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ABSTRACT

System GMM techniques are significantly superior to short panels in situations where T is short, and N is big in prior studies. Although the system-GMM coefficients are short-run coefficients, while access to land is critical to long-term food security too. And, the elasticity or responsiveness of food security as a result of access to land and other predictors, in the long run, is not well understood in Ethiopia. The system GMM approach is used in this study. The study addresses this issue by computing the long-run GMM coefficients from its short-run GMM coefficients. Since the explanatory variable is a dummy measure (1/0) and the dependent variable is stated in natural logarithms, year-dummy control is calculated in order to take into consideration temporal fluctuations in the dependent variable across the panels. According to the findings, farm size, TLU, heads completed primary education, adult equivalence, one-year lag of annual food consumption per adult equivalence, number of household parcels, households' distance to the main road (Kms), heads age, households' distance from the market center (Kms), and female-headed households are both short-run and long-run complements of food security.

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Exploring the Long-run Dynamic Links between Access to Land and Food Security: Evidence from Ethiopia

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ABSTRACT

System GMM techniques are significantly superior to short panels in situations where T is short, and N is big in prior studies. Although the system-GMM coefficients are short-run coefficients, while access to land is critical to long-term food security too. And, the elasticity or responsiveness of food security as a result of access to land and other predictors, in the long run, is not well understood in Ethiopia. The system GMM approach is used in this study. The study addresses this issue by computing the long-run GMM coefficients from its short-run GMM coefficients. Since the explanatory variable is a dummy measure (1/0) and the dependent variable is stated in natural logarithms, year-dummy control is calculated in order to take into consideration temporal fluctuations in the dependent variable across the panels. According to the findings, farm size, TLU, heads completed primary education, adult equivalence, one-year lag of annual food consumption per adult equivalence, number of household parcels, households' distance to the main road (Kms), heads age, households' distance from the market center (Kms), and female-headed households are both short-run and long-run complements of food security. The result also showed that household farm size (acre) has a more significant positive effect on food security in the short run (0.179%) than in the long run (0.076%). Thus, besides to answering the issues being addressed, the work also makes methodological contributions.

Keywords: land access, food security, system gmm estimates, long run gmm, panel data, ethiopia.

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I. INTRODUCTION

Ethiopia is the second-most populated country in Africa after Nigeria, with about 113.5 million people living there as of 2022, making it the 13th most populous nation in the world. [1]. Ethiopia's economy is based primarily on agriculture, which is approximately employing 85% of the country's population [2]. Ethiopia had nearly 38.5 million hectares of agricultural land in 2020, corresponding to over 34 percent of the country's total land area [3]. Ethiopia is one of the most food-insecure countries in Sub-Saharan Africa. Since 1980, the government had a persistent food shortage. And, it is ranked 104th out of the 121 nations having enough data to compute the 2022 Global Hunger Index rankings. Ethiopia has a deep sever level of hunger, with a score of 27.6 [4].

In Ethiopia, 22.6 million people are food insecure due to drought, conflict, and increased in food prices [5]. Bodurtha et al. (2011) [6] report that 60% of Ethiopia's rural residents do not have enough acreage to provide enough food for their own families, and 43% of them live in a landless household. The farm size of Ethiopian households ranges from 0 ha to 10 ha. According to Headey (2014) [7], Ethiopia has an average cropland size of 0.96 hectares per household, with regional variances. The Southern Peoples Regions and Tigray both have 0.49 hectares. The region with the greatest land per family is Oromia (1.15 ha), followed by Amhara (1.09 ha). The country has gone through three main types of land tenure systems. The current system of land tenure was implemented in 1991, the Derg military regime

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was in place from 1974 to 1991, and the Imperial government functioned until 1974. Currently, the system of land tenure treats land as a public good. And, the Land policy has not brought the anticipated results and is also not participatory.

As a result, providing households with land and a guarantee of food security will be one of Ethiopia's most significant challenges in the coming decades. The ability of a family to feed itself depends on having access to farmland, which is the bedrock of the livelihoods of many smallholders [8]. Most research in Ethiopia didn't explore the long-run dynamic linkages of food security and farm size, and it includes the works of Diriba, 2020 [9]; Gebissa, 2021 [10]; Frankenberger and Coyle, 1993 [11]; IFPRI, 2020 [12]; Mengistu, 2014 [13]; Teshome, Arega, Mehrete, 2021 [14]; Bodurtha et al., 2011 [6]; Paul and Gĩthĩnji,2017 [15]. Therefore, it is crucial to evaluate the dynamic linkages of food security and access to land in rural households in Ethiopia over time using the system GMM approach.

