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# IMPACT OF THE LABOUR PRODUCTIVITY ON FARM INCOME IN POLAND

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## Abstract

*In the case of all farms, the issue of profitability achieved is crucial. The effectiveness of production factors involved, including labour, shapes income in agriculture to a large extent. Thus, the increase in the productivity of the labour factor determines the increase in the labour profitability. On the grounds of classical microeconomic relationships, it can be pointed out that the increase in farm income, which is the remuneration of the labour factor, can take place, ceteris paribus, with the increase in production. Assuming the permanence of labour factor inputs in the long term, the source of production growth should, in turn, be the increase in the labour productivity. The objective of the paper is to identify differences in the impact of labour productivity on farm income, with the dominance of family labour force and on farms with a dominance of paid labour force in Poland. The results presented may serve as a basis for concluding on the income situation of farms depending on the type of labour factor involved. The study will use the FADN data from 2009-2015 for Polish farms. The impact of labour productivity on farm income will be analysed using the propensity score matching method.*

**Keywords:** efficiency, labour factor, profitability, propensity score matching.

**JEL codes:** D33, J43, Q12.

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## Introduction

The starting point for the deliberations is the impact of the labour productivity on the remuneration of this factor, which constitutes income from farm labour. Although the literature stresses various objectives of the farm's activity (cf. Sielska, 2012), in particular of the family farm, according to the neoclassical model of the producer, the basic objective of the farm is to maximise income (Rembisz, 2007). The agricultural producer optimises its objective function with the production technique used, i.e. the allocation of manufacturing factors and the given capital constraints (Kowalski and Rembisz, 2003; Baer-Nawrocka and Markiewicz, 2013). With exogenous prices of production factors, the producer thus chooses a combination of production factors allowing to achieve the highest possible production, i.e. income, results. At the microeconomic level, agricultural income is used to assess the remuneration of agricultural production factors (Zegar, 2008). By focusing on the labour factor as the primary production factor employed on the farm, income is identical to the remuneration of the labour factor determined by the productivity of the labour factor (Rembisz and Sielska, 2015).

As stressed by Zegar (2012), in addition to the importance of farm income, the basic criterion for classifying farms in the agricultural sector is the type of the labour factor involved. The research objective is, therefore, to identify the difference in the impact of the labour factor's productivity on farm income, with the dominance of family labour force and on farms with the dominance of paid labour force in Poland. The study used the Polish FADN (Farm Accountancy Data Network) data for 2009-2015 for individual farms. The quantification of the labour productivity impact on farm income has been analysed using the propensity score matching method, recommended for the identification of cause-and-effect relationships in observational studies.

## Productivity and remuneration of the labour factor

The classic choice of the agricultural producer is to allocate resources used under the given production function. Due to the research problem undertaken, the production function can be described as being dependent primarily on the labour factor inputs:

$$Y = f(L, \mathbb{x})$$

where:
$Y = f(\cdot)$ – production function,
$L$ – labour factor resource,
$\mathbb{x}$ – vector of other production factors and certain intangible factors affecting the production (e.g. climate change or agricultural policy).

This choice is intended to achieve the objective i.e. maximum income. When adopting certain simplification assumptions concerning the identification of the labour factor as a primary manufacturing factor, the agricultural producer's profit can be defined as:

$$\pi = p_Y \cdot Y - c_L \cdot L$$

where:
$\pi$ – agricultural producer's profit,
$p_Y$ – price of the manufactured product,
$c_L$ – remuneration of the labour factor.

Then, the prerequisite for maximising profit is:

$$\frac{d\pi}{dL} = p_Y \cdot \frac{dY}{dL} - c_L = 0$$

which can be reduced to the following equation:

$$c_L = p_Y \cdot \frac{dY}{dL} .$$

The agricultural producer will thus achieve the maximum profit with such labour factor input, for which its remuneration, i.e. income from labour, will be a product of the price received for the manufactured product and the marginal labour factor productivity. Therefore, the increase in the remuneration of the labour factor can result from the rise in prices of manufactured products and/or the increase in the marginal labour productivity, and in the long term, from the increase in the average productivity (Rembisz and Sielska, 2015). Given the exogenous nature of prices, the only source of income change, depending on the agricultural producer's decision, is, therefore, to improve the labour factor productivity.

## Data and study method

To achieve the assumed study objectives, the balanced panel of the Polish FADN data on individual farms for 2009-2015 was used. The farms were analysed by two groups: units with the permanently dominant share of own labour[1] in total labour inputs (5724 farms) and units with the permanently dominant share of paid labour[2] in total labour inputs (141 farms). The differentiation between the identified groups is evident in the average inputs of production factors and the economic results of farms (see Fig. 1).

