Evaluation of investment support from Common Agricultural Policy with propensity score matching method

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Abstract

The study refers to the microeconomic producer theory as a framework and the expected positive relationship between investment support and labour productivity. The aim of the paper was to evaluate the impact of subsidies from Common Agricultural Policy on an increase in labour productivity on Polish crop farms. The applied research tool was propensity score matching method, based on so-called counterfactual results, i.e. potential results possible to be achieved, if the status of treating the given object was different than observed. The study used data from the Farm Accountancy Data Network for individual Polish farms for 2008-2015.

The results show that the positive effect of investment subsidies occurred only in 2011. Back then, the farms which in 2010 received the analysed support, were characterised, on average, by 39 percentage points higher annual increase in the labour productivity compared to the control group. In the remaining years, in turn, the impact of investment support on the increase in labour productivity was negative. However, given relatively high standard errors, the differences between farms which received and did not receive analysed payments were not statistically significant.

Keywords: *farms, labour productivity, agriculture policy, propensity score matching*

JEL Classification: D24, Q12, Q18

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1 Introduction

Improving the competitiveness of agriculture is one of the main challenges of the Common Agricultural Policy (CAP). This objective should be achieved, by, *inter alia,* an increase in the labour productivity, as the effect of investments carried out in farms. The initiatives aimed at modernisation of farm could be therefore supported by specific policy instruments. In case of Poland, measures supporting investments were, for example, “Modernisation of agriculture holdings” and “Setting up of young farmers” under the Rural Development Programme (RDP) for 2007-2013.

The positive relationship between subsidies on investments and the increase in labour productivity can be demonstrated based on the microeconomic producer theory. The foundations of investment are savings collected by the (agricultural) producer. If the investment needs are greater than the possibilities determined by savings, support under the

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CAP could be a catalyst for investment in fixed factors of production, which, in turn, leads to the increase of capital-to-labour ratio. Assuming that at the level of a single farm the labour input is constant, it allows obtaining higher production and consequently leads to increased labour productivity (Rembisz et al., 2014). In accordance with Fig. 1, farms which received investment support in 2007-2015 achieved, on average, higher labour productivity compared to farms which did not receive analysed support, which is to a certain extent confirmed by the mentioned positive relationship between investment (subsidies on investment) and labour productivity.

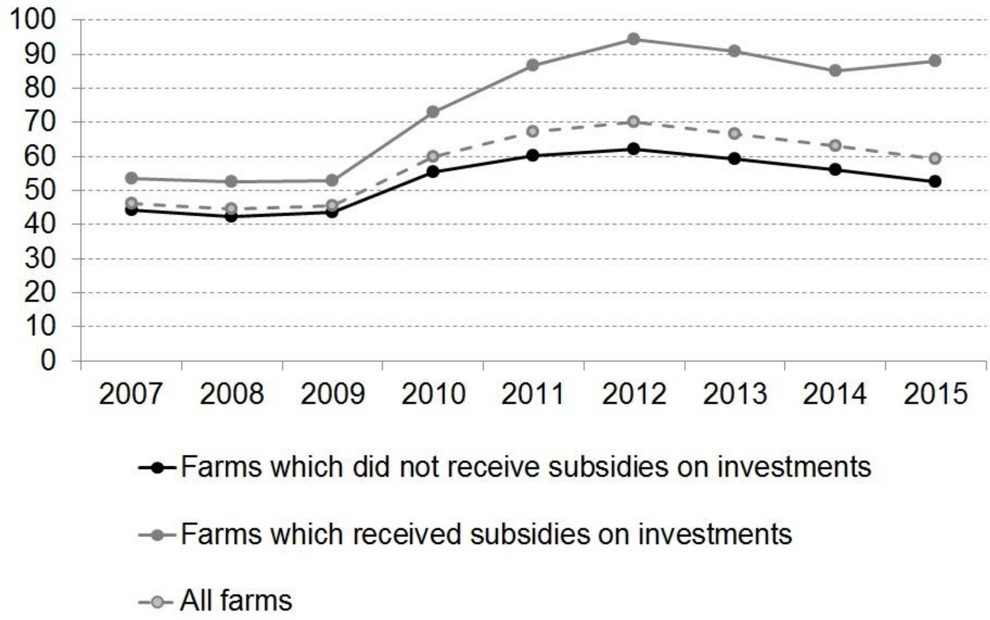


Fig. 1. Average labour productivity vs subsidies on investments in Polish farms in 2007-2015. Source: (Pawłowska and Bocian, 2017).

