Factors Influencing Productivity of Cereals in Polish Agriculture

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Abstract

The aim of the paper is to evaluate the relative importance of the selected inputs for cereals yields in Poland. The official statistics of the Central Statistical Office of Poland is used for the analysis. The following data types have been used for the study: inputs of artificial fertilisers per hectare, consumption of pesticides per hectare, certified seed inputs per hectare and average soil quality. All data were collected on the province level for the period from 1991 to 2007.

The patterns of the source of productivity were investigated using two methods: interpretation of estimated parameters in Cobb-Douglas production function, and the analysis of squared semi partial correlations. The results applied in the research are similar from both methods. The paper argues that the least "pure impact" is connected with certified seeds, medium impact on chemical originated inputs (fertilisers and pesticides), and the largest impact - to soil quality. The findings of the study indicate that:

- pure impact of "certified seeds" is below 10%,
- impact of chemical origin inputs is ca. 30% - (influence of pesticides and artificial fertilisers are not to be separated (as they strongly depend on each other),
- pure impact of "soil quality" – about 60%.

The era with governing biological progress for the increase of has not yet begun in Polish agriculture. The inputs fertilisers and pesticides are still more important for the growth of productivity. Similar situation was observed in the developed countries as the USA or Germany in the 1970s.

Key words: technical progress, biological progress, cereals production in Poland, Cobb-Douglas function, squared semi partial correlations method.

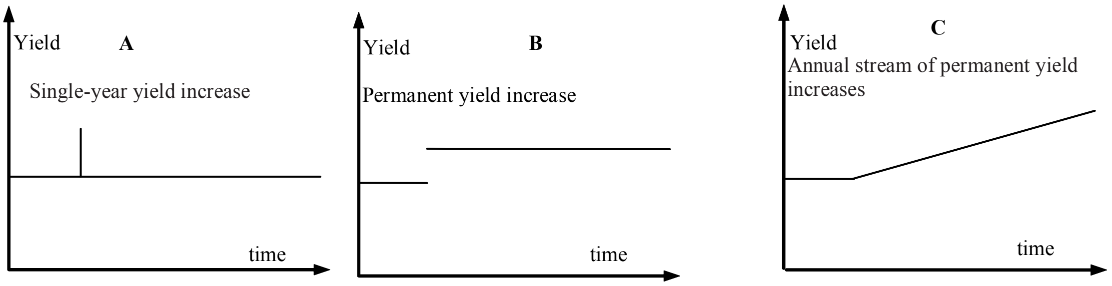
Introduction

Technological progress makes it possible to obtain an increase of productivity of production factors and lower unit manufacturing costs (Esposti 2000). Technological progress is the main factor leading to the increase of productivity also in agriculture. Not always, on the conditions of flexible demand and in case of innovation resulting in the increase of production and the increase of total costs, the growth of the manufacturer's income takes place, so the implementation of technological progress does not have to result in benefits at the level of a single enterprise. This group of innovations includes innovations of biological character (Heady 1967).

The most significant factors allowing the increase of productivity in agriculture include the implementation of biological progress. In a long-term perspective (1930-2000), thanks to biological progress it was possible to obtain about 50% of the detected increase of plant productivity (Duvick 2005; Lorgeou 2004; Nalborczyk 1997; Woś 1995, Thirtle 1995). It was more than the impact of such factors as: fertilisation, plant chemical protection, and mechanisation of production processes.

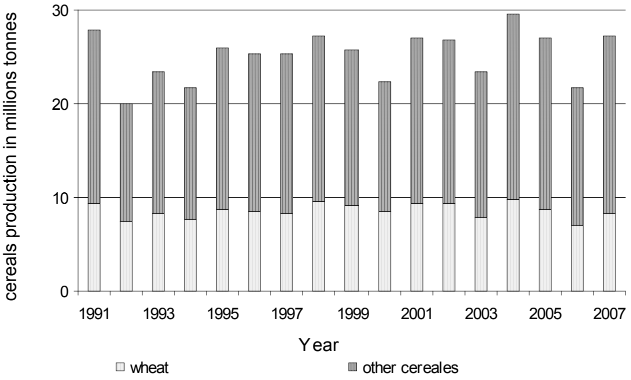
The significance of biological progress is greater than of other outlays, because the effect of their implementation remains in a period longer than one season (Figure 1). Outlays in form of fertilisers, plant protection agents, or even more diligent care entail a one-time increase of crops only (A). Improved varieties allow a rapid and permanent increase of the level of crops (B). A continuous inflow of improvements entails the continuous long-term increase of productivity (C) (Day-Rubenstein et al. 2005). Technological improvements have a similar effect.