II. METHODS AND MATERIAL

2.1 Data Source

The ESS survey, which collected information from 3288 households, provided the household parcel-level data used in our study. Ethiopian Socioeconomic Survey (ESS), the first-panel survey with a household questionnaire and comprehensive agricultural data, was conducted by the World Bank [16] Living Standards Measurement Study, Integrated Surveys of Agriculture (LSMS-ISA) group, and Ethiopian Central Statistical Agency (CSA) [17]. ESS1 stands for the first wave of the ESS, which took place between 2011–2012; the second wave, which took place in 2013–2014; the third wave, which took place in 2015–2016; and the fourth wave, which took place in 2018–2019. Since ESS4 for 2018–19 is a new panel and not a continuation of the ESS3 wave, we did not include it in the study. Finally, the data is organized, coded and estimated using STATA 17.

2.2 Estimation Approach

We used the system GMM method as an estimation strategy for the study because it accounts for time-invariant household-specific effects, addresses the endogeneity issue of the lagged dependent variable, permits some degree of endogeneity in the other regressors, and optimally combines information on cross-individual variation in levels with that on within-household variation in changes [18, 19]. Two-step system GMM estimates were also chosen over the one-step estimation because they are robust to heteroskedasticity and panel-specific autocorrelation with Windmeijer correction for limited samples, which helps to remove standard-error biases. Some prerequisites are dealing with data before estimating the long-run GMM coefficients. First, the short-run system GMM has to be calculated along with post-diagnosis tests (instrument validity test, serial correlation tests, and robustness check). The GMM estimate, a new estimator that combines the regression-in-differences with the regression-in-levels in a system, has obtained considerable traction in the empirical literature employed for this study. The two models (at "level", "first-difference") are specified as follows in light of this introspection:

$$Log\text{-}ann\text{-}food\text{-}cons\text{-}peraeq_{ilt}=\alpha_i+\beta log\text{-}food\text{-}cons\text{-}ann\text{-}peraeq_{il,\,t-1}+\pi log\text{-}Farmsize_{ilt}+\sum_{j=1}^{k}\mu jXjit+\varepsilon_{ilt};$$

$$j=1......k;\ i=1...n;\ t=1...,\ T_{+}\ \varepsilon_{ilt};\ i=1...,\ n;\ t=1...,\ T \qquad (1)$$

$$\Delta log\text{-}ann\text{-}food\text{-}cons\text{-}peraeq_{ilt}=\beta\Delta log\text{-}food\text{-}cons\text{-}ann\text{-}peraeq_{il,t-1}+\pi\Delta log\text{-}Farmsize_{ilt}+\sum_{j=1}^{k}\mu j\Delta Xjit+\Delta\, u_{it} \qquad (2)$$

Where log-ann-food-cons-peraeq$_{ilt}$ denotes food security and for household ***i*** for location ***l*** over period t; log_food_cons_ann_peraeq$_{il,t-1}$ entails the lagged dependent variable's value for household ***i*** in location ***l*** over period t; log-Farmsize$_{ilt}$ denotes logarithm of HHs total

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farm size (acre) a proxy to access to land for household ***i*** in location ***l*** over period **t**; *Xjit* is other predictors in the model for family i over period ***t*** and ***j*** is the number of included control variables (It has log-TLU$_{ilt}$; log-adulteq$_{ilt}$; log-Number-of-Parcel$_{ilt}$; log-HH-dist-road-Kms$_{ilt}$; log-HH-dist-market-Kms$_{ilt}$; log-Heads-age$_{ilt}$; dummy variables (Head completed primary school (=1), and Female-headed households (=1)) and time dummies); ε_{ilt}=the error term. For the disturbance-term, the following household-specific fixed effect is assumed: $\varepsilon il\ t = \phi i + u_{it}$.

Secondly, the long-run effect for the kth parameter is computed as follows:

$$\beta_k / [1- \phi] \qquad (3)$$

Where $\boldsymbol{\beta_k}$ represents the short-run coefficients of the independent variables and ϕ represents the coefficient of one period-lagged value of the dependent variable.

Finally, year dummies control for time variations of the dependent variable across the panels is also estimated. Therefore, the year dummies are computed as:

$$[e^{\breve{a}} - 1] \text{ X } 100 \qquad (4)$$

Where ***ӑ*** represents the year dummies coefficients, and ***e*** represents the exponent (i.e., the base or the anti-log) of the natural-logs. This is always used when the dependent variable is expressed in natural logarithms, and the explanatory variable is a dummy (1/0) measure.