However, so far, the relationship between subsidies on investments and labour productivity was extensively examined primarily in the context of evaluation of the implemented agriculture policy instruments. The results presented in literature do not give a clear answer as to the positive or negative impact of this specific payments on the increase in the efficiency of the production factors on farms (Nilsson, 2017). The conclusions reached by Zhu and Lansink (2010) and Latruffe (2010) suggest that subsidies have a negative impact on efficiency or productivity. These studies, however, considered only the total amount of subsidies, so they cannot provide evidence on the impact of specific CAP measures. Similar conclusions about the negative impact of investment support on TFP (total factor productivity) were demonstrated by Mary (2013), but in contrast with previous studies it was shown that in case of French crop farms the effect of investment subsidies was not statistically significant.

The aim of the paper is to evaluate the impact of subsidies on investment from CAP on the increase in labour productivity on Polish crop farms using propensity score matching. The study contributes to the literature on the productivity effects of investment support under RDP for 2007-2013 in Polish crop farms.

2 Propensity score matching

Propensity score analysis was used to assess the net effect of investment support on an increase in labour productivity. This class of statistical methods, and generally the causal analysis introduced by Rosenbaum and Rubin (1983), is based on counterfactual framework.

Let $D = 1$ denote the receipt of treatment (treatment group), $D = 0$ denote non-receipt (control group) and Y_i indicate the measured outcome variable. Each *i*-th subject under evaluation would have two potential outcomes, i.e. Y_{0i} and Y_{1i}, corresponding respectively to the potential outcome in the untreated and treated states. The observed outcome variable is defined as (Guo and Fraser, 2015):

$$Y_i = D_i Y_{1i} + (1 - D_i) Y_{0i} \tag{1}$$

The fundamental problem of causal inference is that we observe only Y_{1i} for treatment group and Y_{0i} for control group (Holland, 1986). The potential outcome that is not observed is the so-called counterfactual result.

The main aim of propensity score analysis is to estimate the counterfactual by evaluating the difference in mean outcomes between treatment and control group. For each *i*-th unit the propensity score $b_{PS}(\mathbf{x}_i)$ can be estimated from logistic regression of the treatment condition D_i on the covariate vector $\mathbf{x}_i$ (Pan and Bai, 2015):

$$ln\left(\frac{b_{PS}(\mathbf{x}_i)}{1 - b_{PS}(\mathbf{x}_i)}\right) = \boldsymbol{\beta}\mathbf{x}_i \tag{2}$$

Rosenbaum and Rubin (1983), defining propensity score as a balancing score, introduced two assumptions about the strong ignorability in treatment assignment (see Pan and Bai, 2015; Leite, 2017):

$$(Y_{0i}, Y_{1i}) \perp D_i | \mathbf{x}_i \tag{3}$$

$$0 < P(D_i = 1|\mathbf{x}_i) < 1 \tag{4}$$

In accordance with the first assumption (formula (3)), treatment assignment D_i and outcomes Y_{0i}, Y_{1i} are conditionally independent, given $\mathbf{x}_i$. In the second one (formula (4)) it is assumed a common support between treatment and control group.

After estimation of the propensity score and evaluation of matching quality, the outcome variable could be analysed. Assuming the absence of the self-selection phenomenon, at the population level one of the treatment effects to be calculated is average treatment effect for the treated (ATT), in accordance with the formula (see Sekhon, 2011; Strawiński, 2014):

$$ATT = E(Y_{1i}|D_i = 1) - E(Y_{0i}|D_i = 1) \tag{5}$$

3 Data

The study used data from the Farm Accountancy Data Network (FADN) for individual Polish farms for 2008-2015. To ensure the homogeneity of analysed farms, only the farms specializing in field crops was considered.

Given that the aim of the study was to estimate the effect of investment support form CAP, $D = 1$ and $D = 0$ denoted, respectively, farms which received and did not receive the subsidies on investments. The potential outcome Y_i was the annual increase in labour productivity, defined as gross value added per annual work unit.

