Regression Models Including Interaction Terms between Land Concentration and Farm Size

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE gross income				Dep var: total per-FTE gross income			
Gini	-0.5238 (0.102)				-1.3727 (0.000)***			
Gini * farm >10 ha	0.1681 (0.319)				0.2381 (0.024)**			
skewness		0.0013 (0.658)				-0.0042 (0.033)**		
skewness * farm >10 ha		0.0014 (0.760)				0.0074 (0.004)***		
CV			0.0024 (0.808)				0.0126 (0.024)**	
CV * farm >10 ha			0.0007 (0.903)				-0.0209 (0.000)***	
land in farms of >10 ha				-0.7311 (0.063)*				-1.0693 (0.000)***
land in farms of >10 ha * farm size >10 ha				0.1602 (0.314)				0.2582 (0.009)***

Notes: Dependent variables are log-transformed per-FTE gross income measured in 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the 2011 and 2013 rounds of the NPS. All models include the Mundlak-Chamberlain device. Models include weighting for attrition. Full model results shown in Appendix A4. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

6.3. Inter-Period Income Changes Regressed on Lagged Dependent Variables

As an alternative specification of our basic model, we regressed the changes in household income (measured as the average annual growth in the two-year period between panel waves) against lagged exogenous regressors in the following form:

$$\Delta Y_{i,j,(t,t-1)} = \boldsymbol{\beta X}_{i,j,t-1} + \delta I_{j,t-1} + \gamma Z_{j,t-1} + \boldsymbol{\epsilon}_{i,j,(t,t-1)} \qquad 4$$

Estimation results (shown in Appendix A5), while generally not significant, are otherwise similar in the sign and magnitude of coefficient estimates as those of our baseline estimations. These results are consistent with the overall story coming from the other specifications shown in this section, i.e., a growth dampening effect of land concentration.

6.4. Simulated Impacts of Changes in Density

To give a more intuitive sense of the magnitude of these impacts, we simulate the impacts of a change in the land concentration variables on total and farm per-FTE income, using the baseline specification (Table 6). We consider a change in land concentration at the 25th percentile to the 75th percentile (for example the 25th and 75th percentiles of the landholding Gini coefficient in our sample are 0.71 and 0.92, respectively).[8] Results, shown in Table 8 below, show that such an increase in land concentration, as measured by the Gini coefficient, is associated with an average drop of 443,000 TSh in total per-FTE gross income (about US$300), which is equivalent to about 60% of the mean level of total per-FTE gross income in our dataset. While there is considerable variety in the impact estimates across alternative land concentration measures, the magnitude of these impacts is quite large. The estimated impacts on farm income are even larger: an equivalent change in the Gini coefficient (from 25th to 75th percentiles) results in a drop of 80% of total estimated per-FTE farm income.

[8] Here, we measure percentiles in terms of the sample-weighted households in our dataset, i.e., we compare the land concentration experienced by the sample household at the 25th percentile, when households are ranked by that land concentration measure, to that experienced by the household at the 75th percentile.

Table 8. Simulated Impacts of Changes in Land Concentration on Total Income and Farm Income

	Land concentration measure	(a) Average per-FTE income predicted for land concentration at 25th percentile (1000s of 2010 TSh)	(b) Average per-FTE income predicted for land concentration at 75th percentile (1000s of 2010 TSh)	(c) difference (b) - (a) (1000s of 2010 TSh)	(d) difference as % of average per-FTE income	(e) difference as % of median per-FTE income
Total income	Gini	1,770	1,327	-443	-61%	-59%
	Skewness	1,636	1,538	-98	-13%	-13%
	CV	1,694	1,451	-243	-33%	-32%
	Share of land under farms >10ha	1,700	1,418	-282	-39%	-37%
Farm income	Gini	842	619	-223	-77%	-79%
	Skewness	771	683	-89	-31%	-31%
	CV	813	657	-156	-54%	-55%
	Share of land under farms >10ha	809	648	-161	-56%	-57%

Note: Values in columns (a), (b) and (c) are thousands of real 2010 Tanzanian shillings (TSh). In 2010, 1 U.S. Dollar (US$) ≈ 1450 TSh. These simulation results based on the baseline regression specifications for farm- and total income, i.e., specifications corresponding to results shown in columns 1-4 and 13-16 in Tables 6 and A3.

7. CONCLUSIONS

This paper has attempted to address the question of whether or not land concentration is beneficial or detrimental to rural development as measured by per-FTE gross income within rural households. We have argued that standard LSMS sampling frames are likely to under-represent the presence of large farms and, consequently, the concentration of landholdings in any given area. Furthermore, we show that alternative empirically derived measures of land concentration differ considerably from one another, a fact which suggests caution is warranted in empirical efforts to understand the impacts of farm structure. Given these caveats, we estimate a number of regression models which suggest that (a) better measurement of concentration may correct for upward bias in the estimates of impacts on per-FTE gross income; and (b) to the extent that there are positive spillovers, larger farms are better able to capture them. These results are offered tentatively, pending confirmation from additional and improved data collection exercises. In particular, we advocate for data collection that will enable robust identification of land concentration measures at district or lower levels. This caveat notwithstanding, we believe the results compiled in this paper are an important contribution to our understanding of how land access, farm structure, and farmland distributions may affect agricultural development trajectories.

Our research underscores the importance of good data on the rural economy in developing countries. The relatively recent bounty of nationally representative data available through such initiatives as the World Bank's LSMS-ISA program is certainly to be applauded. Nonetheless, we would advocate for even greater investments in expanding the sampling frame – both to ensure adequate representation of larger farms (which some research suggests to be the most dynamic component of the rural sector; see Jayne et al. 2014), as well as to enable more spatially disaggregated measures of farm structure and land access.

Although this will require increased investments in data collection, the analytical payoffs stand to be substantial, particularly in countries where medium- and large-scale land acquisitions are taking place. Because much of these acquisitions are taking place under the radar of traditional data collection mechanisms, and in some cases may be transforming rural farm structure quite rapidly, it is important to plan for such investments now. Unfortunately, discussions of land policy and agricultural policy in SSA remain largely disconnected (Jayne et al. 2016). Ultimately, the scope for African states to rationally guide how land access contributes (or not) to rural development will depend upon how well we are able to monitor and evaluate the changes taking place on the ground.

