Productivity and Efficiency of Individual Farms in Poland: A Case for Land Consolidation

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Abstract
The article examines productivity and efficiency of Polish individual farms, contributing to the policy debate on excessive fragmentation and the need for land consolidation. Data of a rural household survey conducted in the spring of 2000 show that Polish individual farms in the size range of up to 100 hectares have positive marginal productivity of land and increasing returns to scale. Among the individual farms surveyed, larger farms report higher household incomes from farm and non-farm sources combined. Rural families cultivating larger land holdings are observed to be substantially better off than families with relatively small allotments.

Introduction

Poland, the largest country in Central Eastern Europe, is still highly agrarian, with 27% of the labor force employed in agriculture. However, despite its large share in employment, Polish agriculture contributes less than 10% to the country's gross value added. Agricultural productivity is thus far below the average for the economy, and Polish policy-makers continue to focus on ways for improving productivity and efficiency of their agriculture.

Low productivity is a general feature of the inherited agriculture in former socialist countries in Europe and Central Asia. This feature is commonly attributed to the weaknesses of the collective form of organization that was dominant in most of the region during the Soviet era. Yet Poland is unique among transition countries in this respect: Polish agriculture was not subjected to sweeping collectivization after World War II and individual farms have consistently controlled about 80% of agricultural land in this country. Low agricultural productivity in Poland is thus low productivity of individual farms, not collectives or cooperatives.

The post-World War II land reform in Poland distributed the land of most large estates to the rural population, creating an agriculture of smallholders. The fragmented farm structure produced by this reform did not undergo significant adjustment during the Socialist regime due to lack of land markets. Although transactions in agricultural land were never prohibited in Poland, various administrative restrictions and high legal costs prevented the development of functioning land markets in the decades after World War II. Today, there are 3 million farmers in Poland, and one-third have average holdings of 0.4 hectares (Csaki and Lerman 2002). This situation, combined with the acknowledged inefficiency of Polish agriculture, keep the questions of farm fragmentation and consolidation at the center of the public debate in Poland.

There is evidence that farm consolidation could improve family incomes in rural Poland. Thus, both cash family income and imputed family income (including the value of farm products from own production consumed in the household) increase with the amount of land cultivated by the household (Csaki and Lerman 2002). Households with land enjoy higher incomes than rural households without land. Larger individual farms produce higher incomes and achieve higher levels of family welfare than smaller farms. This finding has naturally led to the conclusion that consolidation of individual farms (within the range of up to about 100 hectares) is a desirable process and has produced certain policy recommendations relating to land markets as a medium for farm size adjustment. In this paper, we extend the previous analysis of rural family incomes and examine the relationship of productivity and efficiency to farm size in the individual farming sector in Poland. The analysis is based on the data of a rural household survey in Poland conducted by the World Bank with the support of the Polish Ministry of Agriculture in the spring of 2000 (for more details of this survey, see World Bank 2001). The views expressed in this paper are those of the author and in no way reflect the policy, official or otherwise, of the World Bank.

Variables in the Analysis

Three measures of output are used in this analysis: the value of production (or output); farm value added; and imputed family income. The value of production is calculated from the farm sales revenue and the percentage of output sold as reported by respondents in the survey (households reporting some farm sales and characterized as "sellers"). The resulting figure combines sales revenue and the value of consumption of own farm products in the proportions specified by the respondents.[1] For households that do not report any sales of farm products and yet report some farm production ("non-sellers"), the value of output is calculated from their land holdings based on a simple regression model estimated for the "sellers". "Non-sellers" and "sellers" are thus assumed to have the same marginal output by land. Farm value added is calculated as the value of production net of the cost of purchased inputs. In this sense, it represents the contribution of farm operations to labor, land, and other capital. Finally, imputed family income is calculated as the sum of cash family income plus the value of own-produced food consumed by the family. It is equal to farm value added (i.e., value of production net of cost of purchased inputs) plus off-farm salary income, unearned income (pensions and other transfers), and any income from non-farm business activities reported by the respondents. Payments for hired labor (reported by a very small percentage of farms) are subtracted as a cash outflow. Income from sales of assets (land or other property) is not included in our calculation of family income for two reasons: conceptually, this is a one-time extraordinary item that does not necessarily affect the level of family income over time; practically, asset sales are reported by a minute percentage of households and their impact on mean cash income is negligible.