III. RESULT AND DISCUSSION

3.1 'Generating' Long Run GMM Coefficients

This section briefly discusses the long-run estimates. The results of system GMM estimates (Annex-I) are Computed. The results are further validated using different diagnostic tests, which include serial correlation and "Sargan / Hansen" tests (Annex-II). the result further confirmed the authenticity of the estimated model and the instrumental variables, respectively. Robustness of the GMM results was checked from the pooled OLS (Anex-III), the fixed effect (Annex-IV), and the difference GMM (Annex-V) model results. Hence, the findings are robust when applied to too many different model specifications and instrument sets. Given the usual ceteris paribus assumption, the system-GMM coefficients are short-run coefficients. If the System-GMM result is significant it is also possible to compute the long-run GMM coefficients. The system GMM test in Annex-I shows that, all the coefficients at 5 % were found significant. The long-run GMM coefficients could be generated only for the significant short-run coefficients. Thus, Table 1 below gives the long-run effect for the kth parameter.

Table 1: Long-run GMM coefficients of the significant system GMM coefficients

Log-food-cons-ann-paraeq	Coef.	Std.Err.	z	P>z	[95%Conf. Interval]
_nl_1:(b[log-food-cons-ann-paraeq-L]) / (1-_b [log-food-cons-ann-paraeq-L])	-0.576	0.040	-14.27 0	0.000	-0.655 -0.497
_nl_1: (b [log-Farm Size acre]) / (1-_b [log-food-cons-ann-paraeq-L])	0.076	0.033	2.280	0.023	0.011 0.141
_nl_1: (b[log-TLU]) / (1-b [log-food-cons-ann-paraeq-L])	0.521	0.088	5.890	0.000	0.348 0.695
_nl_1: (b[log-adulte]) / (1-_b [log_food-cons-ann-peraeq-L])	-1.315	0.362	-3.640	0.000	-2.023 -0.606
_nl_1: (b [log-Number of Parcel]) / (1-_b [log-food-cons-ann-paraeq-L])	-0.144	0.034	-4.300	0.000	-0.210 -0.079
_nl_1: (b [log-HH-dist-road Kms]) / (1-_b [log-food-cons-ann-paraeq-L])	-0.032	0.008	-4.010	0.000	-0.048 -0.016
_nl_1: (b [log-Heads age]) /	-0.131	0.044	-3.000	0.003	-0.216

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(1-_b [log-food-cons-ann-peraeq-L])					-0.045
_nl_1: (b [log-HH-dist-market Kms]) / (1-_b [log-food-cons-ann-peraeq-L])	-0.123	0.012	-10.38 0	0.000	-0.146 -0.100
_nl_1:(b [Head completed primary education]) / (1-_b [log-food-cons-ann-peraeq-L])	0.177	0.030	5.850	0.000	0.118 0.237
_nl_1: (b [Female-headed (=1]) / (1-_b [log-food-cons-ann-peraeq-L])	-0.377	0.137	-2.750	0.006	-0.646 -0.108

Source: Authors' own computation (2023)

We were looking closely the STATA outputs of the long-run coefficients. First, we observed that, we had found ***Z***-statistics instead of ***t*** statistic but it doesn't loss the interpretation**.** The estimated long-run coefficients or the test output of the long-run GMM model in Table 1 simply shows that, a percentage change in adult equivalence, one year-lagged of annual food consumption per adult equivalence, number of household parcel, households distance to main road (Kms), heads age, households distance from the market center (Kms) and female-headed households leads to about 1.315%, 0.576%, 0.144%, 0.032%, 0.131%, 0.123%, 0.377% decrease in annual food consumption per adult equivalence or food security level of household in the long run at 1% significance level, respectively. It also shows that, a percentage change in total farm size of families (acre), tropical livestock units, and heads completed primary education leads to about 0.076%, 0.521%, 0.177% increase in annual food consumption per adult equivalence (food security level of a household) in the long-run, at 1% significance level. Adult equivalence and annual food consumption per adult equivalence exhibit an elastic relationship, and the other independent variables were found to have an inelastic relationship with the dependent variable. Household's Farm size (acre), tropical livestock unit, and household head completed primary education has a more significant positive effect on annual food consumption per adult equivalence in the short-run (0.179%, 1.23%, 0.419%) than in the long-run (0.076%, 0.521%, 0.177%) respectively.

3.2 "Plotting" Year Dummies in System GMM

Year dummies control for time variations of the dependent variable across the panels is also computed using the general formula. This is used when the dependent variable is expressed in natural logarithms, and the explanatory variable is a dummy (1/0) measure. Therefore, the 2016 (y_3) from the system GMM output is computed as follows:

$$[e^{0.2613757} - 1] X100 = 29.87\%$$

As a result, in Ethiopia's rural and small-town areas, the average yearly food intake per adult equivalence in 2016 was 29.87% greater than the average in 2014, ceteris paribus. The 'computation result' that was previously displayed is supported by Figure 1 which also depicts the trend of food consumption over time.