Biological progress affects not only quantity, but also quality of products, allows energy savings in various forms; it is characterised by a short payback period, it semi neutral in relation to scale, however a high level of production technology is indispensable in order to reveal its effects. The results of application of this kind of progress are much delayed in the whole agriculture in relation to its first application (Tomczak 2005; Runowski 1997; Klepacki 1997; Reisch, Zeddies 1995; Herer 1970, Heady 1967).



Źródło: (Day-Rubenstein et al. 2005).

Figure 1. **Alternative assumptions about benefits from genetic enhancement**



Source: Figure drawn based on statistical data from CSO of Poland.

Figure 2. **Cereals production in Poland in the period of 1991-2007 (million tons)**

Most important factors determining the application of new varieties in production, and the use of their potential are as follows: information on varieties, availability of varieties, availability of seeds as well as the adaptability of varieties to local conditions and their applicability on certain agroecological conditions (Evenson 1994).

The following barriers to the increase of productivity exist due to the introduction of biological progress: need to increase outlays for fertilisers with plant protection, necessity to apply the correct technology, and a lack of appropriate knowledge of farmers (Day, Klotz-Ingram 1997). On the conditions of unfavourable outlay versus product price relations, and in the event of limitations resulting from manufacturing technologies of low intensity, the introduction of progress is not profitable (Wicki 2007).

The research results show that production potential of new varieties in Poland is applied on an insignificant scale on the account of a low use of certified seeds (Krzymuski 2003), inappropriate technology (Wicki, Dudek 2005), and also a high level of poor soils, on which the maximum yield does not exceed 2.5-3 tons/ha (Krasowicz 2007).

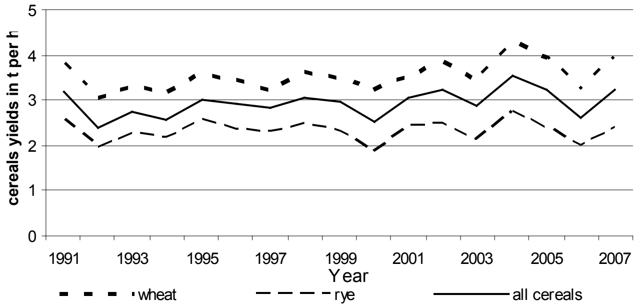
Cereals production in Poland

Cereals production in Poland is about 27 million of tons annually, and is subject to significant fluctuations as a result of changeable weather conditions (Figure 2). Droughts happening every few years negatively affect crops.

The observed small increase of the cereals production was mainly the result of an increase of the arable surface versus the stagnation of the crops level. Cereal yields in Poland have not significantly risen since 1991, and oscillate around 3 tons per hectare (Figure 3).

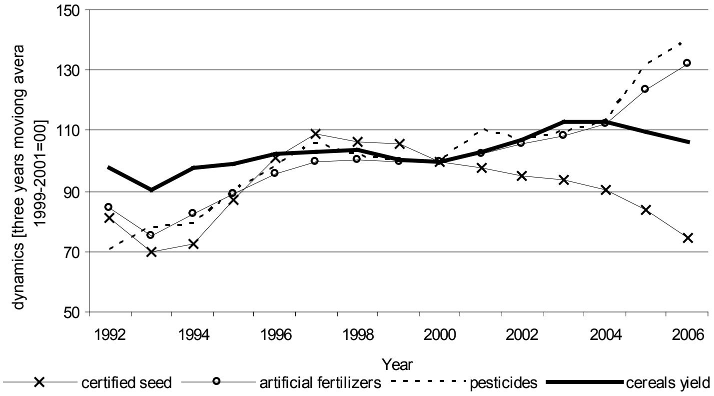
Consumption of seeds, fertilisers and pesticides

The level of mineral fertilisers, the quantity of applied pesticides and changes in the consumption of certified seeds are illustrated in Figure 4. Certified seeds of cereals constituted in the general consumption of the seed only from 5% in case of rye to 15% in case of wheat and barley. By comparison, in Spain it was respectively 17% in case of barley and 22% in case of wheat (Villarroel 2007), in France from 50% to 70% (Roger, Palle 2007), and in the USA in 1997 – 37% in case of wheat (Fernandez-Cornejo 2004).