The logit models were used to estimate the impact of all possible combinations of the selected 14 variables on the dichotomous variable that express the fact of receiving (or not) investment support. The observed characteristics of farms, included in the propensity score model, were: economic class size, education of farmer, age of farmer, total utilised agricultural area, total agricultural area out of production, total livestock units, farm use, total external factors, total assets, total liabilities, change in net worth, average farm capital, gross investment on fixed assets and cash flow (see Floriańczyk et al., 2017).

Following the suggestion by Heckman, Ichimura and Todd (1997), the set of such variables was selected, for which the classification accuracy was the highest. However, the main objective of propensity score analysis is obtaining balanced characteristics to ensure the similar distribution of observed covariates for treated and untreated subjects. Hence, if it was not possible for the model with the highest prediction accuracy, for further analysis the author selected the logit model with lower accuracy rate, but ensuring balanced covariates.

In the propensity score matching, the matching ratio 1:1 with replacement was used. For propensity score matching the genetic search algorithm was used, allowing to find automatically the optimal covariate balance (Sekhon, 2011).

Examining the treatment effect of investment support on the increase in labour productivity in Polish crop farms, it was assumed, that the observed covariates from the year t affected receiving analysed subsidies in the year $t+1$, the result of which was an increase in the labour productivity in year $t+2$.

