Farmers and their groves: How efficient are farms with forested land?

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Abstract

This study examines the performance of the forested land ownership by farmers in Poland this paper compares the efficiency of farms reporting a portion of their operated land as a forest with those that do not own any forested land. Using FADN data, the study focuses first on cost efficiency, which was estimated using the fixed effects stochastic cost frontier model (Kumbakhar and Knox Lovell, 2003). A generalized multiproduct translog cost function (Caves, Christensen, and Tretheway, 1980) was selected to represent the deterministic part of the cost function because it imposes fewer a-priori restrictions than other functional forms commonly used for the task.

The efficiency scores (i.e., the fixed effects) were subject to further analysis, to establish the differences between farms with and without forest land (where forest land was measured as the proportion of the total farm area that was under forest land). The results strongly indicated, both in aggregate and considering estimates by farm type, that most of the farms with forest land were relatively less efficient than farms without them.

Because the average farm size has been steadily increasing (although it remains relatively small) in response to a decreasing farm numbers in Poland, while the commercial agricultural production contracts in some peripheral areas without creating a shortage of food or agricultural commodities, there is an opportunity to reallocate land from its current uses to reforestation on farms already managing small groves. The speed of reallocating land will, however, depend greatly on ability of forested land to generate a stream of income. Given the FADN data, the transfer of all remaining agricultural land operated by farms with forested acreage to reforestation would add about 170 thousand hectares of privately owned forests in Poland. Additionally, the transition of farms owing woodlands may lead to their new role in the national environmental policy and efforts to cut the greenhouse gas emissions.

Keywords: Cost efficiency, FADN data, forest ownership, renewable energy policy, reforestation

JEL: Q15, Q23, D24, Q59

INTRODUCTION

The land reform introduced by the Soviet-imposed government in Poland following WWII re-distributed land from some large estates among farmers, while creating a sizable state-owned farm sector on selected nationalized domains. The takeover of large private estates also involved the nationalization of forests representing the natural part of an estate. The state-owned forest sector expanded greatly although the share of forests in the total country's area shrunk. The expansion of state-owned forested areas was accompanied by the rapid expansion of the state forest service, which has already been functioning prior to the World War II. By 1985, for example, the state forest service employed 131 thousand personnel. The number of employees gradually declined reaching 25 thousand in 2009 (Kancelaria Senatu, 2010) and continued to decrease in 2010. Only in 2011-14, did the state forest service employment increase slightly reaching the 2009 level (GUS, 2016).

The transition to the market-driven economy in 1989-1990, left the forest service largely unchanged despite fundamental shifts in ownership of other state-owned assets, especially the state farm sector. While the state farm sector was promptly liquidated, forests remained in the government domain. The state farm sector sustained by government support under the centrally planned economy (Florkowski et al., 1986; 1988) could not compete with the family farm sector once the administered price and subsidy system was abolished. Large, inefficient state farms were divided into original estates and leased or sold to farmers. State forest service, in turn, benefitted from freeing prices. Distorted wood and lumber prices subjected to administrative control were abolished with the adoption of the market as the resource allocation mechanism in 1989. Market pricing increased the forest service revenues. The primary disturbances faced by the forest service were periodic administrative shifts from one Ministry to another. Currently, the forest service is administered by Ministry of the Environment.

The reallocation of land away from state to the private sector and subjecting the agricultural production to the market economy mechanism forced new and old owners to reconsider farming of less productive land. Price liberalization resulted in one time increase of prices in 1989-1991. The inflation rate was 585.5 percent in 1990 and 70.1 percent in 1991 (Barbone, 1992). Price increase led to a decrease in food demand creating a surplus of all types of food, a phenomenon on a scale unknown in Poland in decades of the centrally planned economy. Farmers faced not only a contraction of food demand, but an unfamiliar competition from the imported food. The latter was the result of abolishing the monopoly of state on international trade. Price re-adjustment and weak food demand were associated with the change in environmental policy in the country. The environmental policy was focused on the protection of land and landscape, among others, and stimulated the reforestation of poor quality agricultural land. As a result land classified as Vth (i.e., Va and Vb) and VIth quality class (Zawadzki, 2002) could be planted with trees with the government assistance. The goal of the policy was to increase the total forested area in Poland, but the result was also the permanent withdrawal of poor quality arable land from production. A number of farmers joined the program and planted trees benefitting from government subsidies. The program created a substantial privately-owned forested area.

It is plausible that the primary motive of farmers in participating in the program of planting trees was the eligibility for subsidies, while not having to till land that was not suitable for agricultural production. However, since the program was implemented, there has been a lack of a study that examined the effects of reallocating arable land to forestry. Can the re-allocation of land, besides helping to achieve the goal of increasing the share of forested land, increased the efficiency of farms? Farmers were unlikely to re-allocate all their land to forest, but only that of the lowest quality and eligible for the subsidy.