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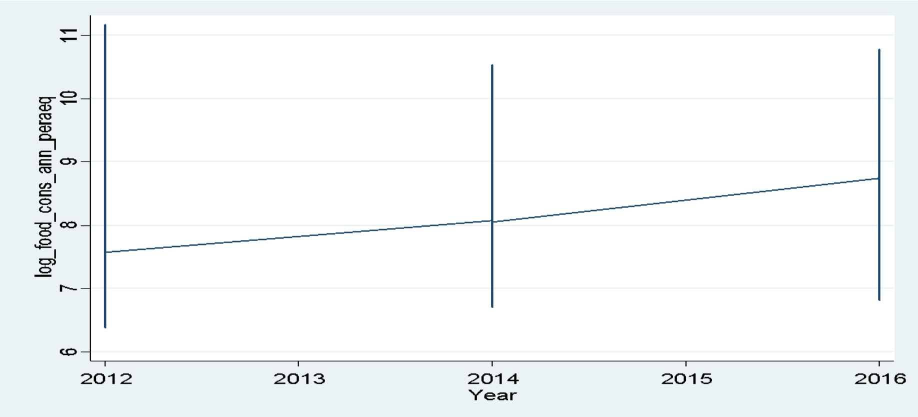

Source: Authors' own computation (2022)

Figure 1: Plotted log of food consumption annual per adult equivalence

IV. CONCLUSION

We concluded that farm size, measured in acres, had a significant and favorable impact on food security both in the short-run and long-run. And, there is an inelastic relationship between farmland availability and long-term food security level of families. Since there is an inelastic relationship between farmland and food security, the data strengthens the argument that farmers' productivity is harmed by public land ownership. As farmers seek to raise food for their families, this causes serious issues. To grant farmers their land rights, land policy should be centered on households' access to land. The government should also take steps to increase agricultural productivity, promote education, prioritize women in policy, and close long-term infrastructural gaps that affect rural households.

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Declaration of competing interest

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ANNEXES

Annex-I: Result of dynamic panel-data estimate, two-step system GMM

Log-food-cons-ann_per aeq	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1. log-ann-food-cons-paraeq-L1	-1.359	0.225	-6.05	0.000	-1.799	-0.919	***
2. log-Farmsize acre	0.179	0.078	2.31	0.021	0.027	0.332	**
3. log-TLU	1.23	0.235	5.24	0.000	0.770	1.69	***
4. log-adulteq	-3.101	0.871	-3.56	0.000	-4.809	-1.394	***
5. log-Number of Parcel	-0.34	0.081	-4.19	0.000	-0.499	-0.181	***
6. log-HH-dist-road Kms	-0.076	0.02	-3.86	0.000	-0.114	-0.037	***
7. log-HH-dist-market Kms	-0.291	0.04	-7.30	0.000	-0.369	-0.212	***
8. log-Heads-age	-0.308	0.108	-2.85	0.004	-0.520	-0.096	***
9. Head completed primary education (=1)	0.419	0.079	5.32	0.000	0.264	0.573	***
10. Female headed (=1)	-0.89	0.326	-2.73	0.006	-1.528	-0.251	***
y-1	0.038	0.037	1.02	0.307	-0.035	0.11	
y-3	0.261	0.048	5.45	0.000	0.167	0.355	***
Constant	24.68	2.517	9.81	0.000	19.749	29.618	***
Mean dependent var	8.145		SD dependent var			0.664	
Number of obs	9855		F-test			11779.118	

**** p<.01, ** p<.05, * p<.1*

Note: Dependent variable: log-foo-cons-ann-peraeq.

Source: Authors' own computation (2023)

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Annex-II: Test of validity of instruments

Sargan test of overid. Restrictions: (Not robust, but not weakened by many instruments.)	chi2(1)	= 0.04 prob > chi2 = 0.834
Hansen test of overid. Restrictions: (Robust, but weakened by many instruments.)	chi2(1)	= 2.32 prob > chi2 = 0.128

Source(s): Authors' own analysis (2023)