Source. Figure made based on the data of CSO of Poland.

Figure 3. **Cereals yields in Poland in the period of 1991-2007**



Source: author's calculations based on the CSO of Poland data.

Figure 4. **Dynamics of cereals yield and selected inputs in Polish agriculture in 1991-2007 (based on three year moving average)**

Since 1992 the level of mineral fertilisers has grown from the level of 65 kg NPK/ha to 121 kg NPK/ha in 2007. Consumption of pesticides has increased significantly. On average, about 0.4 kg of active substance per 1 ha of cultivation was applied in Poland, and there was observed a continuous increase of pesticides consumption. In 2007 pesticides consumption was about 0.9 kg of active substance per 1 ha.

Figure 4 illustrates the dynamics of consumption of basic crop-generation outlays: certified seeds, artificial fertilisers and pesticides in Polish agriculture in relation to the obtained cereal yield. The observed increase in crops was attained thanks to a significant increase of outlays for artificial fertilisers and pesticides; at the same time decreasing the consumption of certified seeds.

The aim of research and the methods

The aim of the paper is to evaluate the relative importance of the selected inputs for cereals yields in Poland. The first task of the research is to evaluate the relative influence of inputs of certified seeds, fertilisers, pesticides and soil quality on cereals yield, and the second one is to find whether the factors chosen to analysis describe well enough cereals yield variability.

The official statistics of the Central Statistical Office of Poland (CSO) as well as the Inspectorate of Plant Health and Seed Inspection (PIORiN) and Research Centre for Cultivar Testing (COBORU) were used in the analysis. Soil classification for the provinces in Poland was based on Witek (1981). The maximum possible score is 100 points and the minimum observed in Poland is 19 points for some mountain regions.

The following data types have been used for the study: inputs of artificial fertilisers per hectare, consumption of pesticides per hectare, certified seed inputs per hectare, and the average soil quality. All data were collected on the province level for the period of 1991-2007.

The use of agricultural inputs is important to boost agricultural productivity, and to mitigate the

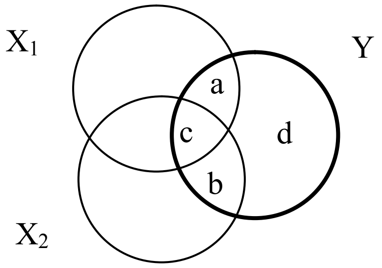


Figure 5. **Graphical relationship between the coefficient of determination and the squared semipartial correlations**

risk of a bad harvest. Agricultural inputs such as certified seeds, chemical fertilisers and pesticides enhance the quality and growth of crops. The Cobb-Douglas production function and squared semipartial correlations approaches are applied to find the influence of factors of production on yield.

The relevance of pesticides and fertilisers to agricultural productivity has become a stylised fact in developing economies. Fertilisers are one of the most enhancing productivity agricultural inputs in the agricultural economy. The authors as Hayami et al (1970), Headley (1968) and Carrasco and Moffit (1992) have found that fertilisers have an economically and statistically significant influence on agricultural productivity.

Parameters of model panel data was used for the estimation: information on the yield of cereals, certified seeds chemical fertilisers, pesticides use for each voivodship (province) over time.

Semipartial correlations are analysed for assessing the relative "importance" of various factors in determining dependent variable. They show how much each variable uniquely contributes to R^2 over and above that which can be accounted for by the other variables (Meyers, Gamst, Guarino 2006). To better understand the meaning of squared semipartial correlations, it will be helpful to consider Figure 5. In this figure, the variance of each variable is represented by a circle of unit area (i.e., each variable is standardised to have a variance of 1). Hence, $a+b+c+d=S_y^2=1$.