Private forests help to achieve important policy goals. First, Poland has relatively lower share of forested land than many other EU countries and forests are viewed as important element of sustainable environment. An increase in the forested area remains a major objective of the environmental policy. Second, forest-based resources provide feedstock that contributes to the use of renewable energy to the country's total energy balance. Laws passed in recent years aim at increasing renewable energy's share in total energy produced in the country to 14% by 2020. Increasing domestic agricultural production not only satisfies food security needs, but generates surplus and forces changes in the farm sector. The average farm size has been steadily increasing in Poland in recent decades and the number of farmers has been declining. Most recently, the new law restricted agricultural land market granting priority of purchase of any farm land to the government agency over its sale to another farmer. Such law may encourage retiring farmers and their non-farming heirs to retain the land ownership. A relatively low quality land may be converted into timber land representing both a long term family investment and contributing to the goal of reforestation as well as increase renewable energy feedstock in the future.

To examine the performance of farms with the forested land ownership in Poland, this study compares the efficiency of farms reporting any portion of their operated land as a forest with those that do not own any forested land. It is hypothesized that a farm with a timber stand operates agricultural land of low quality and reforested the part of the lowest productivity. Farming such land is relatively costly because of the natural low productivity of soil and farms with forested acreage have difficulty competing with farms that lack forested acreage, presumably operating more productive land. Owners of farms with forested acreage are likely to face the problem of transferring the farm operation within a family. High costs limit the potential revenues making farming unattractive for an offspring. An option of retaining the ownership of land, besides renting, is reforestation of all owned acreage. Such operation requires less input, while still generating income and is feasible for an absentee ownership of heirs, who migrated to jobs in urban areas. Reforestation rather than lease helps to achieve important national and EU policy goals. First, reforestation increases the share of forests in the country's total area, a currently stated goal of national policy. Second, a properly selected mix of species enhances the quality and future value of stands. Third, reforested area becomes a source of feedstock in the renewable energy generation helping to achieve the EU-imposed mandate regarding the share of renewable energy in the total energy balance. Fourth, the withdrawal of low quality agricultural land contributes to national policy of enhancing the quality of environment because it lowers the use of fertilizers, herbicides, and other inputs that could contribute to the pollution of soil, surface water or air. Finally, the land is retained as a family asset. Renting the acreage is not likely to generate substantial revenues because of the low quality of soil and, possibly, reluctance of a renting party to invest in improving its productivity. The study focuses on cost efficiency, which was estimated using the fixed effects stochastic cost frontier model. A generalized multiproduct translog cost function represents the deterministic part of the cost function and is estimated using the Farm Account Data Network (FADN). The applied approach recognizes eight different farming operations distinguished in the FADN database and examines the effects of farms with forested acreage on cost efficiency in each type class. Furthermore, the study estimates the potential increase in the area of forests assuming all farms owning a stand would reforest the operated land and provides an estimate of gain in total forested area of the country.

Forest Ownership in Poland

Historically, forests were owned by nobility or royalty in Poland. After re-gaining independence following World War I, the government organized the state owned-forests as an enterprise, but it soon was converted into the state forest service organization. Major changes followed World War II when all forests exceeding 25 hectares in size were nationalized. The combination of forest nationalization and re-shaping of Poland's borders meant that nearly 90 percent of forests was state-owned prior to 1989 and concentrated in the western and northern parts of the country.

In 2013, state-owned forested area accounted for 81.1 percent of the 9.177 million hectares of total forest area in the country (Leśnictwo 2014, 2016). Not all state-owned forests are operated by the forest service. About two percent are national parks, nearly one percent represents communal forests, and the balance is owned by other government entities. State forest service manages about 77 percent of forested area. The total area of the country covered by forests, which amounted to 38 percent in 1920 (within post WWI national boundaries) declined to 20.6 percent in 1945 (within post WWII national boundaries), has reached 29.4 percent in 2013, or 0.1 percent more than a year earlier. The goal of national policy is to increase the share of forest to 30 percent of the country's total area by 2020 and 35 percent by 2050. The expansion of the forest area must primarily come from the re-allocation of privately-owned agricultural land.

Expansion of Privately-owned Forests

Privately owned forests accounted for 18.9 percent of all forests in Poland in 2013 (Leśnictwo 2014, 2016). Under the centrally planned economy, private forest area was fairly stable because a larger parcel of land could have been owned only by farmers, who farmed every bit of it. Those who had forests (25 hectares or less) seldom were reforesting any of the arable land or pasture because the demand for food was insatiable and heavy dependence on own forage supply for livestock due to restrictions placed by the government on family farm access to commercial feed. The centrally planned allocation system and distorted prices resulted in inefficiencies (Penn, 1989) and those, in turn, encouraged farming of even the lowest quality land.

The adoption of the market economy and the fundamental economic, political, and social changes following the "Round Table" agreement in 1989 in Poland led to the reduction of the state's role in the economy. For example, in 1995 state-owned forested area accounted for 82.9% of the total forested area in the country. The small portion of forests that remained private after the nationalization were small patches of land owned by farmers, whose farms did not exceed the area limits set by the land reform act of 1945. Such groves were typically very small, seldom exceeding one hectare and often planted in a single tree species like pine or birch. The groves were planted on very poor quality soil, which presented a challenge for growing any agricultural crops or permanent pasture.