APPENDIX

Table A 1. Variables Used in the Econometric Analysis

Variable	Description	Unit	Data Source
farm labor prod.	log transformation of farm per-FTE gross income	log(TSh)	NPS
off-farm non-ag. labor prod.	log transformation of off-farm non-ag. per-FTE gross income	log(TSh)	NPS
non-farm ag. labor prod.	log transformation of off-farm ag. per-FTE gross income	log(TSh)	NPS
total labor prod.	log transformation of total (farm+non-farm) per-FTE gross income	log(TSh)	NPS
farm size (ha)	land area controlled by the household	hectares	NPS
age of head	age of household head	years	NPS
size of hhold	number of household members	#	NPS
max.edu.attainment	maximum educational attainment in household	years	NPS
female head (=1)	household head is female	binary	NPS
# of plots	number of plots on farm	#	NPS
log (prod.assets)	Log value of productive assets: real 2009 TSh	log(TSh)	NPS
has ox plough (=1)	household owns an ox plough	binary	NPS
has tractor (=1)	household owns a tractor	binary	NPS
log (fert.kg)	log of inorganic fertilizer application	log(kg)	NPS
km to road	distance to nearest paved road	km	NPS
km to market	distance to nearest regular market	km	NPS
elevation	average elevation within locale	m	NPS
slope	average slope of terrain within locale	degrees	NPS
pop. density	population density within locale	persons/km^2	NPS
bimodal (=1)	area receives bimodal rainfall	binary	NPS
rainfall (mm)	annual rainfall total (current season)	mm	NPS
Regional Land Concentration:			
Gini	Gini coefficient of landholdings, using National Panel Survey		ASC & NPS
skewness	Skewness of landholdings, using National Panel Survey		ASC & NPS
% in farms >10 ha	Share of farmland under farms of 10+ hectares, using National Panel Survey		ASC & NPS

Table A 2. Descriptive Statistics for Variables Used in Econometric Models

Variable	Unit	5th	10th	25th	50th	75th	90th	95th	99th	Mean
farm labor prod.	1000s real 2010 TSh	0	14	100	320	865	2,093	3,840	11,500	944
non-farm non-ag. labor prod	1000s real 2010 TSh	171	400	1,004	2,400	6,171	16,800	32,900	100,000	8,006
non-farm ag. labor prod.	1000s real 2010 TSh	300	427	727	1,200	2,400	5,029	8,000	14,400	2,207
total labor prod.	1000s real 2010 TSh	44	118	344	1,005	2,753	7,552	14,500	53,800	3,694
farm size	hectares	0	0.1	0.4	1.1	2.4	4.7	7.2	18.3	2.2
age of head	years	24	27	33	43	56	70	76	86	45.9
size of household	#	1	2	3	5	7	9	10	15	5.1
max. edu. attainment	years	4	5	7	7	10	12	15	22	8.3
female head	binary	0	0	0	0	1	1	1	1	0.3
# of plots		1	1	1	2	3	4	5	7	2.3
Value of productive assets	1000s real 2009 TSh	<1	<1	<1	18	40	159	3,768	10,400	530.3
has ox plough	binary	0	0	0	0	0	1	1	1	0.2
has tractor	binary	0	0	0	0	0	0	1	1	0.1
fertilizer application	kg	0	0	0	0	0	200	800	3000	156.0
distance to road	km	0.1	0.3	1.1	8.3	23.1	43.7	56.0	88.1	16.1
distance to market	km	3.3	5.4	21.3	64.3	97.3	137.9	162.6	209.6	67.0
elevation	meters above sea leve	21	40	489	1147	1277	1522	1682	2028	945.3
slope	degrees	1.2	1.4	2.1	3.4	6.2	12.0	16.7	27.2	5.3
pop. density	persons/km2	10	20	60	190	960	6,850	14,100	30,760	2210.0
bimodal rainfall area	binary	0	0	0	1	1	1	1	1	0.5
rainfall (avg. annual)	mm	420	495	677	827	967	1044	1154	1666	821.8

Table A 3. Determinants of Household per-FTE Gross Income (Baseline Specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Farm per-FTE income				Non-farm per-FTE income			
Main Model:								
Gini	-1.4190				-0.7949			
	(0.000)***				(0.000)***			
skewness		-0.0073				0.0030		
		(0.004)***				(0.161)		
CV			-0.0264				-0.0030	
			(0.000)***				(0.458)	
share under farms >10 ha				-1.0124				-0.8068
				(0.000)***				(0.000)***
female head (=1)	-0.0793	-0.0811	-0.0814	-0.0820	-0.1119	-0.1120	-0.1119	-0.1121
	(0.193)	(0.185)	(0.183)	(0.179)	(0.038)**	(0.037)**	(0.038)**	(0.038)**
km to road	-0.0007	-0.0002	-0.0004	-0.0007	0.0005	0.0007	0.0007	0.0004
	(0.587)	(0.902)	(0.738)	(0.594)	(0.686)	(0.545)	(0.512)	(0.699)
km to market	0.0016	0.0021	0.0016	0.0020	-0.0011	-0.0008	-0.0009	-0.0009
	(0.003)***	(0.000)***	(0.003)***	(0.000)***	(0.022)**	(0.094)*	(0.059)*	(0.058)*
elevation	0.0003	0.0003	0.0003	0.0003	-0.0002	-0.0002	-0.0002	-0.0002
	(0.000)***	(0.002)***	(0.001)***	(0.000)***	(0.014)**	(0.014)**	(0.011)**	(0.035)**
slope	-0.0262	-0.0302	-0.0298	-0.0283	-0.0097	-0.0126	-0.0127	-0.0114
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.048)**	(0.009)***	(0.009)***	(0.019)**
pop.density	-0.0001	0.0000	0.0000	-0.0001	0.0001	0.0001	0.0001	0.0000
	(0.387)	(0.767)	(0.742)	(0.283)	(0.148)	(0.109)	(0.082)*	(0.254)
pdsq	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.275)	(0.990)	(0.958)	(0.233)	(0.259)	(0.198)	(0.147)	(0.338)
bimodal (=1)	0.5874	0.4290	0.4410	0.5499	0.2776	0.1678	0.1718	0.2904
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.026)**	(0.024)**	(0.001)***
farm size (ha)	0.0089	0.0088	0.0088	0.0090	-0.0030	-0.0030	-0.0037	-0.0019
	(0.351)	(0.350)	(0.346)	(0.353)	(0.799)	(0.809)	(0.762)	(0.873)
age of head	0.0089	0.0072	0.0081	0.0074	0.0093	0.0076	0.0077	0.0081