The total area of Y covered by the X_1 and X_2 areas represents the proportion of Y's variance accounted for by the two variables. The figure shows that this area is equal to the sum of the areas designated *a*, *b*, and *c*. The coefficient of determination in model with X_1 and X_2 can be expressed in the following form: $R_{12}^2=a+b+c$, whereas the coefficient of determination in model is equal with only X_1: $R_1^2=a+c$ and the coefficient of determination in model with only X_2 $R_2^2=b+c$

The areas *a* and *b* represent those portions of Y overlapped uniquely by X_1 and X_2, respectively, whereas area *c* represents their simultaneous overlap with Y. The "unique" areas, expressed as proportions of Y variance, are squared semipartial correlation coefficients, and each equals to the increase in the squared multiple correlation which occurs when the variable is added to the other independent variable. Thus, squared semipartial correlation coefficient $semiR_1^2$ is equal to a and $semiR_2^2=b$.

For the computational purposes one can apply the following formulae:

- for two independent variables: $semiR_1^2=R_{12}^2-R_2^2$ and $semiR_2^2=R_{12}^2-R_1^2$;
- for three independent variables: $semiR_1^2=R_{123}^2-R_{23}^2$, $semiR_2^2=R_{123}^2-R_{13}^2$ and $semiR_3^2=R_{123}^2-R_{12}^2$, and so on.

In the literature, the Cobb-Douglas specification is commonly used for the production function for ease estimation and clear interpretation of the parameters (Headley, 1968; Carrasco-Tauber and Moffit, 1992; Babcock *et al*., 1992; Carpentier and Weaver, 1997; Saha *et al*., 1997). In such case the model has the following form:

$$y_{it}=\beta_0 x_{1it}^{\beta_1} x_{2it}^{\beta_2} x_{3it}^{\beta_3} x_{4it}^{\beta_4} \xi_{it}$$

where:

y_{it} - yield of cereals,

β_0, β_1, β_2, β_3, β_4 - parameters,

x_{jit} - explanatory characteristics, j=1, 2,..,p:

x_{1it} - certified seeds,

x_{2it} - chemical fertilisers,

x_{3it} - pesticides,

x_{4i} - soil quality (this input is fixed over time),

ξ_{it} -random error, $\xi_{it} \approx i.i.d.\ (0,\sigma_\xi^2)$,

i indexes voivodshipds, *t* indexes years, i = 1, …, n, t = 1, …, T. In our study n=16, T=17 (data from years 1991-2007) and number of explanatory variables p=4.

In the Cobb-Douglas specification parameter β_j is partial elasticity of production with respect to each input X_j, j=1, 2, 3, 4, as $E_j = \frac{\%\Delta y}{\%\Delta x_j} = \frac{\partial y}{\partial x_j}\frac{x_j}{y} = \beta_j$. Partial elasticity of production can be interpreted as the percentage change in output resulting from a given percentage change in the amount of the variable input X_j employed in the production process with other inputs remaining constant.

The Cobb-Douglas function is a special class of homogeneous production functions. A production function is homogeneous if, when all inputs are increased by a factor of *k,* the output increases by a factor k^r of where *r* is termed the degree of homogeneity. If a production function is homogeneous of degree *r*, the following relationship shall be hold:

$$f(k \cdot X_1, k \cdot X_2, .., k \cdot X_p) = k^r \cdot f(X_1, X_2, .., X_p) .$$

The *r* determines how much the output changes with a change of scale. Thus, the returns to scale are increasing, constant, or decreasing as *r >1, r=1, r < 1*. In other words, if all inputs are increased by the factor *k*, then output may either increase more than *k*, less than *k*, or increase by exactly the factor *k* . It can be shown that the Cobb-Douglas production function $f(X_1, X_2, .., X_p) = \beta_0 X_1^{\beta_1} X_2^{\beta_2} \ldots X_p^{\beta_p}$ is homogeneous of degree $r = \sum_{j'1}^{p} \beta_j$. Thus, the Cobb-Douglas production function exhibits increasing, constant, or decreasing returns to scale depending on whether $\sum_{j'1}^{p} \beta_j > 1$, $\sum_{j'1}^{p} \beta_j = 1$, $\sum_{j'1}^{p} \beta_j < 1$. The analysis of estimated values of $\beta_1, \beta_2, \ldots, \beta_p$ enables assessment of relative impact of each input. In order to compute the share of individual input in returns to scale one can also consider $\frac{\beta_1}{\sum_{j'1}^{p} \beta_j}$, $\frac{\beta_2}{\sum_{j'1}^{p} \beta_j}, \ldots, \frac{\beta_p}{\sum_{j'1}^{p} \beta_j}$.