After the transition to a market economy in 1989, the state farm sector was gradually liquidated and the land sold or leased to family farms. The pressure to maximize production eased once market prices replaced the government-controlled pricing and free trade was allowed, flooding the market with food products. In the 1990s, the government also introduced subsidies for reforestation of low quality agricultural land in efforts to protect the environment. Private land owners, including farmers and buyers of land auctioned from the former state-farms, took advantage of the program. The share of privately-owned forests increased from 17.1% in 1995 (GUS, 2001) to 18.5% in 2010 (GUS, 2011) reflecting the faster rate of growth of privately-owned forests in the increasing total forest area during that period. The withdrawal of poor quality land from farming could be expected to increase efficiency. The issue that has never been examined is whether the farms that owned a forest perform better than those without forested land. On one hand, withdrawing land from production may reflect a sound management decision to improve production costs and competitiveness, but on some farms forests might have been an intended source of fuel and possibly timber.

Farmers as Forest Owners

The nationalization of forests that exceeded 25 hectares following WWII limited any ownership to farmers, who operated small stands. Moreover, the severely regulated land market (Penn, 1989) and ideologically driven priority of state ownership made an expansion of a farm by land purchase impossible under the centrally planned regime. The expansion of forest area was managed by the state forest service. Not until the reduction of restrictions placed on land market and the liquidation of the state farm sector following the 1989 change of the economic and political system could private individuals purchase a sizable parcel of land. Land market liberalization combined with the general liberalization of the economy created conditions to consider land reforestation by farmers and private land owners.

Private forest share varies across the 16 administrative districts (or voivodships) of the country. In eastern and central voivodships, the share of private forests reported by farmers is larger than in western or northern areas. Private forests' share in eastern-most voivodships of Lubelskie and Podkarpackie represents 36.9 percent and 16.9 percent, respectively, and the largest share of 43.3 percent is reported in Mazowieckie Voivodship (GUS, 2012). In the western voivodships of Lubuskie private forest are 1.2 percent of the total, while in Zachodniopomorskie they account for 1.6 percent, for example.

The average private stand covers 1.17 hectares in Poland. The largest average forest is owned by farms in Podlaskie Voivodship, 2.67 hectares, while the smallest area of 0.59 hectares is in Slaskie Voivodship. The aforementioned Lubelskie and Podkarpackie farms average 1.30 hectares and 1.02 hectares, respectively. A farm in Mazowieckie Voivodship averaged 1.49 hectares of forested area, if it owned one.

The farm forested area needs to considered in the context of the total operated land. In 2011, the average farm operated 10.49 hectares in Poland in 2015 (ARiMR, 2016). The current average farm size has been strongly influenced by the land reform and forest nationalization following WWII. The relatively small farms and the largest private forest ownership is in voivodships, where the state farm sector's presence was limited, i.e., in eastern (Lubelskie), central (Mazowiecki, Swietokrzyskie, Lodzkie) and southeastern regions (Podkarpackie). The average farm size in those regions is considerably smaller than in other parts of Poland, while the land quality is poor in most of them. Such farms are unlikely to continue their existence because they do not provide opportunities to generate income adequate to sustain a household. The majority of those regions also experiences depopulation and once the current operators retire, the heirs may consider reforestation as an option that retains the land in the family permitting absentee ownership and requiring less resources. Reforestation of low quality farm land will contribute to the share of forested land helping to achieve the stated policy goal of reaching 35 percent of total country land surface by 2050 without burdening the state forest service. Additionally, private forests could become a source of feedstock for production of energy from renewable sources either through production of biogas or pellets. Renting acreage to other farmers although feasible may not be as attractive in the long run because of inefficient farms low quality land. Knowledge of the farm relative cost efficiency helps to estimate the size of potential transfer of land from agricultural use to forestry.

COST FRONTIER ESTIMATION APPROACH

An improved input use makes an inefficient farm more productive (Langemeier 2010). The current study examines cost efficiency to empirically verify the extent it may be lacking among farms owning forest stands in Poland. The stochastic cost frontier framework applies an index, which value ranges from zero to one, as the cost efficiency measure. According to that measure, the index of most efficient farms equals one and such farms are positioned on the frontier function. Kumbakhar and Knox Lovell (2003) propose the following fixed effects stochastic cost frontier model can be written in the following way where i denotes farms and t the periods:

$$\text{(1)} \qquad \ln E_{it} = \ln C(Q_{it}, W_{it}, \tau_t; \Omega) + v_{it} + u_i \ .$$

In equation (1), The observed expenditure $\ln E_{it}$ is the logarithm and the deterministic cost function, $\ln C(Q_{it}, W_{it}, \tau_t; \Omega)$, is the logarithm that depends on the outputs Q_{it}, the input prices W_{it}, a deterministic trend τ_t that captures technological change, and a vector of parameters Ω. The statistical error, v_{it}, is independent and identically distributed with mean zero and variance σ_v^2. The time invariant inefficiency term u_i is positive.