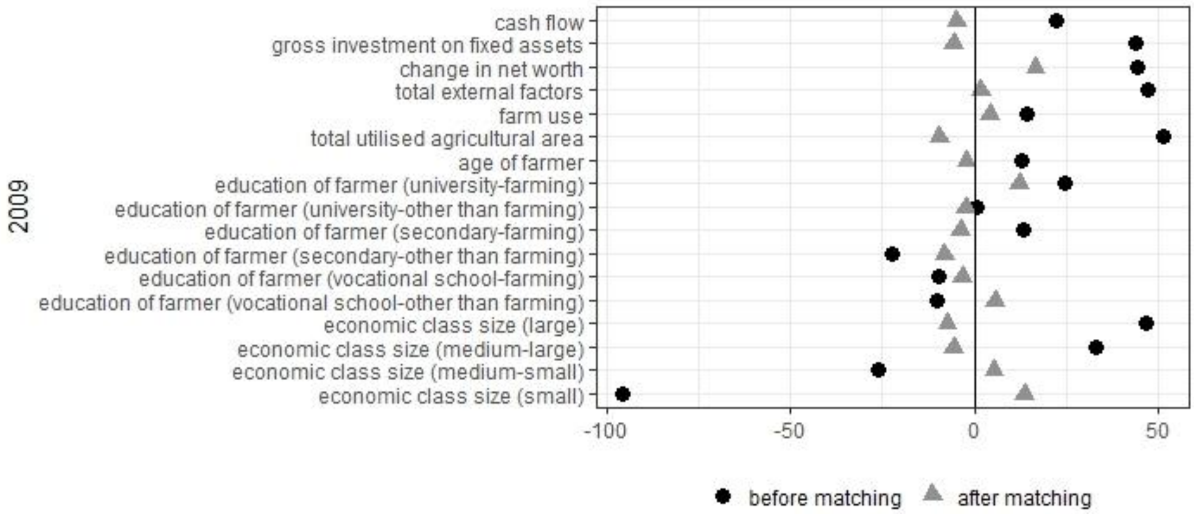
4 Results

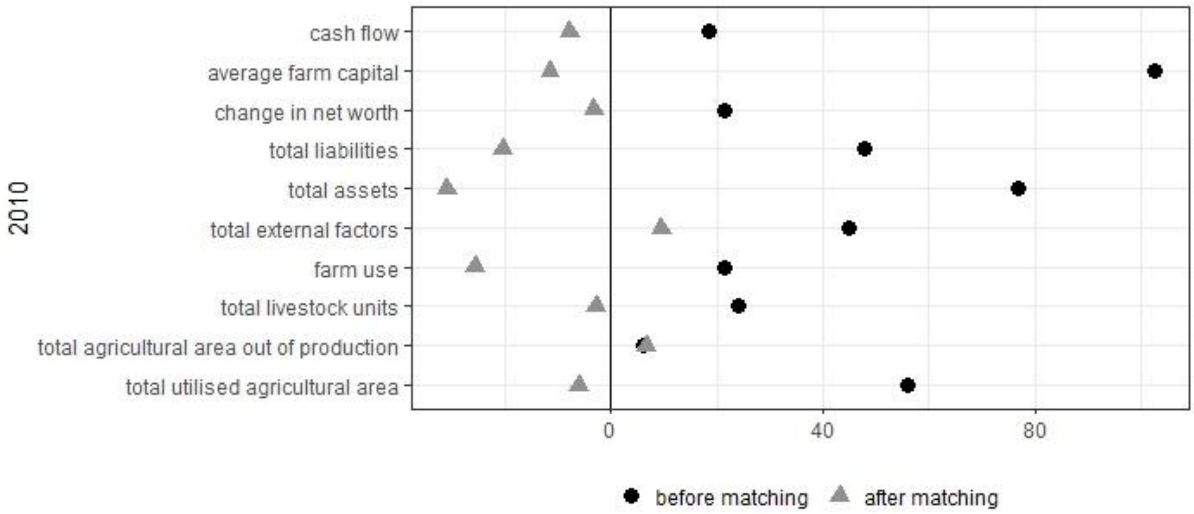
According to Table 1, the characteristics which mostly impacted in 2009-2014 on the probability of farm being assigned to the treatment group (receiving the investment support), were: farm use (positive impact), total external factors (positive impact), total utilised agricultural area (negative impact), change in net worth (positive impact) and average farm capital (positive impact). For each estimated logit model the accuracy rate was at least 0.89.

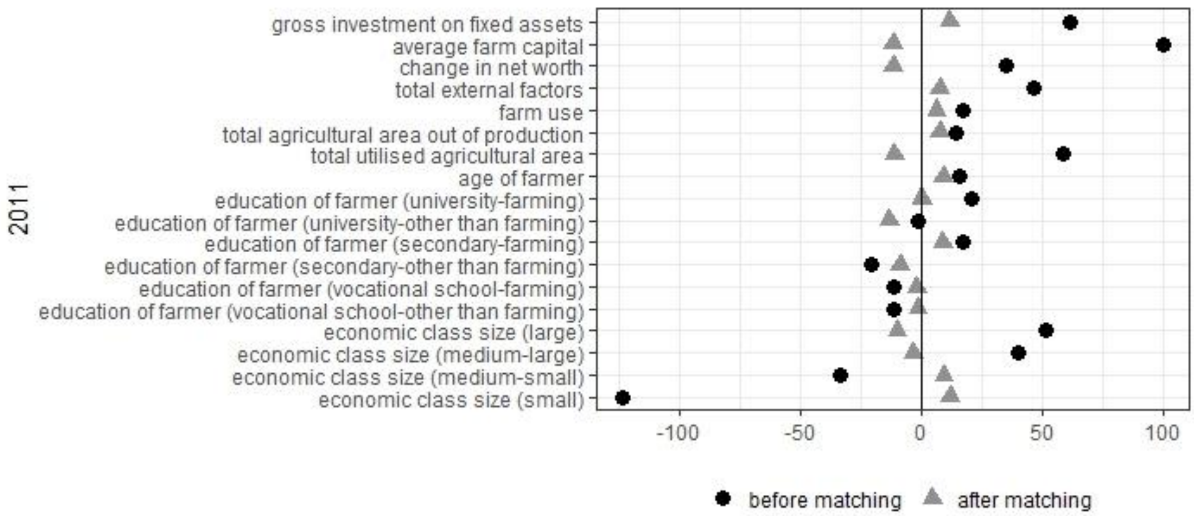
Table 1. Balanced variables included in propensity score model.

variable	2009	2010	2011	2012	2013	2014
economic class size	yes	no	yes	yes	no	yes
education of farmer	yes	no	yes	no	yes	no
age of farmer	yes	no	yes	no	no	no
total utilised agricultural area	yes	yes	yes	no	yes	yes
total agricultural area out of production	no	yes	yes	no	no	no
total livestock units	no	yes	no	yes	no	yes
farm use	yes	yes	yes	yes	yes	yes
total external factors	yes	yes	yes	yes	yes	yes
total assets	no	yes	no	no	yes	yes
total liabilities	no	yes	no	yes	yes	no
change in net worth	yes	yes	yes	no	yes	yes
average farm capital	no	yes	yes	yes	yes	yes
gross investment on fixed assets	yes	no	yes	yes	yes	no
cash flow	yes	yes	no	yes	yes	no
classification accuracy for model	0.91	0.9	0.89	0.93	0.91	0.89

Source: own elaboration based on the FADN data.