Annex-III: Pooled Ordinary Least Square (POLS) regression results

Log-food-cons-ann-peraeq	Coef.	St.Err	t-value	p-value	[95% Conf	Interval]
1. *Log-food-cons-ann-paraeq-L*	0.213	0.009	22.59	0.000	0.194	0.231
2. log-Farmsize acre	0.018	0.005	3.50	0.000	0.008	0.029
3. log-TLU	0.184	0.01	17.58	0.000	0.163	0.204
4. log-Number of Parcel	-0.054	0.011	-5.14	0.000	-0.075	-0.033
5. log-adulteq	-0.384	0.013	-28.49	0.000	-0.41	-0.358
6. log-HH-dist-road Kms	-0.007	0.002	-4.41	0.000	-0.01	-0.004
7. log-HH-dist-market Kms	-0.092	0.007	-13.03	0.000	-0.106	-0.078
8. log-Heads-age	-0.034	0.019	-1.78	0.075	-0.072	0.003
9. Head completed primary education (=1)	0.153	0.018	8.43	0.000	0.118	0.189
10. Female-headed (=1)	-0.046	0.016	-2.84	0.004	-0.077	-0.014
y-1	-0.163	0.015	-10.69	0.000	-0.193	-0.133
y-2	-0.083	0.015	-5.50	0.000	-0.113	-0.053
O	0.000	.	.	.	.	.
Constant	7.334	0.118	62.01	0.000	7.102	7.566
Mean dependent var	8.145	SD dependent var			0.664	
R-squared	0.181	Number of obs			9857	
F-test	180.861	Prob > F			0.000	
Akaike crit. (AIC)	17961.345	Bayesian crit. (BIC)			18054.892	

**** p<.01, ** p<.05, * p<.1*

Annex-IV: Fixed-effects model results

log_food_cons_ann_peraeq	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1. *log-food-cons-ann-peraeq-L*	-0.32	0.011	-30.50	0.000	-0.341	-0.3	***
2. log-Farmsize acre	0.011	0.007	1.62	0.105	-0.002	0.025	
3. log-TLU	0.09	0.016	5.75	0.000	0.059	0.121	***
4. log-Number of Parcel	-0.047	0.022	-2.12	0.034	-0.091	-0.004	**
5. log-adulteq	-0.43	0.024	-17.64	0.000	-0.478	-0.383	***
6. log-HH-dist-road Kms	-0.005	0.002	-2.29	0.022	-0.009	-0.001	**
7. log-HH-dist-market Kms	0.029	0.042	0.69	0.489	-0.053	0.111	

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8. log-Heads-age	0.083	0.054	1.54	0.123	-0.023	0.189	
9. Head completed primary Education (=1)	0.071	0.076	0.93	0.351	-0.079	0.221	
10. Female-headed (=1)	-0.08	0.039	-2.03	0.042	-0.157	-0.003	**
y-1	-0.11	0.014	-7.72	0.000	-0.138	-0.082	***
y-2	-0.099	0.013	-7.52	0.000	-0.125	-0.073	***
O	0.000	.	.	.	.	.	
Constant	10.926	.281	38.87	0.000	10.375	11.477	***

Mean dependent var	8.145	SD dependent var	0.664
R-squared	0.177	Number of obs	9857
F-test	117.872	Prob > F	0.000
Akaike crit. (AIC)	10052.461	Bayesian crit. (BIC)	10146.008

*** *p<.01*, ** *p<.05*, * *p<.1*

Annex-V: Dynamic panel-data estimation, two-step difference GMM

Log-food-cons-ann-peraeq	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1. *log-food-cons-ann-peraeq-L*	-1.331	0.212	-6.29	0.000	-1.746	-0.916	***
2. log-Farmsize acre	-0.053	0.06	-0.87	0.383	-0.171	0.066	
3. log-TLU	-0.384	0.221	-1.74	0.083	-0.818	0.05	*
4. log-adulteq	2.012	0.916	2.20	0.028	0.216	3.808	**
5. log-Number of Parcel	-0.419	0.339	-1.24	0.216	-1.084	0.246	
6. log-HH-dist-road Kms	0.018	0.016	1.14	0.254	-0.013	0.049	
7. log-HH-dist-market Kms	-0.101	0.542	-0.19	0.852	-1.163	0.961	
8. log-Heads age	-2.249	1.39	-1.62	0.106	-4.975	0.477	
9. Head completed primary education (=1)	0.223	0.142	1.57	0.117	-0.056	0.503	
10. Female-headed (=1)	0.167	0.148	1.13	0.26	-0.123	0.456	
y_2	-0.001	0.073	-0.01	0.991	-0.144	0.142	
y_3	0.217	0.131	1.65	0.098	-0.04	0.473	*

Mean dependent var	.	SD dependent var	.
Number of obs	6568	F-test	.

*** *p<.01*, ** *p<.05*, * *p<.1*

Source: Authors' own computation (2023)

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