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Farm per-FTE income				Non-farm per-FTE income			
	(0.471)	(0.562)	(0.517)	(0.549)	(0.400)	(0.490)	(0.486)	(0.462)
size of hhold	-0.0520	-0.0540	-0.0518	-0.0533	-0.0196	-0.0191	-0.0194	-0.0186
	(0.091)*	(0.079)*	(0.091)*	(0.084)*	(0.425)	(0.438)	(0.430)	(0.447)
max.edu.attainment	-0.0108	-0.0114	-0.0113	-0.0103	0.0254	0.0249	0.0252	0.0247
	(0.531)	(0.512)	(0.514)	(0.550)	(0.080)*	(0.087)*	(0.082)*	(0.089)*
(max) notharvestbin	-0.3695	-0.3708	-0.3728	-0.3680	0.1935	0.1962	0.1972	0.1929
	(0.002)***	(0.002)***	(0.002)***	(0.002)***	(0.062)*	(0.058)*	(0.057)*	(0.063)*
log(prod.assets)	0.0578	0.0593	0.0561	0.0614	0.0177	0.0186	0.0185	0.0179
	(0.008)***	(0.007)***	(0.010)***	(0.005)***	(0.192)	(0.174)	(0.177)	(0.188)
has ox plough (=1)	0.1608	0.1638	0.1604	0.1693	0.1252	0.1212	0.1225	0.1265
	(0.155)	(0.152)	(0.160)	(0.136)	(0.240)	(0.254)	(0.249)	(0.235)
rainfall (mm)	-0.0006	-0.0005	-0.0006	-0.0005	0.0001	0.0001	0.0001	0.0001
	(0.019)**	(0.022)**	(0.021)**	(0.023)**	(0.731)	(0.720)	(0.721)	(0.700)
Constant	11.9862	11.0268	11.3284	11.5518	14.8871	14.1578	14.3100	14.8986
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
<u>selection</u>								
Gini	1.5189				-0.0337			
	(0.000)***				(0.869)			
skewness		0.0080				0.0022		
		(0.001)***				(0.278)		
CV			0.0230				-0.0009	
			(0.000)***				(0.799)	
share under farms >10 ha				1.0814				0.2214
				(0.000)***				(0.261)
shock w/in 2 yrs: drought	-0.0569	-0.0437	-0.0428	-0.0679	0.1139	0.1167	0.1139	0.1111
	(0.492)	(0.599)	(0.609)	(0.409)	(0.102)	(0.094)*	(0.102)	(0.110)
shock w/in 2 yrs: pest/disease	0.2663	0.2785	0.2738	0.2722	0.0315	0.0356	0.0345	0.0307
	(0.012)**	(0.009)***	(0.010)***	(0.010)**	(0.720)	(0.685)	(0.694)	(0.725)
shock w/in 2 yrs: death in HH	-0.0208	-0.0096	-0.0070	-0.0228	0.1487	0.1485	0.1457	0.1478

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Farm per-FTE income				Non-farm per-FTE income			
	(0.853)	(0.932)	(0.950)	(0.838)	(0.121)	(0.121)	(0.129)	(0.124)
landless=1	-0.8779	-0.9265	-0.8870	-0.9068	0.2032	0.1988	0.1921	0.2132
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.052)*	(0.062)*	(0.069)*	(0.042)**
female head (=1)	-0.0570	-0.0610	-0.0556	-0.0598	0.0111	0.0118	0.0107	0.0133
	(0.252)	(0.219)	(0.263)	(0.226)	(0.814)	(0.802)	(0.821)	(0.777)
km to road	0.0034	0.0028	0.0031	0.0033	-0.0007	-0.0007	-0.0007	-0.0006
	(0.002)***	(0.008)***	(0.003)***	(0.002)***	(0.464)	(0.466)	(0.484)	(0.530)
km to market	-0.0001	-0.0006	-0.0002	-0.0005	-0.0007	-0.0007	-0.0008	-0.0007
	(0.848)	(0.200)	(0.733)	(0.281)	(0.083)*	(0.091)*	(0.077)*	(0.103)
elevation	0.0002	0.0002	0.0002	0.0002	-0.0001	-0.0001	-0.0001	-0.0001
	(0.002)***	(0.001)***	(0.002)***	(0.010)***	(0.058)*	(0.067)*	(0.058)*	(0.046)**
slope	0.0169	0.0210	0.0202	0.0203	-0.0112	-0.0112	-0.0114	-0.0115
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.006)***	(0.006)***	(0.005)***	(0.005)***
pop.density	-0.0000	-0.0001	-0.0001	-0.0000	0.0001	0.0001	0.0001	0.0001
	(0.478)	(0.019)**	(0.027)**	(0.624)	(0.078)*	(0.097)*	(0.071)*	(0.046)**
pdsq	-0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.591)	(0.410)	(0.502)	(0.572)	(0.029)**	(0.040)**	(0.026)**	(0.017)**
bimodal (=1)	-0.0793	0.1292	0.1050	-0.0327	0.0579	0.0500	0.0533	0.0238
	(0.336)	(0.070)*	(0.145)	(0.700)	(0.418)	(0.432)	(0.406)	(0.745)
farm size (ha)	0.0445	0.0459	0.0458	0.0424	-0.0004	-0.0005	-0.0005	-0.0004
	(0.009)***	(0.008)***	(0.008)***	(0.012)**	(0.956)	(0.951)	(0.951)	(0.953)
age of head	-0.0072	-0.0052	-0.0057	-0.0058	0.0036	0.0037	0.0035	0.0034
	(0.479)	(0.616)	(0.577)	(0.567)	(0.726)	(0.719)	(0.730)	(0.737)
size of hhold	0.0644	0.0635	0.0628	0.0648	0.0156	0.0153	0.0156	0.0155
	(0.041)**	(0.046)**	(0.047)**	(0.040)**	(0.482)	(0.489)	(0.481)	(0.484)
max.edu.attainment	0.0388	0.0390	0.0394	0.0385	0.0288	0.0286	0.0285	0.0289
	(0.010)***	(0.009)***	(0.009)***	(0.009)***	(0.027)**	(0.028)**	(0.029)**	(0.027)**
(max) notharvestbin	-0.1520	-0.1513	-0.1511	-0.1510	0.0652	0.0659	0.0649	0.0657
	(0.108)	(0.109)	(0.109)	(0.110)	(0.477)	(0.472)	(0.479)	(0.474)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Farm per-FTE income				Non-farm per-FTE income			
log(prod.assets)	0.0536	0.0507	0.0531	0.0521	-0.0044	-0.0045	-0.0048	-0.0041
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.744)	(0.735)	(0.718)	(0.758)
has ox plough (=1)	0.0713	0.0712	0.0690	0.0708	0.2220	0.2224	0.2216	0.2214
	(0.523)	(0.525)	(0.539)	(0.525)	(0.020)**	(0.020)**	(0.020)**	(0.020)**
rainfall (mm)	0.0003	0.0003	0.0003	0.0003	-0.0002	-0.0002	-0.0002	-0.0002
	(0.116)	(0.130)	(0.129)	(0.116)	(0.352)	(0.342)	(0.351)	(0.357)
Constant	-1.9946	-0.9653	-1.1208	-1.6143	0.9754	0.8758	0.9766	0.7548
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***
ln(sigma)	0.3231	0.3263	0.3234	0.3253	0.2112	0.2136	0.2150	0.2123
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
atanhrho	-0.0318	-0.0369	-0.0547	0.0083	0.5829	0.5855	0.5911	0.5879
	(0.757)	(0.731)	(0.584)	(0.944)	(0.001)***	(0.001)***	(0.001)***	(0.001)***
N	6618	6618	6618	6618	6595	6595	6595	6595