Prior to estimation, it is necessary to select the functional form for the deterministic part of the stochastic cost frontier (i.e., $\ln C(Q_{it}, W_{it}, \tau_t; \Omega)$). Following Caves, Christensen, and Tretheway (1980), this study applies a generalized multiproduct translog cost function. The latter imposes fewer a-priori restrictions than alternative functional specifications. Caves, Christensen, and Tretheway (1980) note that in the context of multiproduct estimation, a farm may not generate a specific output causing the logarithm used in the translog function to produce an error. A Box-Cox transformation can then substitute for the logarithm of the output terms. This study applies $f(Q) = Q$ as a hybrid between the translog function and the quadratic function. The cost function for n inputs and m outputs is:

$$\text{(2)} \qquad \ln C(Q_{it}, W_{it}, \tau_t; \Omega) = \alpha_0 + \varphi_0 \tau_t + \varphi_0 \tau_t^2 + \sum_{j=1}^{n} \alpha_j \ln W_{jt} + \tfrac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} \ln W_{jt} \ln W_{kt}$$
$$+ \tfrac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{n} \delta_{jk} f(Q_{jit}) \ln W_{kt} + \sum_{j=1}^{m} \gamma_j f(Q_{jit}) + \tfrac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{m} \rho_{jk} f(Q_{jit}) \cdot f(Q_{kit})$$

The stochastic cost frontier has to satisfy the properties of any cost function (Chambers, 1988). The imposition of price homogeneity and symmetry conditions in (2) followed from placing restrictions on the parameters (3):

$$(3) \qquad \sum_{j=1}^{n} \alpha_j = 1; \ \sum_{j=1}^{n} \delta_{jk} = 0; \ \sum_{j=1}^{n} \beta_{jk} = 0; \ \sum_{k=1}^{n} \beta_{jk} = 0; \ \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} = 0; \beta_{jk} = \beta_{kj} \ .$$

Inefficiency is a time invariant (Schmidt and Sickles, 1984; Kumbakhar and Knox Lovell, 2003; Greene, 2005) in a fixed effects model of a stochastic cost frontier estimated applying panel data. However, the use of a fixed effect model precludes the use of time invariant variables in estimation. To overcome this restriction, in the context of cost function estimation, the parameters linked to input prices are estimated from the cost share equations, where the inefficiency term (i.e., the fixed effect terms) do not appear.

The equation to be estimated, with the intercept $\alpha_{0i} = \alpha_0 + u_i$ is:

$$(4) \qquad \ln E_{it} = \alpha_{0i} + \varphi_0 \tau_t + \varphi_0 {\tau_t}^2 + \sum_{j=1}^{n} \alpha_j \ln W_j + \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} \ln W_j \ln W_k + \frac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{n} \delta_{jk} f\left(Q_{jit}\right) \ln W_k$$
$$+ \sum_{j=1}^{m} \gamma_j f\left(Q_{jit}\right) + \frac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{m} \rho_{jk} f\left(Q_{jit}\right) \cdot f\left(Q_{kit}\right) + v_{it}$$

The dataset does not contain input prices for each farm, but it is common in cross section estimation, to assume that all farmers face identical prices (e.g., Alvarez and Arias, 2003). However, in a cost function estimation applying panel data, prices are introduced under the assumption that all the farmers face the same input prices within a year (i.e., across farms), while allowing prices to change over time.[1]

Equation (4) was estimated for five inputs (i.e., n) and three outputs (i.e., m). Because of the high number of parameters subject to estimation, the system of $(n-1)$ cost shares was initially computed using Iterative Seemingly Unrelated Regression Equations (ISURE). Thus, the constraints in (3) were imposed. This step provided the values for all the terms in (4) that were

[1] In a different context, similar assumptions can be found in the estimation of demand systems, where price elasticities are sometime estimated from time series because of the lack of variability of prices in cross section datasets (Hsiao, 1993, p.206).

associated to input prices. Second, all the remaining parameters of the cost function, except the fixed effect terms (i.e., output terms not associated with prices) were estimated using the within estimator (ordinary least square applied to the variables expressed as deviations of the means by farm as in Hsiao, 1993). Finally, the fixed effect terms used in the construction of the relative cost efficiency indices were estimated from equation (4) by evaluating the function at the mean value of the variables by farm (Atkinson and Cornwell, 1993; Kumbakhar and Knox Lovell, 2003; Pierani and Rizzi, 2003).[2]

As shown in Kumbhakar and Knox Lovell (2003), the relative cost efficiency index ($\mathrm{CEI_i}$) for a sample size N was computed as equation (5) based on the estimated fixed effect intercepts (i.e., $\hat{\alpha}_{0i}$), where for the most cost efficient producers it has a value equal to one:

$$(5) \qquad \mathrm{CEI_i} = \exp\{-(\hat{\alpha}_{0i} - \min_i\{\hat{\alpha}_{0i}\})\} \qquad i = 1,\ldots,N\,.$$

The results of the cost function estimations for eight farm type categories and for the whole sample provided insights into cost efficiency differences. For each farm type, the study reports the calculated elasticities of substitution among five input categories (Table 1A). The majority of the calculated elasticities are statistically significant[3].