[1] Own labour inputs are unpaid labour inputs as part of the farm's operating activities, expressed in family work units (FWU) (Floriańczyk et al., 2018).

[2] Paid labour inputs are paid or given labour inputs as part of the farm's operating activities, expressed in annual work units (AWU).

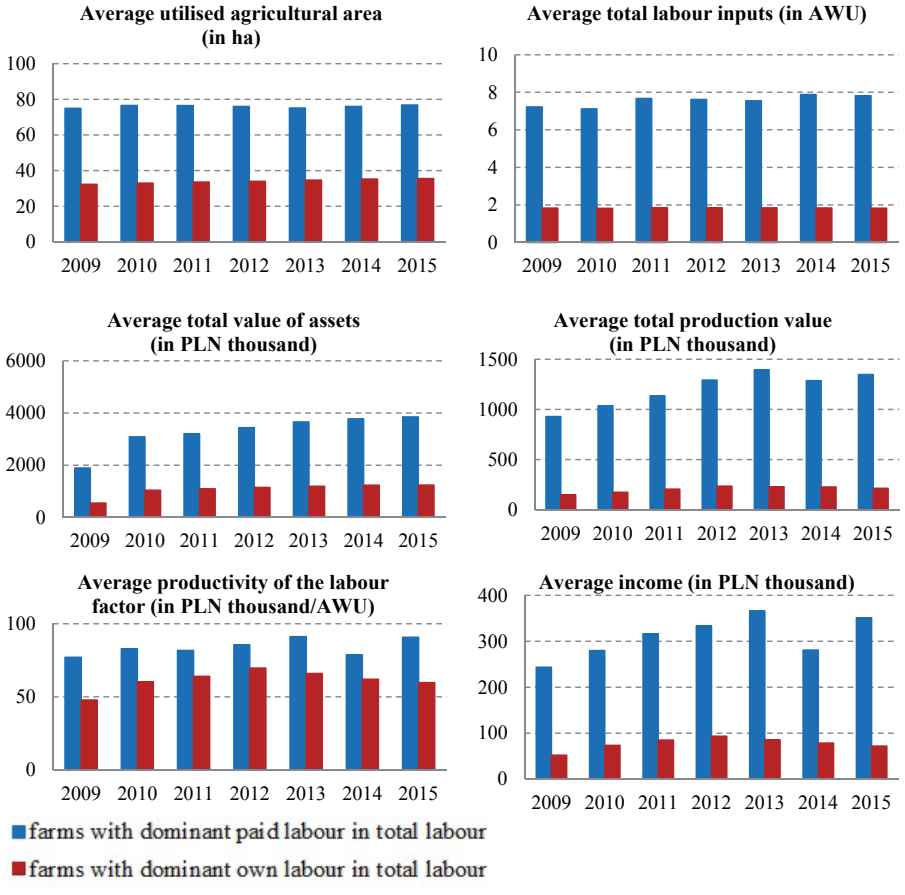



*Fig. 1.* Average inputs and results of farms.
Source: own study based on the Polish FADN data.

Farms employing mainly paid labour force had utilised agricultural area more than twice larger than those where the share of own labour dominated in total labour. The average resource of the land factor in the first group ranged between 75 ha in 2009 and approx. 77 had in 2015, while in the second group – between approx. 32 ha in 2009 and approx. 36 hectares in 2015. The differences between the analysed groups were also visible at the level of inputs of the labour factor involved on the farm. In fact, units with the permanently dominant share of paid labour force were characterised by nearly four times higher labour inputs when compared to farms using mainly own labour force. Farms with dominant paid labour force engaged in 2009-2015, on average, about 7.55 AWU. Units in which the own labour input exceeded each year the paid labour input, in turn, used, on average, about 1.84 AWU. In terms of the capital factor involved in the production process and measured by the value of assets, farms using primarily own labour force had about three times less fixed and working assets (on average, PLN 1.1 million) compared

to the group of farms with dominant paid labour force (on average, PLN 3.2 million). In the case of production volume produced in the analysed groups of farms, significantly higher effects were achieved by farms with the dominance of paid labour force. The difference between the groups was, on average, PLN 998 thousand and was from around PLN 780 thousand in 2009 to approx. PLN 1.1 million in 2015. The analysed groups of farms were not so significantly different in terms of productivity of the labour factor. The average labour productivity on farms with dominant paid labour force was approx. PLN 84 thousand/AWU while on farms with the higher share of own labour force – about PLN 61 thousand/AWU. Despite the relatively close values of the average labour productivity, the high discrepancies occur in income of the groups analysed. On average, farms using mainly paid labour inputs achieved income of about PLN 310 thousand. In turn, units involving mainly own labour force in the production process recorded average income of about PLN 77 thousand.