The following Cobb-Douglas function in a log-linear form is considered: $\ln y_{it} = \alpha + \sum_{j=1}^{k} \beta_j \ln x_{jit} + \varepsilon_{it}$, where ε -random error. This approach facilitates the estimation of parameters[1].

The panel data methods are used in the research. Panel data analysis endows the regression analysis with both a spatial and temporal dimension. The spatial dimension pertains to a set of cross-sectional units of observation. The temporal dimension pertains to periodic observations of a set of variables characterising these cross-sectional units over a particular time span. We have a set of explanatory variables and a dependent variable both observed for a number of cross-sectional units i = 1, …, n and through time t = 1, …, T.

There are three basic types of static panel data models: pooled regression, fixed effect and random effect models (Baltagi 2001; Greene 2000; Wooldridge 2002). The choice between the specifications of the model is an important aspect of panel econometrics. There are three basic tests for comparison of models. Fixed effects versus pooled regressions are tested by the F-test, while random effects versus pooled regressions are tested by the Breusch-Pagan test. The Hausman specification test is the classical test to show the use of either the fixed or random effects model.

Results

First, models based on the “rough” data from individual years from the period of 1991-2007 were considered. However, in such case, the hypothesis of normal distribution of the error term was rejected. Moreover, the estimated goodness of fit by looking at the coefficient of determination was not very good - $R^2 \approx 0{,}50$. Next “smooth data” - simple moving averages for five years period was taken into account. This method reduces the impact of anomalies associated with climatic changes, like flood or *drought.* For such “smooth data” pooled regression, fixed effect, and random effect models are estimated. Several tests, such as the Breusch-Pagan test, Hausman specification test and the F-test, were employed to choose the most appropriated model (Baltagi 2001, Greene 2000). The results of comparison between the models are presented in Table 1.

The panel diagnostic tests suggest that the fixed effect model is the most appropriate. However “soil quality” is time-invariant characteristics, thus a typical fixed effect specification cannot be applied. Econometric textbooks typically recommend the Hausman-Taylor procedure for panel data with time-invariant variables and correlated unit effects (Baltagi 2001). The Hausman-Taylor estimator requires several conditions in order to be implemented

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[1] Taking logs transforms the non-linear model into linear one in respect to parameters.

Table 1

The results of panel diagnostics tests

Result:	F-test	Breusch-Pagan test	Hausman test
Value of statistics	74.62	712.99	26.73
P-value	less than 0.001	less than 0.001	less than 0.001

Source: authors' calculations obtained by using Gretl software, the F. Breusch-Pagan and Hausman tests are panel diagnostic tests. .

Table 2

Values of Pearson correlations for the analysed variables

Variables:	lny	$\ln x_1$	$\ln x_2$	$\ln x_3$	$\ln x_4$
lny	1	0.45	0.64	0.50	0.57
$\ln x_1$	0.45	1	0.50	0.39	0.08
$\ln x_2$	0.64	0.50	1	**0.90**	0.06
$\ln x_3$	0.50	0.39	**0.90**	1	-0.03
$\ln x_4$	0.57	0.08	0.06	-0.03	1

Source: authors' calculations. x_1 - certified seeds, x_2 - chemical fertilisers, x_3 - pesticides, x_4 - soil quality.

effectively. First, the unobserved cross-sectional level effect must indeed be random, i.e., it has a zero mean, finite variance, and is independently and identically distributed over the cross-section units. Second, one needs to classify our explanatory variables into four types: time-varying and exogenous, time-varying and endogenous, time-invariant and exogenous, and time-invariant and endogenous. Fulfilment of these conditions is a formidable task especially since the unit effects are unobserved, thus finally we decided to apply a pooled regression model.

As "chemical fertilisers" and "pesticides" (Table 2) are highly correlated, these two variables should not be included together as explanatory variables due to the multicollinearity. One of the features of multicollinearity is that the standard errors of the affected coefficients tend to be large. In that case, the test of the hypothesis showing the coefficient equal to zero against the alternative where it is not equal to zero leads to a failure to reject the null hypothesis.