Table 1 presents the value of farm output as calculated from sales revenue for several farm-size categories. The last two columns show that the percentage of own production consumed in the household decreases with the increase of farm size, while the level of commercialization correspondingly rises. The difference between the value of farm output and sales revenue represents the value of farm products consumed by the family (column 1 in Table 2). Combined with cash farm income (i.e., sales revenue net of purchased input costs and payments to hired

[1] This technique of determining the value of output was applied instead of the conventional technique of multiplying quantities by prices for each commodity produced because the survey did not collect direct price information and provided only data for the quantity produced, quantity sold, and value of sales by product. Any calculation based on these data would ultimately involve using the percentage of output sold by product to derive the value of output. We carried out essentially the same calculation using aggregate data, instead of by-product data.

labor – column 2), this gives the total farm component in imputed family income (column 3). Based on farm sales only, the households with the smallest land holdings (up to 5 hectares) are "unprofitable", showing negative cash farm incomes. Yet when allowance is made for the value of own products consumed in the household, the net (imputed) farm income becomes positive, i.e., the value of production exceeds the cost of purchased inputs even for the smallest farms, although sales revenue does not. The share of farm income in total family income increases rapidly with farm size, while the share of off-farm salaries and unearned income correspondingly decreases (columns 4 and 6). Non-farm business income is small for farms of all sizes.

Table 1. Production, Sales, and Own Consumption by Farm Size

	Number of respondents	Value of output, zloty	Sales revenue, zloty	Percent of output sold	Percent of output consumed
Up to 1 ha	292	2641	757	29	71
1-2 ha	162	7085	1752	25	75
2-5 ha	292	14252	4144	29	71
5-7 ha	127	23312	9002	39	61
7-20 ha	323	49544	23262	47	53
20-30 ha	118	107599	64871	60	40
Over 30 ha	105	209219	126610	61	39

Table 2. Components of Family Income

	Own products consumed, zloty	Cash net farm income, zloty	Imputed family income, zloty	Farm income, %	Off-farm business income, %	Personal income, %
	1	2	3	4	5	6
Up to 1 ha	1885	-872	16824	6	2	92
1-2 ha	5334	-567	22094	22	2	76
2-5 ha	10108	-397	26752	36	2	62
5-7 ha	14309	1767	33177	48	14	38
7-20 ha	26282	8740	45244	77	1	22
20-30 ha	42728	29276	83360	86	1	13
Over 30 ha	82609	66424	170201	88	7	5

Partial Productivity Measures

Farm output and farm value added naturally increase with the increase of farm size. Yet the partial productivity of land (farm value added per hectare) remains constant at 3,000 zloty/ha across farms of different sizes (the differences between farm size categories are not statistically significant). This effect is shown in Figure 1, with more details supplied in Table 3.

The total labor input including family members, relatives, and hired workers (reported in work days) also generally increases with farm size, but at a much slower rate than farm value added. Thus, while value added increases at a rate of 38% with increasing farm size, the labor input increases at a rate of 1% only (linear regression estimates: ValAdd = 6003 + 2290*farmsize; WorkDays = 431 + 2.7*farmsize). Based on grouped means (Table 3), the farm value added increases 15-fold (from about 1,000 zloty for farms of up to 1 hectare to 150,000 zloty for farms larger than 30 hectares), while the labor input increases by a factor of 2-2.5 (from 250 work days to 550-600 work days). As a result, the productivity of labor (farm value added per work day) shows a clear increasing trend with farm size (Figure 1). It rises from a median of 4 zloty per work day for farms of up to 1 hectare to over 200 zloty per work day for farms larger than 30 hectare (the mean productivity increases even more steeply, from 5 to 1,000 zloty per work day – see Table 3).