To measure the impact of the change in the labour productivity on the change in farm income, the method of combining data according to probability (propensity score matching) was used which is a sort of equivalent to the fully controlled randomised experiment when conducting observational studies. This approach is based on the model of the potential outcome variable introduced by Neyman and Rubin (Pan and Bai, 2015). It is assumed that the observable treatment effect of the factor concerned, and hence income resulting from the change in the labour productivity, is the sum of outcome variables in the individual states of impact and this sum is weighted by the treatment (Guo and Fraser, 2015). For a given sample unit, however, we observe the result of the treatment effect in only one of two mutually exclusive states (treated or non-treated). Therefore, the propensity score matching method uses the analysis of the so-called counterfactual states which constitute a hypothetical value of the outcome variable that the unit would have if the state of the treatment was different from that in reality. The average counterfactual state for the units analysed is estimated based on the information on the sample observations, and these units are "similar" in terms of the adopted observable characteristics for observing those treated by the factor. The method of combining data, therefore, requires pairing of observations treated by the factor (experimental group) with "similar" units that have not been treated (control group). When combining data according to probability, the units are paired based on the propensity score, which is usually estimated using logit models. Table 1 summarises the variables taken into account to estimate the propensity score value.

Table 1

*Characteristics of variables used in the model*

| Name of the variable according to FADN | Characteristics |
|---|---|
| SE025 | Utilised agricultural area (in ha) |
| SE365 | Costs on involving external factors in the production process (in PLN) |
| SE436 | Fixed and working assets belonging to the farmer (in PLN) |
| SE485 | Value of short- and long-term liabilities (in PLN) |
| SE521 | Net investments (in PLN) |
| SE530 | Cash flow II (in PLN) = cash flow I + sale of fixed assets – purchases and investments in fixed assets + state of liabilities as of the end of the year – state of liabilities as of the beginning of the year |
| D_INW | Investment subsidies (in PLN) |
| JPO | Single area payment (in PLN) |
| UPO | Complementary payment (in PLN) |
| W_R | Agri-environmental payment (in PLN) |
| W_ONW | Supporting agricultural activities in less-favoured areas (in PLN) |
| D_P | Production subsidies (coupled and decoupled) (in PLN) |
| D_KP | Production cost subsidies (in PLN) |
| WYK | Farmer's level of education (categories: primary, basic non-agricultural, basic agricultural, secondary non-agricultural, secondary agricultural, higher non-agricultural, higher agricultural) |
| WIEK | Farmer's age (in years) |

Source: own study based on Floriańczyk et al. (2018).

After adjusting the observations from the experimental group to their counterpart states in the control group, it is possible to designate, inter alia, the average treatment on the treated (ATT), defined as[3]:

$$ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1)$$

where:

$Y_1$ – income achieved as a result of the increased labour productivity on the farm,

$Y_0$ – income achieved as a result of the lack of change or decreased labour productivity on the farm,

$D$ – binary variable assuming the value of 1 for farms where the labour productivity increased, otherwise 0.

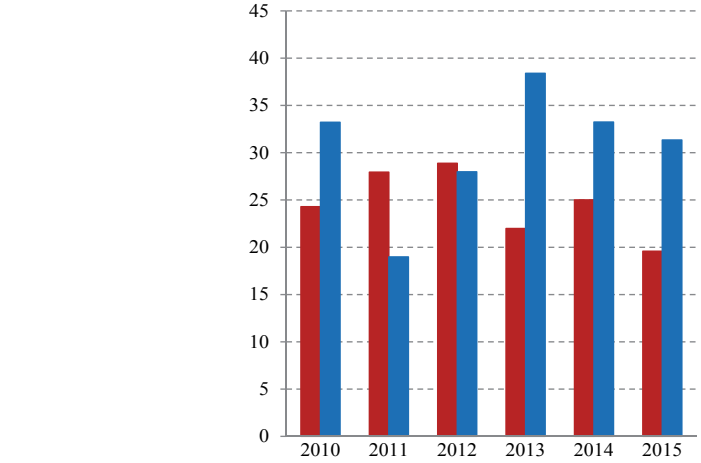
[3] Assuming that if there is a phenomenon of selection, it depends only from observable characteristics of the analysed units (Strawiński, 2014).