First, x_{2it} (chemical fertilisers) is dropped due to the multicollinearity.

$$
\begin{array}{l}
\hat{\ln} y_{it} = 3{,}35629 \;+ 0{,}0633 \ln x_{1it} + 0{,}2099 \ln x_{3it} + 0{,}6588 \ln x_{4it} \\
\qquad\qquad (75{,}6190)^{*} \;\; (5{,}3200)^{*} \qquad\; (9{,}3810)^{*} \qquad\; (13{,}5080)^{*}
\end{array}
$$

(Model 1)

The t-statistics are reported in the parenthesis, * denotes significant parameter at 0.05 level. Based upon Jarque-Berra statistics, we can not reject the hypothesis of normality of error term (JB=2.10^2, p-value=0.35). The values of squared semipartial correlations for each explanatory variable are reported in Table 2.

The coefficient of determination consists of two parts: the sum of squared semipartial correlations and the common part (a proportion of explanation coming from the combinations of explanatory variables). The difference between the coefficient of determination and the sum of squared semipartial correlations is about 13%, thus this part of total sum of squares of logarithms of yields of cereals is explained by the interaction of certified seeds, pesticides and soil quality. About 5% of total sum of squares of logarithms of yields of cereals refers to "pure impact" of logarithms of certified seeds, 15% of this sum - to logarithms of pesticides and 32% - to soil quality.
Taking into account only the sum of squared semipartial correlations one can state that near 10% of the sum of "pure effects" deals with certified seeds, near 30% of this sum deals with certified seeds and a little more than 60% - with soil quality (third row of Table 3).

One can compare this assessment with the result of estimation of the Cobb-Douglas parameters, which can be interpreted in terms of elasticity of production. This elasticity is defined as the average percentage change in production associated with a 1% increase

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[3] JB indicates the Jarque-Berra statistics.

Table 3

Values of squared semipartial correlations in Model (1)

Certified seeds	Pesticides	Soil quality	Sum of squared semipartial correlations	Coefficient of determination
$semiR_1^2$ =4.92%	$semiR_3^2$ =15.28%	$semiR_4^2$ =31.68%	$\sum_j semiR_j^2$ =51.88%	R^2 =64.58%
$\frac{semiR_1^2}{\sum_j semiR_j^2}$ =9.47%	$\frac{semiR_3^2}{\sum_j semiR_j^2}$ =29.4%	$\frac{semiR_4^2}{\sum_j semiR_j^2}$ =61.07%	-	-

Source: authors' calculations obtained by using Gretl software

Table 4

Values of squared semipartial correlations in Model (2)

certified seeds	fertilizers NPK	soil quality	Sum of squared semipartial correlations	Coefficient of determination
$semiR_1^2$ =1.70%	$semiR_2^2$ =21.09%	$semiR_4^2$ =27.43%	$\sum_j semiR_j^2$ =50.22%	R^2 =70.38%
$\frac{semiR_1^2}{\sum_j semiR_j^2}$ =3.39%	$\frac{semiR_2^2}{\sum_j semiR_j^2}$ =41.99%	$\frac{semiR_4^2}{\sum_j semiR_j^2}$ =54.62%	-	-

Source: authors' calculations obtained by using Gretl software

in one input, with the other inputs held constant. The estimated parameters of model (1) can be interpreted in the following manner:

- If the application of certified seeds increases by 1%, and the use of pesticides and soil quantity is unchanged, the yields would increase by 0.06%. If certified seeds consumption increases by 1%, and other inputs do not change, increasing of cereals yield by 0.06% is expected.
- Given a 1% change in the use of pesticides, shows a 0.21% change in the yields of cereals, ceteris paribus.
- One percent improvement of soil quality leads to a 0.66% increase in the yields of cereals; while the use of certified seeds and pesticides are held constant.

It was found that the least "pure impact" refers to certified seeds, medium one to pesticides, and the largest - to soil quality. Therefore the approximated size of impact of inputs is close to that obtained by the analysis of squared semipartial correlations.

