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Farm Fragmentation and Productivity Evidence from Georgia

by

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Farm Fragmentation and Productivity: Evidence from Georgia

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The following analysis is based on the survey of 2,520 rural households in 40 Georgian villages conducted by the Hebrew University of Jerusalem (HUJ) with USAID/CDR funding in March-April 2003. The villages were selected from four administrative districts: Dusheti, Mtskheta, Sagarejo, and Gardabani. While the survey was designed to explore general reform-related issues, it contained detailed questions on both farm fragmentation and farm production. The database of this HUJ 2003 survey thus provides a relatively unique opportunity for exploring the impact of farm fragmentation on productivity in a transition country.

Farm fragmentation in Georgia is the outcome of a land-reform strategy that strove, back in 1992, to endow all the rural population with land on an equitable basis. The land endowments distributed to rural households were intended to satisfy local subsistence needs and to ensure a fairly regular flow of surplus food commodities to urban markets in a time of general unrest and civil strife. The land distribution strategy has been often credited with enabling Georgia to avert widespread famine during the early years of disruption and civil war.

The average farm in the HUJ 2003 survey had 1.6 hectares divided into 2.4 parcels. The average farm size is biased upward by a small number of relatively large farms. Thus, just 1% of the farms in the survey were larger than 10 hectares. As a result, the median farm size is much smaller than the mean size (0.75 hectares only).

Judging by the number of parcels, farm fragmentation in Georgia is close to that in Moldova, where the average holdings is split into 2-3 parcels. However, there is one significant difference: the data for Georgia represent fragmentation of land use ("farm fragmentation"), whereas the available data for Moldova represent fragmentation of land ownership, which is distinct from land use. No data on land-use fragmentation are currently available for Moldova.

For purposes of our analysis, farm fragmentation was expressed by three measures (**Table 1**):
-- the number of parcels;
-- the average distance to the parcels in each farm;
-- the Simpson index, calculated as 1 minus the ratio of the sum of squared parcel areas to the squared area of the total farm (the Simpson index is 0 when the farm consists of a single parcel and approaches 1 for farms split into numerous plots of equal size).

Farm productivity was represented by the partial productivity of land, calculated as the aggregated value of farm output per hectare. To determine the aggregated value of output, the production quantity of each commodity as reported in the survey (including both crops and livestock products) was multiplied by the median price of that commodity as estimated from the questions on commodity sales. Constant median prices were applied to all observations in the database because the large number of missing values in the sales section ruled out the option of using case-by-case prices to calculate the value of output. **Table 2** and **Figure 1** present the land productivity versus the number of parcels (from 1 to 8). The immediate visual impression is that farm productivity decreases with the increase in the number of parcels, although the pairwise differences are generally not statistically significant. Lack of statistical significance is clear from Figure 2, where the median productivity of each successive fragmentation category (the black horizontal strokes) generally falls within the interquartile range of the next category (the gray vertical bars).

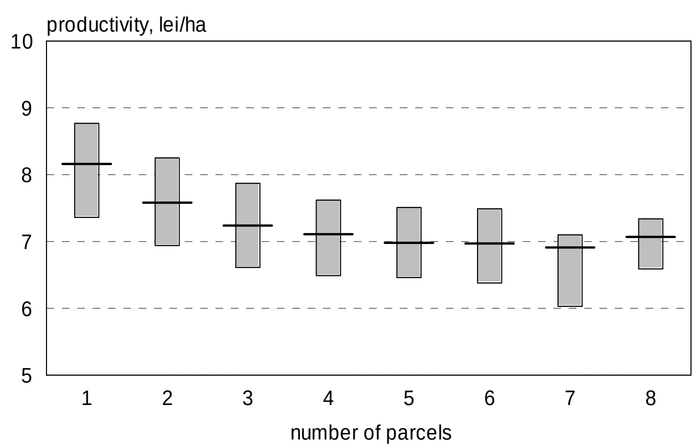
Table 1. Measures of farm fragmentation in Georgia

	Mean	Median	Lower quartile	Upper quartile
Farm size, ha	1.61	0.75	0.34	1.15
Number of parcels	2.40	2	1	3
Average distance of parcels from home, km	1.37	1	0.25	2
Simpson index	0.36	0.43	0.00	0.56

Table 2. Land productivity versus number of parcels

Number of parcels	Number of observations	Productivity, lari/ha			
		Mean	Median	Lower quartile	Upper quartile
1	611	8.02	8.16	7.36	8.77
2	895	7.53	7.58	6.94	8.25
3	572	7.17	7.24	6.61	7.87
4	232	6.95	7.11	6.49	7.62
5	78	6.91	6.98	6.46	7.51
6	51	6.88	6.97	6.38	7.49
7	19	6.66	6.91	6.03	7.10
8	8	6.94	7.07	6.59	7.34
All farms	2466	7.47	7.51	6.81	8.23