2009
cash flow
gross investment on fixed assets
change in net worth
total external factors
farm use
total utilised agricultural area
age of farmer
education of farmer (university-farming)
education of farmer (university-other than farming)
education of farmer (secondary-farming)
education of farmer (secondary-other than farming)
education of farmer (vocational school-farming)
education of farmer (vocational school-other than farming)
economic class size (large)
economic class size (medium-large)
economic class size (medium-small)
economic class size (small)
-100
-50
0
50
before matching
after matching


2010
cash flow
average farm capital
change in net worth
total liabilities
total assets
total external factors
farm use
total livestock units
total agricultural area out of production
total utilised agricultural area
0
40
80
before matching
after matching


2011
gross investment on fixed assets
average farm capital
change in net worth
total external factors
farm use
total agricultural area out of production
total utilised agricultural area
age of farmer
education of farmer (university-farming)
education of farmer (university-other than farming)
education of farmer (secondary-farming)
education of farmer (secondary-other than farming)
education of farmer (vocational school-farming)
education of farmer (vocational school-other than farming)
economic class size (large)
economic class size (medium-large)
economic class size (medium-small)
economic class size (small)
-100
-50
0
50
100
before matching
after matching

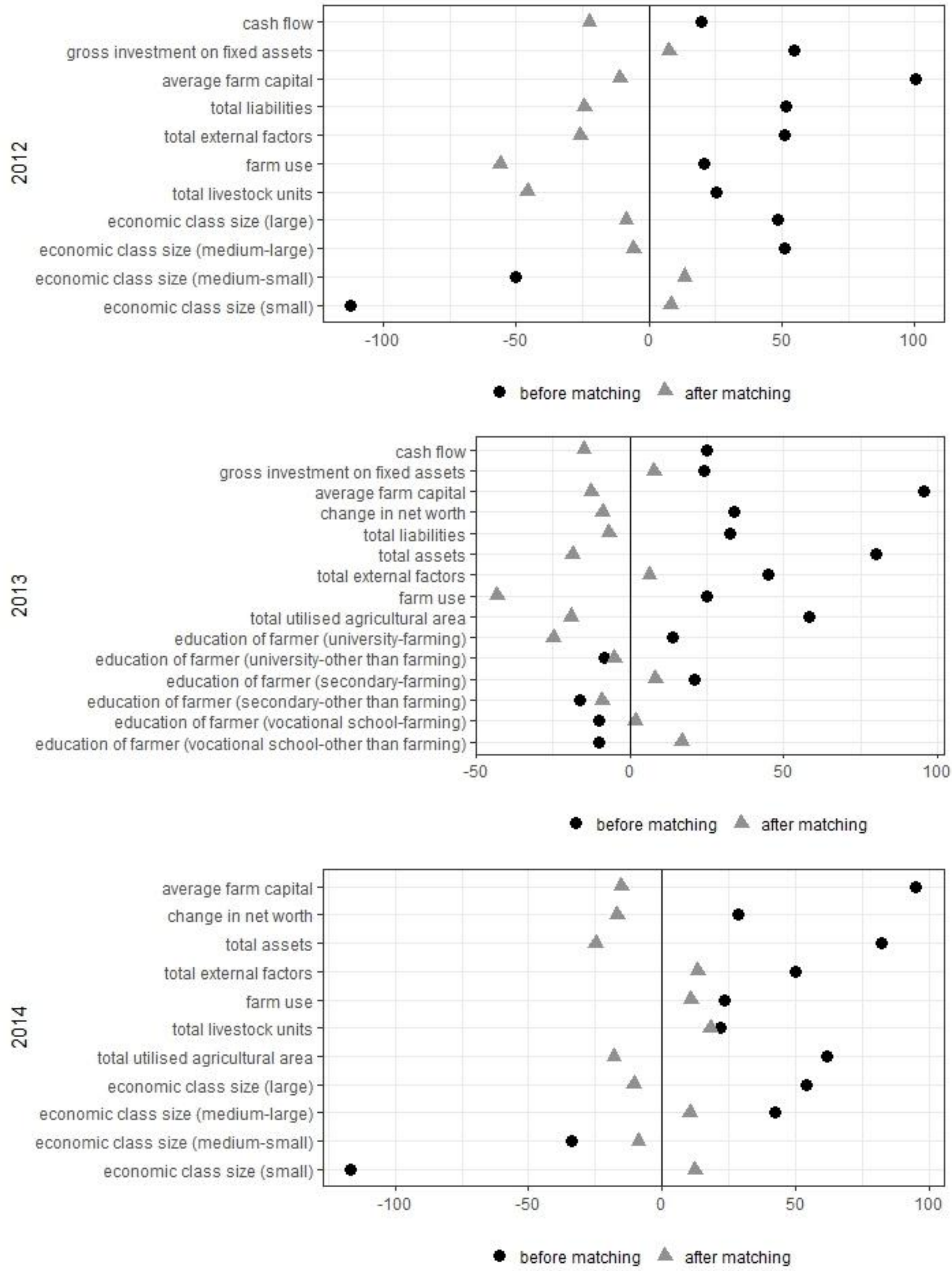


Fig. 2. Standardized differences in means.

Source: own elaboration based on the FADN data.

Fig. 2 shows the standardized mean differences for each explanatory variable in logit models.[2] It confirms that, comparing to unmatched samples, the matching procedure ensured significantly more balanced treatment and control groups.

The crop farms, which in 2009-2014 received support for investment, recorded both negative (in 2010 and 2012-2015) and positive (in 2011) effect of those subsidies on the increase in gross value added per annual work unit. According to Table 2, the negative treatment effect of subsidies on investment was dominant, when compared to the units which did not receive those subsidies. For example, the crop farms which in 2009 did not receive the investment support, recorded, on average, by 14 percentage points higher annual increase in labour productivity compared to the beneficiaries of the programme. Given relatively high standard errors for almost every estimates of ATT, it should be noted that the negative effects were not statistically significant, what confirm the results presented by Mary (2013)