DATA

Data used in this paper is from the Farm Accounts Data Network (FADN) database. Initiated in 1965, the data collection goal was to verify the effect of the Common Agricultural Policy of the European Union (EU) on farm income. Farm participation is voluntary. As is often

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[2] The farm level estimated fixed effects used to compute the relative cost efficiency indices were assumed to be constant over time due to the short period covered by the sample (in the best case, information was available for some farms for eight years) (Kumbakhar and Lovell, 2003, p. 170).
[3] Results of estimation are not shown due to space limitations, but are available from the authors upon request.

the case in voluntary participation, the Polish farms that are likely to be omitted are those with less commercial production, less income and having relatively high costs due to low quality of land. FADN specifies FADN data collection regions for every country participating in the program and in the case of Poland there are four macro-regions each consisting of four voivodships (administrative districts overlap exactly with FADN subregions in the case of Poland).

The FADN annually records a wide range of financial (e.g., assets, liabilities), economic (e.g., crops, stocks), and physical (e.g., livestock number, crop area) data from a selection of farms realizing commercial sales across the EU applying the same accounting principles. Polish farms sharing the information represent well the farms engaged in commercial agricultural production. Farms are classified in each of eight farm types as defined in the FADN database; for example, mixed cropping farms, livestock farms.

In the case of Poland, the data were available only since the 2004/05 production year (after the country's accession to the EU on May 1, 2004). The voluntary participation of each farm causes some farms to drop from the panel and the available set is an unbalanced panel data. The data are annual observations for the period 2004/05-2011/12. The unbalanced panel applied in this study included 19,455 farms, representing 93,916 observations. The study examines the cost efficiency of farms of all types included in the sample.

Costs and outputs by farm type were computed directly from the FADN data. The estimation of cost functions requires input prices; however, a shortcoming of the FADN data for the estimation of cost functions is that it only presents input expenditures and not the prices paid for inputs (or their used quantities). Therefore, Eurostat's input price indices data (base year 2005) were used for agricultural materials, energy, and capital as an estimate of those prices paid by farmers over the study period. Labor and land input prices were estimated from the FADN data.

RESULTS

Prior to the estimation of the effect of having any forested area on the efficiency score, price elasticities for inputs were calculated for each farm type and for the whole sample (Table 1A) using the estimation result of the cost efficiency functions. The vast majority of input elasticities has the expected signs and is statistically significant. The only own price elasticity that is positive and significant is in the case of energy input in "specialist grazing livestock." This type of highly specialized farming operation is likely limited to mountainous regions (seasonal grazing of sheep herds) of Poland and the energy use is atypical.

The efficiency scores (i.e., the fixed effects) were analyzed to establish the differences between all farms in the sample and for each farm type category. The comparison is made within the group or within the total sample. Each farm's score is compared against the most cost efficient farms located on the frontier for each farm type category. Histograms of the scores reveals substantial variation within each group in terms of cost efficiency. There is a heavy concentration of farms in the lower portion of the index 0-to1 range suggesting the discrepancy between the most cost efficient farm in each group and in the total sample, and the large portion of farms lagging in efficiency. Figure 1 illustrates the distribution of index scores for the mixed livestock farms, a fairly common type of enterprise in many regions of Poland. The majority of farms in the sample have scores below one-third of the most efficient farm in the category. The discrepancies within other farm types tend to be even bigger in the

FADN sample data used to calculate the scores. Overall, it appears that a significant number of farms in all categories are cost inefficient and, presumably, not competitive in the foreseeable future. Many of such family farms will probably withdraw from active farming and will face a decision how to manage the land. For those operating low quality lands, reforestation can become a viable option, especially given the government reforestation support program.

The presence of any forested area in the farm's total area was further examined by regressing the cost efficiency scores on the economic size of a farm and a binary variable capturing ownership of forested acreage (Table 2). The economic size measure is listed in FADN data and defined by European Commission (European Commission, 2011). The measure is the standard gross margin expressed in euros. The set of equations representing each farm type and the whole sample was estimated using the hetoreskedasticity consistent OLS. The values of the adjusted R square are reasonable given the cross-sectional nature of the data with the exception of "Mixed livestock" category. Still, even in the latter equation the coefficients are statistically significant with expected signs, i.e., the positive effect of the economic size and the negative effect of the ownership of forested acreage.