Notes: Dependent variables are log-transformed per-FTE gross income measured in real 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Table A 3. Cont. Determinants of household per-FTE gross income (baseline specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
main model:								
Gini	-0.5051				-1.3441			
	(0.115)				(0.000)***			
skewness		0.0015				-0.0037		
		(0.619)				(0.058)*		
CV			0.0011				-0.0193	
			(0.855)				(0.000)***	
share under farms >10 ha				-1.0067				-1.0216
				(0.000)***				(0.000)***
female head (=1)	0.0622	0.0592	0.0599	-0.1134	-0.1148	-0.1124	-0.1160	-0.1137
	(0.412)	(0.435)	(0.430)	(0.026)**	(0.023)**	(0.026)**	(0.021)**	(0.024)**
km to road	-0.0013	-0.0012	-0.0011	-0.0011	-0.0011	-0.0007	-0.0008	-0.0011
	(0.430)	(0.471)	(0.498)	(0.284)	(0.272)	(0.521)	(0.427)	(0.279)
km to market	-0.0000	0.0002	0.0002	0.0008	0.0004	0.0009	0.0005	0.0008
	(0.998)	(0.750)	(0.761)	(0.050)*	(0.299)	(0.035)**	(0.226)	(0.059)*
elevation	-0.0003	-0.0003	-0.0003	0.0001	0.0001	0.0000	0.0001	0.0001
	(0.028)**	(0.027)**	(0.024)**	(0.173)	(0.380)	(0.586)	(0.476)	(0.209)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
slope	-0.0042	-0.0063	-0.0064	-0.0311	-0.0271	-0.0313	-0.0308	-0.0300
	(0.508)	(0.309)	(0.300)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
pop.density	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	(0.322)	(0.269)	(0.248)	(0.125)	(0.058)*	(0.008)***	(0.008)***	(0.124)
pdsq	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.438)	(0.384)	(0.360)	(0.291)	(0.211)	(0.038)**	(0.035)**	(0.275)
bimodal (=1)	0.1670	0.1200	0.1182	0.4275	0.4495	0.2795	0.3006	0.4212
	(0.178)	(0.325)	(0.330)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
farm size (ha)	0.0007	0.0009	0.0010	0.0085	0.0084	0.0083	0.0084	0.0084
	(0.965)	(0.956)	(0.952)	(0.234)	(0.233)	(0.238)	(0.233)	(0.241)
age of head	0.0051	0.0038	0.0037	-0.0017	0.0019	0.0003	0.0007	0.0006
	(0.709)	(0.786)	(0.789)	(0.890)	(0.875)	(0.977)	(0.957)	(0.963)
size of hhold	0.0186	0.0172	0.0171	-0.0064	-0.0076	-0.0081	-0.0073	-0.0078
	(0.624)	(0.650)	(0.652)	(0.791)	(0.749)	(0.737)	(0.761)	(0.746)
max.edu.attainment	-0.0054	-0.0054	-0.0049	0.0098	0.0096	0.0091	0.0094	0.0090
	(0.827)	(0.827)	(0.842)	(0.446)	(0.448)	(0.472)	(0.456)	(0.479)
(max) notharvestbin	0.2767	0.2735	0.2732	-0.0096	-0.0028	-0.0025	-0.0023	-0.0018
	(0.061)*	(0.065)*	(0.066)*	(0.924)	(0.978)	(0.980)	(0.982)	(0.985)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
log(prod.assets)	0.0053	0.0060	0.0059	0.0072	0.0068	0.0071	0.0067	0.0074
	(0.804)	(0.781)	(0.784)	(0.623)	(0.638)	(0.622)	(0.646)	(0.608)
has ox plough (=1)	0.1468	0.1510	0.1507	0.1898	0.1785	0.1807	0.1788	0.1828
	(0.329)	(0.319)	(0.320)	(0.045)**	(0.057)*	(0.055)*	(0.057)*	(0.052)*
rainfall (mm)	0.0002	0.0002	0.0002	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
	(0.528)	(0.523)	(0.521)	(0.141)	(0.196)	(0.211)	(0.211)	(0.208)
Constant	14.9325	14.4195	14.4505	14.1082	14.4201	13.4475	13.6540	14.1530
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
<u>selection</u>								
Gini	0.6438				0.6619			
	(0.002)***				(0.028)**			
skewness		0.0038				0.0060		
		(0.065)*				(0.050)**		
CV			0.0084				0.0085	
			(0.026)**				(0.112)	
share under farms >10 ha				0.5474				0.5277
				(0.042)**				(0.047)**
shock w/in 2 yrs: drought	0.1614	0.1656	0.1652	-0.0608	-0.0518	-0.0417	-0.0431	-0.0593

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
	(0.028)**	(0.024)**	(0.025)**	(0.570)	(0.625)	(0.695)	(0.685)	(0.574)
shock w/in 2 yrs: pest/disease	0.1259	0.1353	0.1332	0.2167	0.2114	0.2186	0.2166	0.2099
	(0.188)	(0.159)	(0.166)	(0.097)*	(0.105)	(0.094)*	(0.097)*	(0.107)
shock w/in 2 yrs: death in HH	0.0909	0.0978	0.0977	-0.0269	-0.0202	-0.0079	-0.0117	-0.0186
	(0.384)	(0.345)	(0.347)	(0.838)	(0.877)	(0.952)	(0.929)	(0.887)
landless=1	-0.0498	-0.0724	-0.0591	0.0335	0.0507	0.0197	0.0359	0.0362
	(0.700)	(0.576)	(0.650)	(0.814)	(0.719)	(0.890)	(0.801)	(0.798)
female head (=1)	0.1078	0.1055	0.1069	-0.1534	-0.1500	-0.1541	-0.1515	-0.1510
	(0.032)**	(0.036)**	(0.033)**	(0.010)***	(0.011)**	(0.009)***	(0.010)**	(0.010)**
km to road	0.0010	0.0007	0.0009	0.0022	0.0022	0.0020	0.0021	0.0022
	(0.335)	(0.490)	(0.415)	(0.106)	(0.094)*	(0.112)	(0.100)*	(0.091)*
km to market	0.0001	-0.0001	0.0000	-0.0013	-0.0012	-0.0014	-0.0012	-0.0013
	(0.911)	(0.762)	(0.985)	(0.027)**	(0.052)*	(0.016)**	(0.035)**	(0.022)**
elevation	-0.0001	-0.0001	-0.0001	0.0002	0.0002	0.0002	0.0002	0.0001
	(0.066)*	(0.104)	(0.080)*	(0.064)*	(0.059)*	(0.035)**	(0.048)**	(0.096)*
slope	-0.0054	-0.0032	-0.0036	0.0038	0.0039	0.0049	0.0048	0.0051
	(0.225)	(0.469)	(0.412)	(0.532)	(0.518)	(0.414)	(0.421)	(0.398)
pop.density	-0.0001	-0.0001	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
	(0.186)	(0.100)	(0.116)	(0.373)	(0.502)	(0.895)	(0.741)	(0.377)
pdsq	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.299)	(0.142)	(0.167)	(0.170)	(0.168)	(0.436)	(0.324)	(0.136)
bimodal (=1)	0.0973	0.1785	0.1731	0.0287	0.0047	0.0911	0.0832	0.0172
	(0.209)	(0.012)**	(0.015)**	(0.782)	(0.963)	(0.288)	(0.341)	(0.867)
farm size (ha)	0.0094	0.0093	0.0093	0.0337	0.0322	0.0328	0.0325	0.0328
	(0.310)	(0.308)	(0.309)	(0.026)**	(0.031)**	(0.031)**	(0.031)**	(0.028)**
age of head	0.0025	0.0037	0.0033	-0.0103	-0.0080	-0.0076	-0.0076	-0.0073
	(0.821)	(0.739)	(0.763)	(0.423)	(0.529)	(0.546)	(0.546)	(0.563)
size of hhold	0.0521	0.0526	0.0524	0.0772	0.0745	0.0737	0.0736	0.0755
	(0.031)**	(0.030)**	(0.030)**	(0.057)*	(0.062)*	(0.064)*	(0.065)*	(0.060)*
max.edu.attainment	0.0177	0.0177	0.0176	0.0632	0.0642	0.0657	0.0652	0.0639
	(0.231)	(0.232)	(0.233)	(0.001)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
(max) notharvestbin	-0.0342	-0.0363	-0.0356	-0.1116	-0.1032	-0.0949	-0.0988	-0.1017
	(0.730)	(0.714)	(0.719)	(0.354)	(0.386)	(0.423)	(0.405)	(0.393)
log(prod.assets)	-0.0014	-0.0024	-0.0017	0.0135	0.0165	0.0152	0.0162	0.0156
	(0.927)	(0.875)	(0.910)	(0.460)	(0.362)	(0.404)	(0.372)	(0.386)
has ox plough (=1)	0.1675	0.1680	0.1673	0.1975	0.1914	0.1878	0.1880	0.1918