Fig. 1. Productivity of Land and Labor by Farm Size

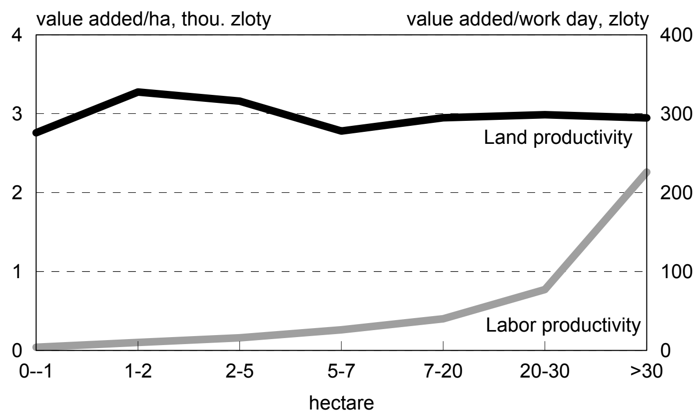


Table 3. Productivity of Land and Labor by Farm Size

	Value added, zloty	Work days	Value added per hectare (mean)	Value added per work day (mean)	Value added per hectare (median)	Value added per work day (median)
Up to 1 ha	1,073	177	2,758	5	2,808	4
1-2 ha	4,875	311	3,274	26	2,731	10
2-5 ha	10,062	431	3,159	44	2,633	16
5-7 ha	16,545	550	2,780	47	2,370	26
7-20 ha	35,520	506	2,947	133	1,947	40
20-30 ha	73,915	542	2,987	209	1,743	77
Over 30 ha	151,110	493	2,945	1,009	2,023	226

Production Function Estimation

The farm data available in the survey make it possible to estimate a basic production function that relates farm output to the main factors of production: land, labor, purchased inputs, livestock, and farm machinery. Alternatively, a farm income specification may be used regressing farm value added (value of output net of the cost of purchased inputs) on factors of production. As with any survey database, our information suffers from a large number of missing values; there are also many cases where a variable (such as machinery or purchased inputs) is legitimately zero. This naturally reduces the number of valid cases that can be used for the standard Cobb-Douglas (or translog) specification of the production function. The value of output could be estimated from sales data for fully 1438 out of 1515 farming households. Yet zeros and missing values for the factors of production effectively left only 873 valid observations for production function estimation using the value of output as the dependent variable. Even fewer valid observations (831) could be used for income function estimation, as about 40 farms had negative value added (with cost of purchased inputs exceeding the value of output) producing missing log values. Difficulties with zeros and negative values in principle can be overcome by using a quadratic (or a general polynomial) specification. Yet in our case the logarithmic specification has produced more meaningful results (in terms of R-square values and significance of the coefficients) despite the somewhat larger number of cases available for the quadratic specification. We accordingly report here only the results of the standard Cobb-Douglas logarithmic specification, in which the regression coefficients directly represent elasticities.

Table 4. Production and Income Regressions

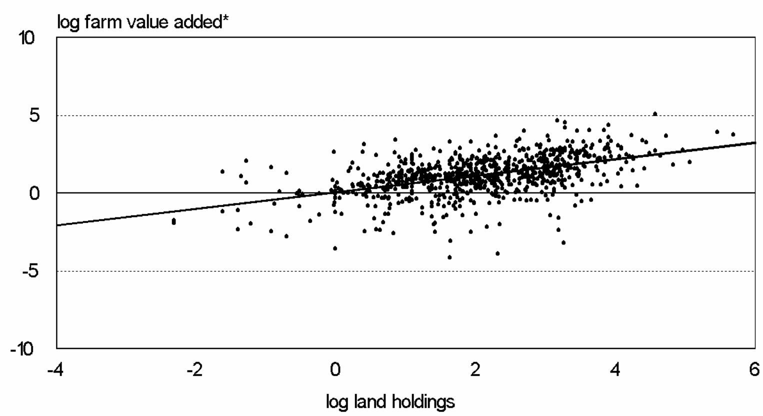
Model	1	2	3		4	
N	869	825	825		882	
Dependent variable	Value of output	Farm value added	Farm value added		Imputed family income	
	Estimated coefficients*	Estimated coefficients#	Estimated coefficients	Signif. P	Estimated coefficients	Signif. P
Land, ha	0.416	0.539	0.519	0.00	0.301	0.00
Purchased inputs, zloty	0.288	--	--		--	--
Labor, work days	0.094	0.127	**0.148**	**0.06**	**-0.024**	**0.53**
Livestock, standard head	0.153	0.211	0.235	0.00	0.144	0.00
Farm machinery, pcs	0.187	0.297	0.208	0.09	0.138	0.03
Number of land parcels			-0.147	0.10	-0.069	0.12
Household size			**0.179**	**0.24**	**0.309**	**0.00**
Dummy variables:						
Use of hired labor			0.405	0.02	0.363	0.00
New farm investment			**0.086**	**0.51**	**0.150**	**0.02**
Off-farm salaries			**-0.125**	**0.34**	**0.437**	**0.00**
Pensions			**-0.144**	**0.27**	**0.206**	**0.00**
Non-farm business			**0.220**	**0.46**	**0.475**	**0.00**
Participation in Krus					-0.062	0.54
Participation in Zus					-0.068	0.52
Household head characteristics						
Age			0.010	0.75	-0.005	0.75
Age squared			-0.000	0.71	0.000	0.57
Education dummy (high/low)			**0.137**	**0.37**	**0.162**	**0.04**
R-square	0.708	0.275	0.288		0.360	
Sum of coefficients	1.138 (p=0.003)	1.174 (p=0.119)				