Land productivity vs. fragmentation



Instead of utilizing just eight observations on medians, as in **Table 2** and **Figure 1**, we can exploit nearly 2,500 observations by regressing the raw productivity values on fragmentation. The regression coefficient of logged productivity on any of the three fragmentation measures (number of parcels, average distance, and Simpson index) was found to be negative and highly significant ($p = 0.001$; the corresponding results are presented as Models 1-3 in **Table 3**). This implies that land productivity indeed decreases with fragmentation, as initially suggested by **Figure 1**. The regression line demonstrating the decrease of productivity with increasing fragmentation (as measured by the number of parcels) is shown in **Figure 2.** However, the explanatory power of these regressions is very low ($R^2 < 0.1$), which means that productivity actually depends on additional variables, and not only fragmentation.

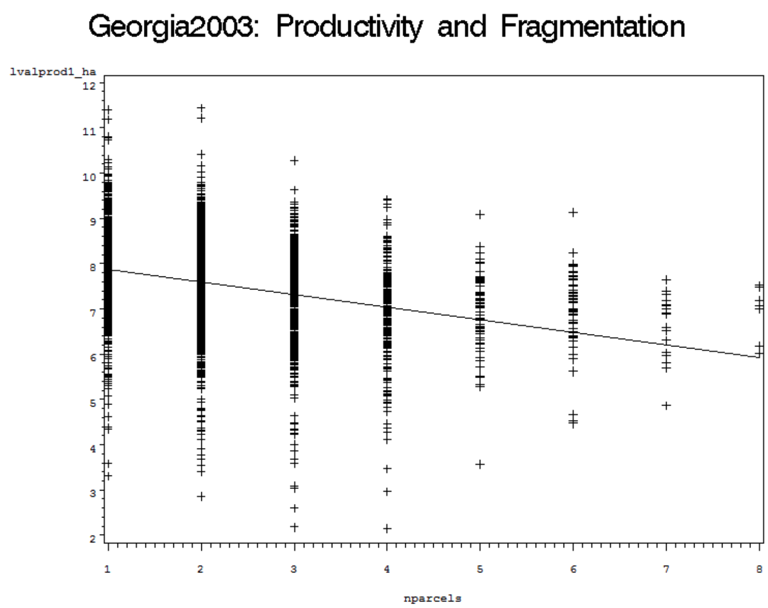


Table 3. Land productivity and fragmentation: regression results with logged output per hectare as the dependent variable

	Number of parcels	Average distance, km	Simpson index	Farm size (logged)	Specialization (share of crop production, %)	R^2
Model 1	-0.275					0.093
Model 2		-0.210				0.098
Model 3			-0.815			0.031
Model 4	-0.040			-0.642	-0.013	0.438
Model 5		-0.083		-0.619	-0.013	0.446
Model 6			-0.215	-0.651	-0.013	0.438
Model 7	-0.035	-0.081		-0.595	-0.013	0.447
Model 8		-0.083	-0.214	-0.601	-0.013	0.448

Since fragmentation may proxy for farm size (the larger the farm, the greater the number of parcels) or for diversification of production (which probably increases with the number of parcels), we augmented the regression model to include the total land used by the farm (in hectares) and the share of crop production in farm output (in percent). Farm size, like productivity, was transformed to logarithmic form, whereas the fragmentation and specialization variables remained unlogged. The results for the augmented models are presented by Models 4-8 in **Table 3**. Models 4-6 present the regression results with each of the three fragmentation variables taken separately (together with farm size and specialization). Models 7-8 combine two of the three fragmentation measures in one model: average distance is included together with the number of parcels (Model 7) and with the Simpson index (Model 8). All coefficients in **Table 3** are significant at p= 0.05 (or better) and R^2 for the augmented models is greater than 0.4. The Simpson index in a certain sense is equivalent to the number of parcels (weighted by parcel areas), and the models that include both these fragmentation variables are not shown in **Table 3** (the corresponding coefficients are not significant).

The results in **Table 3** consistently produce statistically significant negative coefficients for the fragmentation variables – taken on their own or controlling for farm size and specialization. The 2003 farm survey in Georgia thus shows that **fragmentation has a negative effect on productivity: land productivity declines as farm fragmentation increases**.

Another interesting finding is the effect of farm size: controlling for fragmentation and product mix, productivity decreases with the increase of farm size. On the face of it, this result is similar to the finding for Moldova, where small farms have been found to be more productive than large farms. In Moldova, however, small farms were in the range of 1-10 hectares, whereas large farms where in the range of 500-3,000 hectares. In Georgia, “small” and “large” farms are all basically less than 10 hectares, and we would expect a certain increase in productivity as very small farms consolidate into larger units. To investigate the farm size effect in Georgia by the same methodology as in Moldova, we proceeded to calculate Total Factor Productivity (TFP) from two-input production functions (i.e., models that include labor as well as land) estimated using the 2003 survey database.