The analysis conducted used 1:1 combining with returning. Therefore, one farm from the experimental group corresponded to one farm from the control group. A genetic algorithm was used to combine observations into pairs, so as to find such counterfactual equivalents in order to achieve the best possible balance of characteristics (Sekhon, 2011). If to the given experimental observation the algorithm assigned more than one control farm, the information about those units was equally weighted and constituted a basis for estimating the counterfactual state. In addition, it has been assumed that there is a one-time delay in the cause-and-effect relationship between the productivity and income, i.e. the set of observable characteristics of farms from the period t affected the change in the labour productivity during the period $t$+1 affecting farm income during the period $t$+1.

## Study results

According to the objective of the study, the propensity score matching method was used to measure the net effect of the impact of changing the labour factor productivity on farm income. The analysis of the average treatment effect was possible after obtaining a balance between the experimental group, i.e. farms with a positive increase in the labour productivity and the control group, made of farms "similar" to experimental units where, however, the change in the labour productivity was zero or even negative.

Both in the case of farms with the higher share of own labour in total labour and of paid labour in total labour, the increase in the productivity had a significant positive impact on the level of farm income (see Fig. 2).




Key: *** – p-value < 0.001, ** – p-value < 0.01, * – p-value < 0.05.

*Fig. 2.* Average treatment effect of the change in the labour productivity on farm income.
*Source: own study based on the Polish FADN data.*

The net treatment effect of the productivity on income ranged from PLN 19.6 thousand/AWU to PLN 28.9 thousand/AWU for farms with dominant own labour and from PLN PLN 19.0 thousand/AWU to 38.4 thousand/AWU for farms with dominant paid labour. The higher average treatment effect of the labour productivity on income was mainly recorded in the group of units involving mainly paid labour on the farm. It should be stressed, however, that in 2011-2012 the increase in the labour productivity had a higher effect on income of family farms, i.e. those own labour inputs were permanently dominant. Exclusive of estimating the average treatment effect in 2011 in the group of farms involving mainly paid labour, we may concluded on the statistically significant impact of the change in the labour productivity on income in both groups analysed.

## Conclusions

The paper addressed the issue of farm income shaped as a result of change in the labour productivity. The effectiveness of production factors involved, including labour, determines the increase in its profitability. The objective of the study was to identify differences in the impact of the labour productivity on farm income with the dominance of family labour force and on farms with the dominance of paid labour force in Poland. It has been shown that, both in the case of farms with the higher share of own labour in total labour and on farms with the higher share of paid labour in total labour, the increase in the productivity had a significantly positive impact on the level of farm income. However, the scope of the net treatment effect of the labour productivity on income in the individual years has been diversified. On farms involving primarily own labour, the impact of the increased productivity on income was significantly higher, on average, by about PLN 19.6-28.9 thousand/AWU when compared to the control group, while farms using permanently from paid labour force achieved, in turn, from PLN 19.0-38.4 thousand/AWU, it was significantly higher income compared to the control units. Therefore, the increase in the productivity of the labour factor had a significant impact on farm income both among farms with dominant own labour and among agricultural enterprises involving mainly paid labour force.

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# WPŁYW WYDAJNOŚCI PRACY NA DOCHODY GOSPODARSTW ROLNYCH W POLSCE


## Abstrakt

*W przypadku wszystkich gospodarstw rolnych kluczową jest kwestia osiąganej dochodowości. Efektywność zaangażowanych czynników produkcji, w tym pracy, kształtuje w znacznym stopniu dochody w rolnictwie. A zatem wzrost wydajności czynnika pracy warunkuje wzrost jej dochodowości. Na gruncie klasycznych zależności mikroekonomicznych można wskazać, iż wzrost dochodu gospodarstwa rolnego, stanowiącego wynagrodzenie czynnika pracy, może nastąpić,* ceteris paribus*, przy wzroście produkcji. Zakładając stałość nakładów czynnika pracy w długim okresie, źródłem wzrostu produkcji powinien być z kolei wzrost wydajności pracy. Celem referatu jest wskazanie różnic we wpływie wydajności pracy na dochody w gospodarstwach rolnych z przewagą rodzinnej siły roboczej i w gospodarstwach z przewagą najemnej siły roboczej w Polsce. Zaprezentowane wyniki mogą stanowić podstawę wnioskowania o sytuacji dochodowej gospodarstw rolnych w zależności od rodzaju zaangażowanego zasobu czynnika pracy. W badaniu wykorzystane zostaną dane FADN z lat 2009-2015 dla polskich gospodarstw rolnych. Wpływ wydajności pracy na dochody gospodarstw zbadany zostanie za pomocą metody* propensity score matching.


**Słowa kluczowe:** wydajność pracy, czynnik pracy, *propensity score matching*.

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