* All coefficients significant at 0.01.
# All coefficients significant at 0.1.

The first two columns in Table 4 present the estimation results for basic production function and farm income function models (Cobb-Douglas logarithmic specification is used). In both models, land appears to be the major determinant, with elasticities of 0.4-0.5. An increase of 1% in land holdings (keeping all other factors of production constant) contributes 0.42% to output and 0.54% to farm value added. The effect of land on farm value added (controlling for all other factors) is plotted in Figure 2, where the vertical axis is farm value added net of the effect of all non-land factors (i.e., the residual after subtracting from farm value added the sum of all non-land factors weighted by the corresponding regression coefficients from model 2). The slope of the straight line in this figure is 0.53, virtually identical with the elasticity of farm value added by land in model 2.

Among the other factors, labor appears to have the lowest return in both models, with elasticities of 0.09 and 0.13, respectively. Farm machinery and livestock produce substantially higher returns, with elasticities ranging from 0.15 to 0.3 (Table 4).

Fig. 2. Farm Value Added vs Farm Size



*adjusted for non-land factors

Farm income may naturally depend on many other variables in addition to the basic factors of production introduced explicitly in models 1 and 2. The analysis is broadened in model 3 (Table 4), which includes three new groups of variables:

(1) Two continuous (logged) variables, which represent respectively the fragmentation of land holdings (number of land parcels) and the family size (as a measure of the potential pool of labor, given that individual farms rely mainly on family labor, not hired workers).
(2) A set of dummy variables (with yes/no answers) characterizing the use of hired labor, new farm investment during the previous year, existence of off-farm salaries, pensions, and non-farm business income, as well as participation in two alternative social security schemes – the highly subsidized farmers' social insurance scheme Krus and the general workers' social insurance scheme Zus. The coefficients of the dummy variables reported for model 3 correspond to the "yes" level relative to the "no" level.
(3) Household head characteristics: the age and age squared (both non-logged continuous variables) and an education dummy with two levels, "high" including higher, uncompleted higher, and secondary education, and "low" including primary, partial primary, and no education. The coefficient of the education dummy variable corresponds to the "high" level relative to the "low" level and thus represents returns to human capital.

The most significant new factor that appears in model 3 compared with the basic models 1 and 2 is the use of hired labor. The coefficient of the hired labor dummy is 0.40. This means that farms using hired labor on average achieve 40% more farm income than farms relying on family labor only. Hired labor, despite its strong impact, does not account for the total effect of labor on farm value added: the coefficient of total labor input (a continuous variable) remains highly significant and close in its value to the coefficient in the basic model 2. There are positive returns to all labor in individual farms even when we differentiate between hired and family labor. Another interesting factor in model 3 is the fragmentation of land, expressed by the (logged) number of parcels. Fragmentation of holdings has a negative impact on farm income, although its significance is marginal (p=0.1). All other factors included in model 3, and most notably the three off-farm income dummies, have no impact on farm income. Somewhat surprisingly, the coefficient of the farm investment dummy is not significant either. This means that new farm investment undertaken during the previous year did not increase the average farm income in the sample.