The results strongly indicated, both in aggregate and considering estimates by farm type, that most of the farms with forest land were relatively less efficient than farms without them in each farm type category. Indeed, the efficiency scores are positive due to the farm size, which effects offset the typically negative effect of the presence of forested area (Table 2). The dummy variable coefficient indicating the presence of forested land in the total land operated by a farm has a statistically significant and negative sign with the exception of the category "Specialist field crops." The latter result is plausible because farms specializing in field crops are likely to maximize the arable land they operate and any frosted area was likely quite small. Clearly, the presence of forest lowered the efficiency scores suggesting that farms with such land were less cost efficient than those without a stand as expected.

IMPLICATIONS

Important policy implications stem from the results. Because the average farm size has been steadily increasing (although it remains relatively small, especially in some regions) in response to decreasing farm numbers in Poland, as long as commercial agricultural production contracts in some marginal areas without creating a shortage of food or agricultural commodities, there is an opportunity to reallocate land from its current uses to reforestation on farms that already manage small stands. The speed of reallocating land will, however, depend greatly on the ability of forested land to generate a stream of income that would replace the current payments to each farm hectare under the EU CAP. Reforested land would have to generate comparable returns.

Currently, a farmer could qualify for one time subsidy ranging from 4160 PLN to 6260 PLN depending on the proportions of planted conifers and deciduous trees (Konieczny, 2016). The subsidy also favors the seedlings that have been pre-treated as well as the topography of the land. Additional 2590 PLN per hectare can be received for fencing. For the first five years after planting, a farmer qualifies for remuneration for performing the recommended practices. The payment ranges from 970PLN to 1360 PLN per hectare per year. Still another subsidy is paid to farmers who document that at least 25 percent of their income originates from agricultural production. Such farmers can receive 1580 PLN for each reforested hectare for the period of 15 years after planting. The payment is the compensation for the lost revenues after the reallocation of land away from farming. As a result, assuming the lower boundary of the range of payments (excluding subsidy to fencing), a farmer can receive a total of 6710 PLN per hectare annually in the first five years after reforestation.

Given the number of farms that own forested acreage and tend to be already cost inefficient, their agricultural land is the upper limit of the agricultural land that can potentially be reforested area. Using FADN data, the area that could be reforested is 170,934 hectares. If the retired farmers or their heirs retain the ownership of the new stands, the privately owned forests expand in Poland. The calculated, potentially reforested area would more than double the area of 159,300 hectares of land reforested between 2001 and 2014 under the 2001-2020 national reforestation program that projected the addition of 680,000 hectares of forests.

Additionally, the transition of farms to owning woodlands may lead to their new role in the national environmental policy and efforts to cut greenhouse gas emissions. On one hand additional forest contributes to carbon sequestration, on the other hand forest creates feedstock for renewable energy generation. The newly reforested area would not contribute towards the generation of renewable energy in the near term (especially by 2020), it would make a contribution in more distant future.

CONCLUSIONS

Poland strives towards increasing the share of the forested area in the total area of the country, which declined substantially due to WWII destruction and redrawing of the country’s borders. Private forests, which accounted for small stands for decades due to government restrictive policy, have gained in importance after the transition to a market economy in 1989. Since then, the growth of private held forested acreage outpaced that of the state forests.

Forests also play an important role in the country's efforts of carbon sequestration and contribute feedstock generating energy from renewable resources. Poland, like all other EU members, has assumed obligation to increase the share of renewables in energy production and faces a specific target in 2020.

This study examined the potential contribution of family farms to the growth of forested area. The reallocation of land away from agriculture to forestry is hypothesized to take place foremost on farms that already own forested acreage. The presence of forested acreage reflects the low quality of land and high production costs. The calculated cost efficiency indexes for eight farm types showed that the majority of farms are inefficient as compared to farms located on the cost efficiency frontier. Additionally, the study established that farms with forested acreage have lower efficiency scores in all farm type categories. It is, therefore, plausible that farms with forested acreage are less competitive and likely to terminate agricultural production. Such farms are offered and opportunity to reforest their land, while becoming eligible for government subsidies under the reforestation program. A total of 170 thousand hectares could become reforested if all farms already operating forest (as reported in the FADN data) transfer their all agricultural land. Although the calculated area is the upper limit of farms which currently already have forested land, it is likely that many other farms would follow that example. Consequently, the privately reforested area is likely to increase.

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Table 1. Descriptive statistics of farms with the forested area and share of forested area in total operated farm land by voivodship, Poland, 2011.