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ag. wage per-FTE income				Total per-FTE income			
	(0.104)	(0.103)	(0.105)	(0.168)	(0.181)	(0.190)	(0.190)	(0.179)
rainfall (mm)	0.0002	0.0001	0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.532)	(0.547)	(0.541)	(0.575)	(0.726)	(0.668)	(0.700)	(0.713)
Constant	-0.8367	-0.4277	-0.4531	0.3170	0.2760	0.6462	0.6912	0.4013
	(0.001)***	(0.039)**	(0.027)**	(0.310)	(0.412)	(0.013)**	(0.006)***	(0.195)
ln(sigma)	0.0605	0.0635	0.0644	0.2752	0.2677	0.2728	0.2698	0.2705
	(0.064)*	(0.073)*	(0.074)*	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
atanhrho	0.1908	0.2030	0.2087	0.2267	0.2258	0.2370	0.2326	0.2323
	(0.337)	(0.336)	(0.324)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
N	6544	6544	6544	6634	6634	6634	6634	6634

Notes: Dependent variables are log-transformed per-FTE gross income measured in real 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Table A 4. Interactions between Land Concentration Measures and Farm Size Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
main model:								
Gini	-1.3567				-0.8141			
	(0.000)***				(0.000)***			
[farm>10ha] * Gini	0.2363				0.1761			
	(0.025)**				(0.100)			
skewness		-0.0042				0.0026		
		(0.031)**				(0.225)		
[farm>10ha] * skewness		0.0074				0.0050		
		(0.004)***				(0.063)*		
CV			-0.0208				-0.0043	
			(0.000)***				(0.299)	
[farm>10ha] * CV			0.0126				0.0105	
			(0.024)**				(0.079)*	
share under farms >10 ha				-1.0474				-0.8317
				(0.000)***				(0.000)***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
[farm>10ha] * share under farms >10 ha				0.2556				0.1752
				(0.010)***				(0.081)*
female head (=1)	-0.1057	-0.1031	-0.1078	-0.1040	-0.1076	-0.1079	-0.1082	-0.1076
	(0.037)**	(0.041)**	(0.033)**	(0.040)**	(0.046)**	(0.045)**	(0.044)**	(0.046)**
km to road	-0.0012	-0.0007	-0.0009	-0.0012	0.0004	0.0006	0.0006	0.0003
	(0.246)	(0.486)	(0.380)	(0.253)	(0.748)	(0.588)	(0.579)	(0.756)
km to market	0.0004	0.0009	0.0006	0.0008	-0.0011	-0.0008	-0.0009	-0.0010
	(0.312)	(0.031)**	(0.193)	(0.071)*	(0.019)**	(0.089)*	(0.060)*	(0.049)**
elevation	0.0001	0.0000	0.0001	0.0001	-0.0002	-0.0002	-0.0002	-0.0002
	(0.331)	(0.511)	(0.422)	(0.174)	(0.015)**	(0.015)**	(0.011)**	(0.038)**
slope	-0.0267	-0.0310	-0.0305	-0.0295	-0.0095	-0.0126	-0.0125	-0.0112
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.054)*	(0.009)***	(0.010)***	(0.021)**
pop.density	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	(0.052)*	(0.007)***	(0.007)***	(0.115)	(0.141)	(0.099)*	(0.077)*	(0.247)
pdsq	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
	(0.219)	(0.040)**	(0.037)**	(0.286)	(0.250)	(0.184)	(0.139)	(0.329)
bimodal (=1)	0.4626	0.2971	0.3152	0.4368	0.2830	0.1734	0.1772	0.2975
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.022)**	(0.020)**	(0.001)***
farm size (ha)	0.0062	0.0061	0.0069	0.0056	-0.0082	-0.0072	-0.0072	-0.0077
	(0.339)	(0.339)	(0.288)	(0.379)	(0.503)	(0.567)	(0.560)	(0.534)
age of head	0.0013	0.0001	0.0001	0.0001	0.0096	0.0079	0.0080	0.0084
	(0.912)	(0.995)	(0.995)	(0.994)	(0.383)	(0.474)	(0.467)	(0.443)
size of hhold	-0.0070	-0.0074	-0.0063	-0.0074	-0.0192	-0.0181	-0.0183	-0.0184
	(0.769)	(0.758)	(0.793)	(0.757)	(0.430)	(0.459)	(0.454)	(0.450)
max.edu.attainment	0.0089	0.0083	0.0086	0.0082	0.0250	0.0243	0.0244	0.0244
	(0.483)	(0.513)	(0.494)	(0.515)	(0.084)*	(0.094)*	(0.092)*	(0.093)*
(max) notharvestbin	-0.0101	-0.0083	-0.0098	-0.0087	0.1958	0.1980	0.1972	0.1957
	(0.919)	(0.934)	(0.921)	(0.931)	(0.059)*	(0.056)*	(0.057)*	(0.060)*
log(prod.assets)	0.0060	0.0065	0.0062	0.0065	0.0176	0.0184	0.0183	0.0177
	(0.676)	(0.655)	(0.672)	(0.652)	(0.197)	(0.179)	(0.182)	(0.193)
has ox plough (=1)	0.1761	0.1763	0.1767	0.1803	0.1242	0.1202	0.1227	0.1255
	(0.061)*	(0.063)*	(0.061)*	(0.056)*	(0.243)	(0.258)	(0.248)	(0.238)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
rainfall (mm)	-0.0004	-0.0004	-0.0004	-0.0004	0.0001	0.0001	0.0001	0.0001
	(0.172)	(0.191)	(0.185)	(0.185)	(0.717)	(0.700)	(0.711)	(0.684)
Constant	14.4101	13.4379	13.6386	14.1617	14.9133	14.1783	14.3312	14.9315
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
<u>selection:</u>								
Gini	0.6780				-0.0340			
	(0.025)**				(0.867)			
skewness		0.0060				0.0022		
		(0.047)**				(0.277)		
CV			0.0088				-0.0009	
			(0.102)				(0.804)	
share under farms >10 ha				0.5566				0.2220