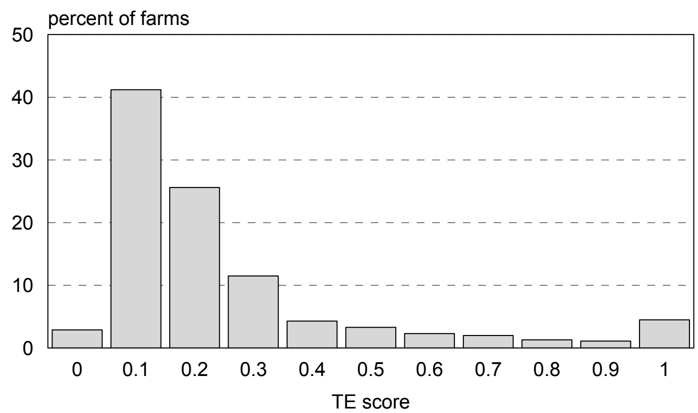
To complete the analysis, model 4 describes the determinants of imputed family income, which includes income from both farm and non-farm sources. The coefficients of farm-related factors generally follow the same pattern as in model 2, although their values are lower. This is understandable, because the coefficients represent factor shares and farm income is only a part (although a very substantial part) of imputed family income. A noteworthy shift in effect is observed between labor input and household size: the farm income model (model 3) shows positive returns to farm labor and no impact of household size; the family income model (model 4), on the other hand, shows a significant positive impact of family size and no significant returns to farm labor. This switch is consistent with the observation that all non-farm income sources (off-farm salaries, pensions, non-farm business income) are highly significant in model 4: non-farm income has a significant positive effect on total family income, while it has no impact on farm income in model 3. Specifically, off-farm salaries and non-farm business income raise the average family income by more than 40% (controlling for other variables) compared with farming households without these income sources. Human capital (as represented by the education of the household head) also provides significant positive returns in model 4, whereas it does not have an effect on farm income in model 3. The age of the household head and participation in different social insurance schemes affect neither farm income nor total family income.

Returns to Scale

We have seen in Figure 1 that the partial productivity of land is practically constant across farms of different sizes, while the partial productivity of labor increases with farm size. A production model allowing for five factors of production – land, labor, purchased inputs, livestock, and machinery – reveals increasing returns to scale in Polish individual farming: the sum of factor shares in model 1 is significantly greater than 1 (Table 4). The sum of coefficients in model 2 with farm value added as the dependent variable is also greater than 1, but the significance level is marginal at p=0.12.

The conclusion of increasing returns to scale that emerges from production function analysis is supported by technical efficiency results obtained by Data Envelopment Analysis. Technical efficiency scores were calculated practically for the same sample of farms and the same set of (logged) variables as in production function analysis. A DEA algorithm allowing for variable returns to scale was used (this is a non-parametric algorithm that uses mathematical programming to construct a strictly downward-concave production efficiency frontier from actual input/output observations; see Coelli et al. 1998). About 10% of the sample farms are the "leaders": they define the production efficiency frontier, reaching technical efficiency scores of 0.9-1.0. However, there is a wide gap between these "leaders" and the rest. Most of the farms (80%) have very low efficiency scores around 0.1-0.3, clustering at the bottom of the efficiency scale. Instead of a typical unimodal distribution with scores dropping monotonically from a peak near the maximum efficiency of 1, Polish individual farms show a distinctly bimodal distribution of technical efficiency scores: the mode at 0.9-1.0 corresponding to the highly efficient "leaders" and the mode at 0.1-0.3 corresponding to the highly inefficient bulk of the farms (Figure 3). As a result, the average technical efficiency score for the entire sample is a very low 0.25, leaving a huge margin for increasing farm output through more efficient use of the factors of production.