Forested area	No of observations	Mean	St. dev.	Variance	Minimum	Maximum	CV
All the sample (2011)							
Forest (ha)	5643	2.28	4.95	24.55	0.01	145.00	2.17
Share of forest	5643	0.07	0.09	0.01	0.00	0.89	1.21
Łódzkie							
Forest (ha)	499	1.62	2.29	5.23	0.01	24.00	1.42
Share of forest	499	0.07	0.09	0.01	0.00	0.76	1.19
Mazowieckie							
Forest (ha)	1045	2.14	2.94	8.63	0.01	38.54	1.37
Share of forest	1045	0.09	0.09	0.01	0.00	0.73	0.98
Małopolskie							
Forest (ha)	253	1.83	5.55	30.77	0.01	84.74	3.03
Share of forest	253	0.13	0.13	0.02	0.00	0.67	1.07
Śląskie							
Forest (ha)	104	1.55	1.80	3.24	0.06	10.30	1.16
Share of forest	104	0.06	0.08	0.01	0.00	0.34	1.37
Lubelskie							
Forest (ha)	605	1.83	6.15	37.81	0.02	145.00	3.37
Share of forest	605	0.07	0.07	0.00	0.00	0.47	1.02
Podkarpackie							
Forest (ha)	129	1.84	2.68	7.16	0.01	22.98	1.45

Share of forest	129	0.08	0.09	0.01	0.00	0.50	1.12
Świętokrzyskie							
Forest (ha)	152	1.41	2.11	4.43	0.05	17.20	1.49
Share of forest	152	0.06	0.07	0.01	0.00	0.40	1.14
Podlaskie							
Forest (ha)	712	3.13	6.22	38.69	0.01	140.00	1.99
Share of forest	712	0.09	0.08	0.01	0.00	0.55	0.90
Wielkopolskie							
Forest (ha)	560	2.46	3.92	15.37	0.02	45.00	1.60
Share of forest	560	0.08	0.09	0.01	0.00	0.52	1.21
Zachodniopomorskie							
Forest (ha)	155	2.28	5.12	26.22	0.01	46.00	2.24
Share of forest	155	0.03	0.05	0.00	0.00	0.31	1.61
Lubuskie							
Forest (ha)	84	3.11	6.36	40.44	0.06	43.71	2.05
Share of forest	84	0.04	0.05	0.00	0.00	0.28	1.36
Dolnośląskie							
Forest (ha)	238	1.64	2.75	7.57	0.01	16.00	1.68
Share of forest	238	0.03	0.06	0.00	0.00	0.44	1.71
Opolskie							
Forest (ha)	167	2.80	8.99	80.80	0.01	97.34	3.21
Share of forest	167	0.04	0.08	0.01	0.00	0.89	2.23
Kujawsko-Pomorskie							
Forest (ha)	390	2.34	4.27	18.21	0.03	34.00	1.82
Share of forest	390	0.05	0.08	0.01	0.00	0.56	1.47

Warmińsko-Mazurskie							
Forest (ha)	283	2.01	3.02	9.14	0.01	30.00	1.51
Share of forest	283	0.05	0.06	0.00	0.00	0.48	1.36
Pomorskie							
Forest (ha)	267	4.13	9.45	89.31	0.01	84.40	2.29
Share of forest	267	0.09	0.13	0.02	0.00	0.81	1.57

Table 2. Heteroskedasticity consistent OLS results of cost efficiency scores for eight farm types and the whole sample with the effect of owning forested area, Poland, 2011.

	Specialist field crops				Specialist horticulture				Specialist permanent crops			
Variable	Coefficient	Std. error	t-statistic	p-value	Coefficient	Std. error	t-statistic	p-value	Coefficient	Std. error	t-statistic	p-value
Constant	0.0034	0.0014	2.39	0.0168	0.0192	0.0064	3.01	0.0027	0.0660	0.0030	21.84	0.0000
Size	2.39E-07	2.61E-08	9.16	0.0000	1.34E-06	1.16E-07	11.56	0.0000	1.35E-06	1.21E-07	11.17	0.0000
Forest area	-0.0076	0.0051	-1.50	0.1347	-0.1163	0.0291	-3.99	0.0001	-0.0963	0.0427	-2.26	0.0242
Adj. R sq.	0.7504				0.5665				0.4803			
F-statistic	7004.78				521.13				347.58			
	Specialist grazing livestock				Specialist granivore				Mixed cropping			
Constant	0.0745	0.0083	8.97	0.0000	0.1471	0.0055	26.82	0.0000	0.0830	0.0080	10.41	0.0000
Size	5.25E-07	2.02E-07	2.60	0.0095	6.36E-07	7.89E-08	8.07	0.0000	3.52E-06	3.85E-07	9.14	0.0000
Forest area	-0.0705	0.0159	-4.42	0.0000	-0.0839	0.0287	-2.92	0.0035	-0.1089	0.0269	-4.05	0.0001
Adj. R sq.	0.4389				0.4022				0.5859			
F-statistic	1873.99				1122.17				513.81			
	Mixed livestock				Mixed crops-livestock				All the types together			
Constant	0.2718	0.0056	48.58	0.0000	0.0536	0.0015	35.23	0.0000	0.0207	0.0009	22.90	0.0000
Size	4.44E-07	1.69E-07	2.63	0.0084	3.09E-07	3.40E-08	9.10	0.0000	2.59E-07	1.89E-08	13.71	0.0000
Forest area	-0.2744	0.0226	-12.14	0.0000	-0.1095	0.0068	-16.14	0.0000	-0.0436	0.0031	-14.19	0.0000
Adj. R sq.	0.1164				0.4884				0.5009			
F-statistic	332.09				3459.36				9756.81			

Table 1A. Input substitution elasticites for farms owning forested area, Poland, 2011.