Table 2. Average treatment effect for the treated.

year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
ATT	-0.143	0.391	-0.099	-0.067	-0.056	-34.56
standard error	0.681	0.175	0.096	0.188	0.106	46.29
p-value	0.83	0.03	0.31	0.72	0.6	0.46
number of observations	940	987	1017	1080	1106	1152
number of treated observations	118	127	127	138	137	142

Source: own elaboration based on the FADN data.

The only significant difference between treatment and control group occurred in 2011. Then, the crop farms which in 2010 received the analysed support, were characterised, on average, by 39 percentage points higher annual increase in the labour productivity compared to the control group.

Conclusions

The study refers to the microeconomic producer theory as a framework and the expected positive relationship between investments, but also subsidies on investments and labour productivity, as a basis of farmers' income from work. It results from the assumption that for a single farm the employment of the labour factor is constant, so the increase in the use of

[2] Due to page restrictions, the histograms of each covariate by treatment groups before and after matching cannot be presented.

(physical) capital factor should imply an increase in the technical equipment of labour and, consequently, lead to increased labour productivity. These processes rely on investments made by farms (producers). The increase in labour productivity could be also supported by implementation of relevant policy instruments.

The objective of the study was to carry out the quantitative assessment of the treatment effect of investment support on the increase in labour productivity in Polish crop farms in 2010-2015. The results suggest that the positive effect of investment subsidies occurred only in 2011. Back then, the farms which in 2010 received the analysed support, were characterised, on average, by 39 percentage points higher annual increase in the labour productivity compared to the control group. In the remaining years, in turn, the impact of investment support on the increase in labour productivity was negative. However, given relatively high standard errors, the differences between farms which received and did not receive analysed payments were not statistically significant. These conclusions confirm the results presented by Mary (2013) that targeted subsidies have no significant impact on productivity.

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