				(0.037)**				(0.259)
shock w/in 2 yrs: drought	-0.0508	-0.0404	-0.0416	-0.0588	0.1139	0.1164	0.1136	0.1110
	(0.632)	(0.704)	(0.696)	(0.578)	(0.102)	(0.094)*	(0.103)	(0.110)
shock w/in 2 yrs: pest/disease	0.2142	0.2214	0.2196	0.2124	0.0314	0.0352	0.0345	0.0305
	(0.101)	(0.091)*	(0.093)*	(0.103)	(0.720)	(0.688)	(0.694)	(0.727)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
shock w/in 2 yrs: death in HH	-0.0175	-0.0051	-0.0088	-0.0156	0.1508	0.1494	0.1469	0.1503
	(0.894)	(0.969)	(0.947)	(0.905)	(0.116)	(0.119)	(0.126)	(0.118)
landless=1	0.0199	-0.0106	0.0057	0.0064	0.2060	0.2016	0.1950	0.2166
	(0.887)	(0.940)	(0.968)	(0.964)	(0.047)**	(0.056)*	(0.063)*	(0.037)**
female head (=1)	-0.1486	-0.1528	-0.1502	-0.1496	0.0108	0.0115	0.0106	0.0130
	(0.012)**	(0.010)***	(0.011)**	(0.011)**	(0.818)	(0.807)	(0.823)	(0.782)
km to road	0.0022	0.0020	0.0021	0.0022	-0.0007	-0.0007	-0.0007	-0.0006
	(0.098)*	(0.119)	(0.105)	(0.094)*	(0.467)	(0.470)	(0.487)	(0.534)
km to market	-0.0011	-0.0013	-0.0012	-0.0013	-0.0007	-0.0007	-0.0008	-0.0007
	(0.065)*	(0.021)**	(0.045)**	(0.029)**	(0.084)*	(0.092)*	(0.078)*	(0.105)
elevation	0.0002	0.0002	0.0002	0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.045)**	(0.026)**	(0.037)**	(0.078)*	(0.057)*	(0.066)*	(0.057)*	(0.045)**
slope	0.0036	0.0047	0.0046	0.0049	-0.0112	-0.0112	-0.0114	-0.0115
	(0.542)	(0.437)	(0.443)	(0.415)	(0.006)***	(0.006)***	(0.005)***	(0.005)***
pop.density	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
	(0.465)	(0.855)	(0.702)	(0.336)	(0.078)*	(0.098)*	(0.072)*	(0.046)**
pdsq	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
	(0.174)	(0.454)	(0.339)	(0.137)	(0.030)**	(0.040)**	(0.026)**	(0.017)**
bimodal (=1)	0.0144	0.1035	0.0951	0.0246	0.0578	0.0497	0.0532	0.0235
	(0.888)	(0.228)	(0.277)	(0.810)	(0.419)	(0.435)	(0.407)	(0.748)
farm size (ha)	0.0326	0.0333	0.0328	0.0331	-0.0004	-0.0005	-0.0005	-0.0004
	(0.032)**	(0.032)**	(0.032)**	(0.028)**	(0.956)	(0.948)	(0.947)	(0.953)
age of head	-0.0077	-0.0073	-0.0074	-0.0071	0.0036	0.0036	0.0035	0.0034
	(0.540)	(0.558)	(0.556)	(0.576)	(0.725)	(0.720)	(0.730)	(0.736)
size of hhold	0.0754	0.0747	0.0746	0.0764	0.0156	0.0153	0.0156	0.0155
	(0.059)*	(0.061)*	(0.061)*	(0.057)*	(0.482)	(0.489)	(0.480)	(0.485)
max.edu.attainment	0.0648	0.0662	0.0657	0.0644	0.0287	0.0285	0.0284	0.0288
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.028)**	(0.029)**	(0.029)**	(0.027)**
(max) notharvestbin	-0.1047	-0.0963	-0.1002	-0.1033	0.0651	0.0658	0.0647	0.0656
	(0.380)	(0.417)	(0.399)	(0.386)	(0.478)	(0.473)	(0.480)	(0.475)
log(prod.assets)	0.0167	0.0155	0.0165	0.0159	-0.0043	-0.0044	-0.0047	-0.0040
	(0.351)	(0.392)	(0.360)	(0.374)	(0.749)	(0.740)	(0.724)	(0.763)
has ox plough (=1)	0.1916	0.1877	0.1880	0.1922	0.2222	0.2224	0.2216	0.2216
	(0.181)	(0.192)	(0.191)	(0.179)	(0.020)**	(0.020)**	(0.020)**	(0.020)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: farm per-FTE income				Dep var: non-farm per-FTE income			
rainfall (mm)	-0.0001	-0.0001	-0.0001	-0.0001	-0.0002	-0.0002	-0.0002	-0.0002
	(0.748)	(0.687)	(0.720)	(0.734)	(0.349)	(0.339)	(0.349)	(0.354)
Constant	0.2242	0.6047	0.6474	0.3373	0.9730	0.8730	0.9734	0.7510
	(0.507)	(0.020)**	(0.011)**	(0.277)	(0.000)***	(0.000)***	(0.000)***	(0.001)***
ln(sigma)	0.2655	0.2702	0.2676	0.2681	0.2121	0.2150	0.2155	0.2135
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
atanhrho	0.2270	0.2369	0.2328	0.2334	0.5887	0.5939	0.5956	0.5956
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.001)***	(0.001)***	(0.000)***
N	6634	6634	6634	6634	6595	6595	6595	6595

Notes: Dependent variables are log-transformed per-FTE gross income measured in real 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Table A 4. Cont. Interactions between Land Concentration Measures and Farm Size Categories

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
main model:								
Gini	-0.5238				-1.3727			
	(0.102)				(0.000)***			
[farm>10ha] * Gini	0.1681				0.2381			
	(0.319)				(0.024)**			
skewness		0.0013				-0.0042		
		(0.658)				(0.033)**		
[farm>10ha] * skewness		0.0014				0.0074		
		(0.760)				(0.004)***		
[farm>10ha] * CV			0.0024				0.0126	
			(0.808)				(0.024)**	
CV			0.0007				-0.0209	
			(0.903)				(0.000)***	
share under farms >10 ha				-0.7311				-1.0693
				(0.063)*				(0.000)***
[farm>10ha] * share under farms >10 ha				0.1602				0.2582