Fig. 3. Technical Efficiency Scores (DEA)



The technical efficiency scores, however low, show a definite tendency to increase for larger farms. A linear regression of the technical efficiency scores on farm size produces a highly significant positive coefficient. Yet a closer examination of the behavior of technical efficiency scores suggests a quadratic pattern of variation with farm size (Figure 4, Table 5): relatively high technical efficiencies are achieved for the smallest farms (up to 2 hectares) and for the largest farms (over 30 hectares). Mid-sized farms with between 5-30 hectares are characterized by relatively low technical efficiencies. Mid-sized farms thus can improve both their farm income and their efficiency by increasing their land holdings. The smallest farms, on the other hand, will need to achieve a very substantial jump in size (from 1-2 hectares to over 30 hectares) if in addition to increasing their farm income they aim to improve efficiency.

The estimated increase of technical efficiency cannot be extrapolated, of course, beyond the range of observed farm sizes, which in no case exceeds 300 hectares. There are limits to increasing returns of scale. Indeed, DEA analysis shows that the percentage of farms with increasing returns to scale is much higher among the smaller farms: 83% of farms with up to 5 hectares display increasing returns to scale in DEA analysis, compared with only 21% of farms with more than 10 hectares.

Fig. 4. Technical Efficiency by Farm Size

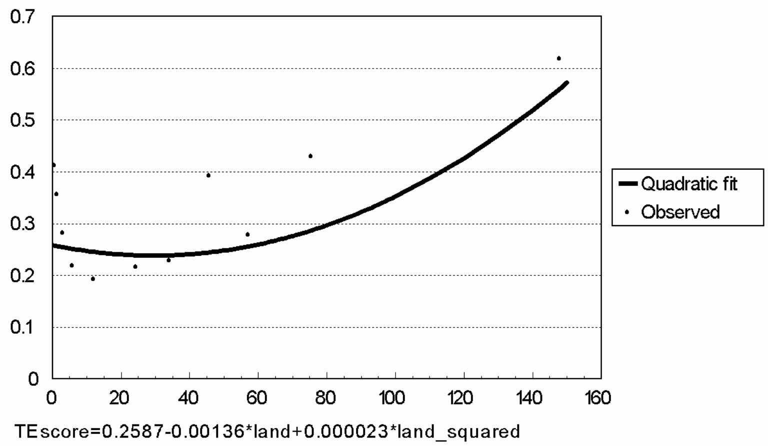


Table 5. Technical Efficiency Scores by Farm Size

Farm size, ha	0-1	1-2	2-5	5-7	7-20	20-30	30-40	40-60	60-100	>100
TE score	0.41	0.36	0.28	0.22	0.19	0.22	0.23	0.36	0.43	0.62
N	28	51	176	104	248	100	39	26	11	6

Conclusion

Our analysis of production functions and technical efficiency scores supports the previous conclusion that farm consolidation will lead to beneficial results in Polish agriculture. The total amount of land in Poland is limited, however, and enlargement of the average farm will necessarily lead to a reduction of the total number of farms in the country. Larger farms will employ more labor, but as is evident from the elasticity of labor in Table 4 and from the output vs. labor growth pattern in Table 3, the net impact will be a reduction of agricultural employment. Consolidation of farms in the interest of improved productivity and increased incomes for families that remain in farming will need to be accompanied by programs for the development of significant non-agricultural rural employment opportunities. If no such programs are implemented, the gain of the increasingly more productive farming population will be offset by the loss of all those who give up their land and the associated income sources.

These issues are addressed in a variety of ways in the World Bank's Rural Development Project recently launched in Poland (Wilczynski, 2001). A major focus of the project is on human capital development, and especially labor redemployment. The objective is to help the rural population take advantage of economic and labor market opportunities through education and training. The project also includes a microcredit component centered on the development of micro-enterprises in rural areas as an alternative source of employment. Substantial funds are earmarked for the development and improvement of rural infrastructure, as regions with better roads, telecommunications, and supply networks better attract private investments, which facilitate the creation of non-farm jobs. By its design, this rural development project contains many of the elements that are necessary for creating non-farm employment opportunities in rural areas and thus stimulating exit of labor from agriculture. Reduction of agricultural employment will encourage land consolidation through transfer of holdings to remaining active farmers and ultimately lead to much needed improvement in agricultural productivity.

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