	Elasticities					Elasticities				
	Materials	Energy	Labor	Land	Capital	Materials	Energy	Labor	Land	Capital
	Specialist field crops					Specialist horticulture				
Materials	-1.421	0.041	0.576	0.370	1.157	-3.055	1.302	0.813	1.989	1.375
	(-22.401)	(0.341)	(14.164)	(8.169)	(19.958)	(-24.129)	(7.440)	(9.789)	(4.114)	(13.848)
Energy		-1.588	0.526	0.139	0.035		-2.867	0.825	-0.479	-0.359
		(-2.478)	(10.232)	(2.226)	(0.249)		(-3.469)	(5.896)	(-0.349)	(-0.799)
Labor			-1.921	0.727	0.577			-1.467	-0.379	0.274
			(-31.401)	(12.246)	(16.529)			(-15.083)	(-0.989)	(3.741)
Land				-6.749	0.372				17.124	-2.124
				(-60.890)	(8.519)				(3.178)	(-2.750)
Capital					-2.005					-1.476
					(-28.284)					(-5.456)
	Specialist permanent crops					Specialist grazing livestock				
Materials	-4.774	0.220	0.790	2.273	1.311	-0.630	-0.802	0.359	0.659	0.563
	(-14.475)	(0.527)	(11.357)	(4.481)	(9.783)	(-10.216)	(-7.017)	(12.609)	(11.981)	(8.888)
Energy		-6.954	0.474	0.166	0.865		2.418	0.326	-0.022	-0.001
		(-4.232)	(6.237)	(0.236)	(3.740)		(3.740)	(8.858)	(-0.282)	(-0.006)
Labor			-1.109	0.232	0.467			-1.126	0.538	0.651
			(-21.629)	(1.527)	(11.562)			(-31.127)	(9.507)	(25.821)
Land				-1.242	-1.178				-12.792	0.317
				(-0.790)	(-4.966)				(-72.035)	(5.736)
Capital					-1.084					-1.543
					(-14.561)					(-19.531)

Table 1A. Cont.

	Elasticities					Elasticities				
	Materials	Energy	Labor	Land	Capital	Materials	Energy	Labor	Land	Capital
	Specialist granivore					Mixed cropping				
Materials	-0.145	-0.336	0.344	0.583	0.137	-2.758	0.929	0.614	0.907	0.911
	(-4.153)	(-3.591)	(7.345)	(7.064)	(1.864)	(-6.977)	(1.306)	(6.595)	(2.555)	(3.825)
Energy		-6.305	0.503	0.240	2.425		-0.040	0.309	0.583	-1.117
		(-5.306)	(5.811)	(1.177)	(8.663)		(-0.014)	(2.502)	(1.046)	(-2.106)
Labor			-1.930	0.293	0.617			-0.786	0.573	0.353
			(-17.216)	(2.049)	(9.138)			(-11.503)	(3.731)	(5.597)
Land				-16.895	0.076				-11.557	-0.194
				(-38.939)	(0.457)				(-14.310)	(-0.771)
Capital					-1.756					-0.763
					(-9.115)					(-3.821)
	Mixed livestock					Mixed crops-livestock				
Materials	-0.667	-0.545	0.604	0.534	0.381	-0.676	0.035	0.387	0.755	0.414
	(-11.589)	(-4.707)	(19.300)	(7.037)	(5.218)	(-11.821)	(0.294)	(13.068)	(13.897)	(6.530)
Energy		-3.453	0.442	0.132	1.292		-5.353	0.400	0.172	1.077
		(-3.727)	(9.564)	(0.977)	(6.422)		(-7.293)	(10.540)	(2.017)	(7.503)
Labor			-1.184	0.441	0.429			-0.990	0.317	0.470
			(-29.567)	(6.480)	(14.640)			(-26.294)	(6.026)	(18.461)
Land				-14.633	0.456				-11.619	0.342
				(-53.060)	(4.857)				(-74.569)	(5.793)
Capital					-1.685					-1.614
					(-14.764)					(-18.537)

Table 1A. Cont.

	Elasticities				
	Materials	Energy	Labor	Land	Capital
			All the types		
Materials	-0.986	-0.375	0.491	0.773	0.932
	(-34.327)	(-6.423)	(28.911)	(22.972)	(31.560)
Energy		0.639	0.377	0.027	-0.066
		(1.601)	(14.476)	(0.455)	(-0.757)
Labor			-1.309	0.463	0.538
			(-62.947)	(14.807)	(36.924)
Land				-11.264	0.031
				(-115.976)	(0.881)
Capital					-1.984
					(-48.626)

Figure 1. Example of cost efficiency indexes calculated for the farm type "Mixed livestock" using FADN data, N=5029.