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
				(0.314)				(0.009)***
female head (=1)	0.0621	0.0592	0.0601	0.0589	-0.1085	-0.1059	-0.1109	-0.1068
	(0.412)	(0.435)	(0.429)	(0.436)	(0.033)**	(0.037)**	(0.029)**	(0.036)**
km to road	-0.0014	-0.0012	-0.0011	-0.0015	-0.0013	-0.0008	-0.0010	-0.0013
	(0.384)	(0.456)	(0.479)	(0.350)	(0.215)	(0.441)	(0.342)	(0.221)
km to market	0.0000	0.0002	0.0002	0.0001	0.0004	0.0009	0.0005	0.0007
	(0.997)	(0.741)	(0.748)	(0.852)	(0.353)	(0.039)**	(0.222)	(0.084)*
elevation	-0.0003	-0.0003	-0.0003	-0.0003	0.0001	0.0000	0.0000	0.0001
	(0.028)**	(0.027)**	(0.024)**	(0.034)**	(0.390)	(0.590)	(0.491)	(0.205)
slope	-0.0040	-0.0062	-0.0064	-0.0041	-0.0265	-0.0309	-0.0304	-0.0294
	(0.532)	(0.310)	(0.303)	(0.514)	(0.000)***	(0.000)***	(0.000)***	(0.000)***
pop.density	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	(0.319)	(0.265)	(0.244)	(0.374)	(0.056)*	(0.007)***	(0.008)***	(0.125)
pdsq	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.433)	(0.378)	(0.355)	(0.467)	(0.204)	(0.035)**	(0.033)**	(0.273)
bimodal (=1)	0.1675	0.1201	0.1183	0.1842	0.4566	0.2878	0.3070	0.4324
	(0.177)	(0.324)	(0.330)	(0.141)	(0.000)***	(0.000)***	(0.000)***	(0.000)***
farm size (ha)	-0.0014	0.0004	0.0006	-0.0020	0.0062	0.0061	0.0069	0.0056

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
	(0.934)	(0.981)	(0.974)	(0.909)	(0.336)	(0.335)	(0.285)	(0.375)
age of head	0.0050	0.0038	0.0038	0.0052	0.0023	0.0010	0.0010	0.0010
	(0.716)	(0.787)	(0.786)	(0.708)	(0.848)	(0.931)	(0.934)	(0.931)
size of hhold	0.0179	0.0172	0.0171	0.0194	-0.0077	-0.0080	-0.0069	-0.0080
	(0.637)	(0.651)	(0.652)	(0.607)	(0.747)	(0.740)	(0.773)	(0.739)
max.edu.attainment	-0.0056	-0.0053	-0.0049	-0.0067	0.0091	0.0085	0.0089	0.0085
	(0.820)	(0.828)	(0.841)	(0.785)	(0.471)	(0.500)	(0.483)	(0.503)
(max) notharvestbin	0.2739	0.2721	0.2716	0.2762	0.0002	0.0016	0.0002	0.0015
	(0.064)*	(0.066)*	(0.067)*	(0.062)*	(0.998)	(0.987)	(0.998)	(0.988)
log(prod.assets)	0.0053	0.0060	0.0059	0.0056	0.0061	0.0066	0.0063	0.0066
	(0.804)	(0.780)	(0.784)	(0.794)	(0.670)	(0.649)	(0.665)	(0.645)
has ox plough (=1)	0.1442	0.1504	0.1497	0.1443	0.1769	0.1773	0.1776	0.1811
	(0.336)	(0.321)	(0.323)	(0.335)	(0.060)*	(0.062)*	(0.060)*	(0.055)*
rainfall (mm)	0.0002	0.0002	0.0002	0.0002	-0.0004	-0.0003	-0.0003	-0.0003
	(0.525)	(0.521)	(0.522)	(0.519)	(0.203)	(0.224)	(0.217)	(0.217)
Constant	14.9658	14.4307	14.4589	15.1624	14.4656	13.4816	13.6839	14.2210
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
selection								

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
Gini	0.6439				0.6618			
	(0.002)***				(0.028)**			
skewness		0.0038				0.0059		
		(0.065)*				(0.051)*		
CV			0.0084				0.0084	
			(0.026)**				(0.114)	
share under farms >10 ha				0.9074				0.5271
				(0.000)***				(0.048)**
shock w/in 2 yrs: drought	0.1610	0.1655	0.1651	0.1536	-0.0520	-0.0420	-0.0433	-0.0596
	(0.028)**	(0.025)**	(0.025)**	(0.035)**	(0.624)	(0.693)	(0.684)	(0.572)
shock w/in 2 yrs: pest/disease	0.1259	0.1353	0.1331	0.1247	0.2116	0.2189	0.2170	0.2100
	(0.188)	(0.159)	(0.166)	(0.192)	(0.105)	(0.094)*	(0.097)*	(0.107)
shock w/in 2 yrs: death in HH	0.0912	0.0978	0.0977	0.0883	-0.0197	-0.0075	-0.0112	-0.0180
	(0.383)	(0.346)	(0.347)	(0.398)	(0.880)	(0.954)	(0.932)	(0.891)
landless=1	-0.0499	-0.0724	-0.0592	-0.0515	0.0517	0.0211	0.0368	0.0378
	(0.700)	(0.576)	(0.650)	(0.688)	(0.713)	(0.882)	(0.796)	(0.789)
female head (=1)	0.1077	0.1055	0.1069	0.1092	-0.1498	-0.1539	-0.1513	-0.1508
	(0.032)**	(0.036)**	(0.033)**	(0.030)**	(0.011)**	(0.009)***	(0.010)**	(0.010)**

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
km to road	0.0010	0.0007	0.0009	0.0011	0.0022	0.0020	0.0021	0.0022
	(0.335)	(0.490)	(0.415)	(0.281)	(0.095)*	(0.114)	(0.101)	(0.092)*
km to market	0.0001	-0.0001	0.0000	-0.0001	-0.0012	-0.0014	-0.0012	-0.0013
	(0.911)	(0.761)	(0.985)	(0.873)	(0.052)*	(0.017)**	(0.035)**	(0.022)**
elevation	-0.0001	-0.0001	-0.0001	-0.0002	0.0002	0.0002	0.0002	0.0001
	(0.066)*	(0.104)	(0.080)*	(0.029)**	(0.058)*	(0.035)**	(0.048)**	(0.095)*
slope	-0.0054	-0.0032	-0.0036	-0.0046	0.0039	0.0049	0.0048	0.0051
	(0.225)	(0.469)	(0.412)	(0.298)	(0.518)	(0.415)	(0.422)	(0.398)
pop.density	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	0.0000	0.0000	0.0000
	(0.186)	(0.100)	(0.116)	(0.314)	(0.502)	(0.894)	(0.740)	(0.378)
pdsq	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.299)	(0.142)	(0.167)	(0.434)	(0.168)	(0.435)	(0.324)	(0.136)
bimodal (=1)	0.0973	0.1785	0.1731	0.0583	0.0047	0.0913	0.0835	0.0173
	(0.209)	(0.012)**	(0.015)**	(0.466)	(0.963)	(0.287)	(0.339)	(0.866)
farm size (ha)	0.0094	0.0093	0.0093	0.0098	0.0326	0.0334	0.0329	0.0332
	(0.311)	(0.309)	(0.310)	(0.304)	(0.030)**	(0.030)**	(0.031)**	(0.027)**
age of head	0.0025	0.0037	0.0033	0.0028	-0.0079	-0.0074	-0.0075	-0.0072
	(0.821)	(0.739)	(0.763)	(0.796)	(0.533)	(0.553)	(0.550)	(0.570)