TFP for Georgian farms

TFP is calculated as the ratio of the value of production to the value of aggregated inputs. The inputs are aggregated by applying the estimated production-function coefficients as the weights.

Table 4. TFP calculation (n = 2418)

	Sample mean	Production function coefficients*	Weights
Value of production, lari	2,009	6.73185	
Land use, ha	1.64	0.32401	0.394
Number of workers**	2.89	0.49891	0.606
Aggregated inputs, lari	2.39		
TFP, lari per unit of aggregated inputs	914		

*Two-input Cobb-Douglas production function; coefficients significant at $p < 0.0001$; $R^2 = 0.202$.
**Full time equivalents calculated by assigning the weight 1 to people who work the whole year on the farm and 0.3 to part-time and seasonal workers. Includes family labor and hired workers.

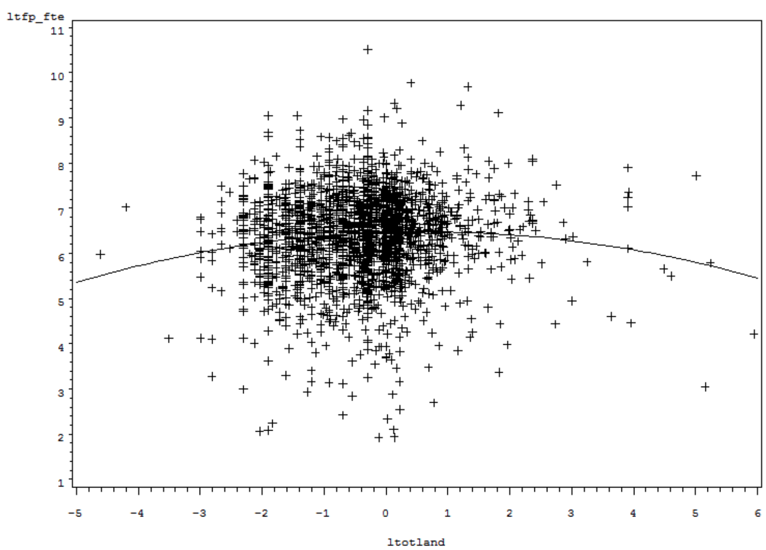
To capture the impact of farm size and fragmentation on total factor productivity, we regressed TFP (logged) on land area (logged), two fragmentation variables (number of parcels and average distance from home to the parcels), and a specialization measure (the share of crop production in total output). The regression results are presented in **Table 5**. Similarly to the productivity of land in **Table 3**, TFP was observed to decrease for higher fragmentation and for higher crop specialization: the corresponding regression coefficients were negative. However, contrary to the productivity of land, which decreased with farm size in **Table 3**, TFP was observed to *increase* with farm size: the corresponding coefficient was positive.

Table 5. Impact of farm size and fragmentation on total factor productivity (*n* = 2250)

	Linear model	Quadratic model
Constant	7.198 ($p < 0.0001$)	7.245 ($p < 0.0001$)
Farm size, ha	0.054 ($p = 0.0148$)	0.058 ($p = 0.0083$)
Farm size squared	--	-0.023 ($p = 0.0045$)
Number of parcels	-0.034 ($p = 0.0496$)	-0.044 ($p = 0.0117$)
Average distance of parcels from home	-0.072 ($p < 0.0001$)	-0.071 ($p < 0.0001$)
Specialization (share of crop production, %)	-0.012 ($p < 0.0001$)	-0.012 ($p < 0.0001$)
R^2	0.183	0.186

To capture possible nonlinear size effects, which initially drive the productivity up as farm size increases but eventually make it decline, we estimated a quadratic regression model with two farm size terms: land area and land area squared (last column in **Table 5**). In this quadratic model the linear size term had a positive coefficient, whereas the quadratic size term had a negative coefficient. This supports the hypothesis that initially productivity rises as farm size increases, but eventually it peaks out and starts decreasing. The farm size coefficients in **Table 5** indicate that the turnaround point falls near 3.5 hectares: TFP rises with increasing size for farms smaller than 3.5 hectares and decreases with increasing size for farms larger than 3.5 hectares (**Figure 3**). The impact of fragmentation and specialization is the same as in the linear model.

Georgia 2003: TFP vs. farm size



Additional evidence of the negative impact of fragmentation is obtained from technical efficiency results of the 2003 survey.[1] A statistically significant negative relationship is observed between the TE scores and the three fragmentation measures. Technical efficiency (like TFP) decreases as fragmentation grows.

[1] The TE scores were calculated by Ofir Hoyman as part of his MSc thesis at the Department of Agricultural Economics and Management, HUJ (2005). The inputs in this TE analysis were land, family labor, and the value of farm fixed assets; the output was sales-based value added, calculated by subtracting the cost of hired labor from sales revenue. The specific procedure used to generate the data for the TE analysis reduced the number of available observations with valid TE scores from the total of 2520 to 1390.

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