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
size of hhold	0.0521	0.0526	0.0524	0.0515	0.0744	0.0736	0.0735	0.0753
	(0.031)**	(0.030)**	(0.030)**	(0.033)**	(0.062)*	(0.065)*	(0.065)*	(0.061)*
max.edu.attainment	0.0177	0.0177	0.0176	0.0183	0.0642	0.0656	0.0651	0.0639
	(0.231)	(0.232)	(0.233)	(0.218)	(0.001)***	(0.000)***	(0.000)***	(0.000)***
(max) notharvestbin	-0.0341	-0.0362	-0.0356	-0.0351	-0.1036	-0.0954	-0.0993	-0.1021
	(0.730)	(0.714)	(0.719)	(0.723)	(0.384)	(0.421)	(0.403)	(0.391)
log(prod.assets)	-0.0014	-0.0024	-0.0017	-0.0016	0.0165	0.0153	0.0163	0.0157
	(0.926)	(0.875)	(0.910)	(0.915)	(0.360)	(0.401)	(0.370)	(0.383)
has ox plough (=1)	0.1676	0.1681	0.1673	0.1664	0.1913	0.1876	0.1879	0.1919
	(0.104)	(0.103)	(0.105)	(0.106)	(0.181)	(0.191)	(0.190)	(0.179)
rainfall (mm)	0.0002	0.0001	0.0001	0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.532)	(0.547)	(0.541)	(0.538)	(0.726)	(0.668)	(0.701)	(0.714)
Constant	-0.8366	-0.4276	-0.4530	-1.0620	0.2753	0.6463	0.6910	0.4006
	(0.001)***	(0.039)**	(0.027)**	(0.000)***	(0.413)	(0.013)**	(0.006)***	(0.195)
ln(sigma)	0.0597	0.0632	0.0642	0.0585	0.2670	0.2718	0.2692	0.2696
	(0.064)*	(0.072)*	(0.074)*	(0.059)*	(0.000)***	(0.000)***	(0.000)***	(0.000)***

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Dep var: ag. wage per-FTE income				Dep var: total per-FTE income			
atanhrho	0.1878	0.2013	0.2073	0.1823	0.2264	0.2368	0.2329	0.2329
	(0.343)	(0.338)	(0.325)	(0.341)	(0.000)***	(0.000)***	(0.000)***	(0.000)***
N	6544	6544	6544	6544	6634	6634	6634	6634

Notes: Dependent variables are log-transformed per-FTE gross income measured in real 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Table A 5. Inter-Period Income Changes Regressed on Lagged Dependent Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: change in log farm per-FTE income				Dep var: Avg annual change in non-farm per-FTE income			
Gini	0.0218				-0.3767			
	(0.962)				(0.364)			
skewness		-0.0062				0.0017		
		(0.168)				(0.676)		
CV			-0.0104				-0.0019	
			(0.238)				(0.807)	
share under farms >10 ha				0.0160				-0.5943
				(0.971)				(0.177)
lag: ha_cult	-0.0340	-0.0324	-0.0325	-0.0340	-0.0187	-0.0201	-0.0198	-0.0182
	(0.031)**	(0.046)**	(0.042)**	(0.032)**	(0.560)	(0.522)	(0.534)	(0.568)
lag: headage	-0.0142	-0.0133	-0.0139	-0.0142	-0.0073	-0.0085	-0.0081	-0.0077
	(0.451)	(0.481)	(0.462)	(0.452)	(0.732)	(0.691)	(0.707)	(0.719)
lag: hhsize	0.0774	0.0796	0.0804	0.0775	-0.0391	-0.0407	-0.0389	-0.0401
	(0.092)*	(0.083)*	(0.080)*	(0.092)*	(0.364)	(0.353)	(0.369)	(0.352)
lag: maxeduc	0.0383	0.0384	0.0384	0.0382	-0.0335	-0.0325	-0.0322	-0.0342
	(0.184)	(0.184)	(0.185)	(0.184)	(0.206)	(0.224)	(0.226)	(0.196)
lag: notharvestbin	0.5166	0.5149	0.5178	0.5167	-0.4091	-0.4195	-0.4136	-0.4135
	(0.019)**	(0.019)**	(0.019)**	(0.019)**	(0.016)**	(0.013)**	(0.015)**	(0.014)**
lag: logassets	-0.1554	-0.1550	-0.1556	-0.1554	-0.0065	-0.0072	-0.0067	-0.0068
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.753)	(0.725)	(0.742)	(0.743)
lag: oxplough	-0.1149	-0.1300	-0.1235	-0.1149	0.0051	0.0001	0.0001	0.0046
	(0.537)	(0.486)	(0.507)	(0.537)	(0.976)	(1.000)	(0.999)	(0.978)
lag: crops07	0.0006	0.0006	0.0006	0.0006	-0.0008	-0.0007	-0.0008	-0.0007
	(0.070)*	(0.067)*	(0.069)*	(0.070)*	(0.149)	(0.154)	(0.148)	(0.152)
lag: femhead	-0.0563	-0.0587	-0.0546	-0.0562	-0.0975	-0.1022	-0.0996	-0.0990
	(0.637)	(0.624)	(0.648)	(0.639)	(0.368)	(0.344)	(0.358)	(0.359)
lag: kmroad	-0.0050	-0.0048	-0.0050	-0.0050	0.0004	0.0005	0.0006	0.0003

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: change in log farm per-FTE income				Dep var: Avg annual change in non-farm per-FTE income			
	(0.030)**	(0.037)**	(0.030)**	(0.031)**	(0.839)	(0.804)	(0.781)	(0.878)
lag: kmmarket	-0.0002	-0.0002	-0.0004	-0.0002	-0.0002	-0.0000	-0.0001	-0.0001
	(0.883)	(0.870)	(0.729)	(0.880)	(0.852)	(0.998)	(0.928)	(0.917)
lag: elev	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000
	(0.188)	(0.223)	(0.172)	(0.193)	(0.888)	(0.881)	(0.907)	(0.782)
lag: slope	0.0121	0.0115	0.0118	0.0121	-0.0060	-0.0075	-0.0074	-0.0066
	(0.148)	(0.162)	(0.150)	(0.143)	(0.636)	(0.537)	(0.550)	(0.594)
lag: pd	-0.0001	-0.0000	-0.0001	-0.0001	0.0000	0.0000	0.0000	0.0000
	(0.677)	(0.833)	(0.765)	(0.688)	(0.795)	(0.784)	(0.736)	(0.940)
lag: pdsq	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.674)	(0.551)	(0.605)	(0.680)	(0.839)	(0.831)	(0.774)	(0.953)
lag: bimodal	0.0259	0.0317	0.0302	0.0263	0.0673	0.0227	0.0197	0.1058
	(0.868)	(0.832)	(0.840)	(0.867)	(0.675)	(0.871)	(0.889)	(0.523)
Constant	0.1734	0.4584	0.4361	0.1791	-0.0213	-0.3780	-0.2863	0.1551
	(0.760)	(0.294)	(0.318)	(0.746)	(0.962)	(0.241)	(0.366)	(0.739)
Time averages?	yes	yes	yes	yes	yes	yes	yes	yes
Year-zone dummies?	yes	yes	yes	yes	yes	yes	yes	yes
N	1642	1642	1642	1642	1460	1460	1460	1460

Notes: Dependent variables are wave-on-wave differences in log-transformed per-FTE gross income measured in real 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

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