Next, a similar analysis was done replacing pesticides with chemical fertilisers. It *results in obtaining the following model:*

$$\begin{aligned} \hat{\ln} y_{it} &= 2{,}0984 + 0{,}0393\ln x_{1it} + 0{,}2751\ln x_{2it} + 0{,}6117\ln x_{4it} \\ &\quad (22{,}8440)^{*}\ \ (3{,}4230)^{*}\ \ (12{,}0520)^{*}\ \ (13{,}2320)^{*} \end{aligned}$$

(Model 2)

The p-value of the Jarque-Berra test for normality is 0.52, thus one *cannot reject* the normality of residuals. For the above model we tried to asses the amount of input "impacts" on the yields of cereals in 1991-2007. The results are presented in Table 4.

In Model (2) the total sum of squares of logarithms of yields of cereals is explained in 70.38% by the logarithms of certified seeds, mineral fertilisers and soil quality. Decomposing the coefficient of determination into two parts, one can state that:

1) about 20% of the total sum of squares of logarithms of yields of cereals refers to the common effects of certified seeds, pesticides and soil quality,
2) about half of variance of the dependent variable is associated with each independent variable uniquely: about 2% with only logarithms of certified seeds, about 21% with logarithms of mineral fertilisers, and about 27% with logarithms of soil quality.

Taking into account the interpretation of estimated parameters in the Cobb-Douglas model one can conclude that:

- If the application of certified seeds increases by 1%, and the use of mineral fertilisers and soil quantity is unchanged, the yields would increase by about 0.04%. Precisely, if certified seeds consumption increases by 1%, and other inputs do not change, increasing of cereals yield by 0.04% is expected.
- Given a 1% change in the use of mineral fertilisers shows a 0.28% change in the yields of cereals, ceteris paribus.
- One percent improvement of soil quality leads to a 0.61% increase in the yields of cereals; while the use of certified seeds and mineral fertilisers are held constant.

Economies of scales are calculated as the sum of the estimated input elasticities: for Model (1) $\hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_4 = 0{,}9319$ and for Model (2) $\hat{\beta}_1 + \hat{\beta}_3 + \hat{\beta}_4 = 0{,}9261$. They are slightly less than one, thus it is a case of decreasing returns to scale – outputs increase slower than inputs. From the economic point of view, only if there is a positive margin profit gained, it is economically efficient to increase the volume of inputs. Higher production intensity can be rational so long as it brings any marginal profit allowing to cover the fixed costs. The analysis of such factors as a scale of production needs to be additionally analysed in separate research for further conclusions.

Concluding remarks

The patterns of source of productivity were investigated via interpretation of estimated parameters in the Cobb-Douglas production function, and the analysis of squared semipartial correlations. The first approach relies on the interpretation of elasticity of production, which is defined as the average percentage change in production associated with a 1% increase in one input, with the other inputs held constant. The second method refers to decomposition of the coefficient of determination into the percent of variance in the dependent variable associated with each independent variable uniquely, and the proportion of explained variance associated with the common effects of predictors.

The results from both methods applied in the research are similar. The paper argues that the least "pure impact" is connected with certified seeds, medium impact with chemical originated inputs (fertilisers and pesticides) and the largest impact - with soil quality. The findings of the study indicate that:

- pure impact of "certified seeds" is below 10%,
- impact of chemical origin inputs is ca. 30% - (influence of pesticides and artificial fertilisers is not to be separated because they strongly depend on each other),
- pure impact of "soil quality" – about 60%.

It was found that the economies of scale are all less than one, thus it is a case of decreasing returns to scale – outputs increase slower than inputs:

Outlays for crop-generation factors of organic origin play the biggest role in Polish agriculture. Also the quality of soils used for production is important, which means that the further use of poor or light soils would be a significant factor delimiting the increase of crops. The significance of biological progress has been determined as less than 10% of the total impact of the examined factors. It means that, on average, the productivity potential of new varieties is not used, as according to the results of tests run in the research institutes, new varieties are characterised by a significantly higher potential of the crop yield. It may be the result of limitations related to a low quality of soils as well as insufficient outlays for fertilisers and pesticides. Polish agriculture seems to be on average at such a level of development which was observed in the Western European countries in the 1970s and 1980s of the 20th century. There is a big number of establishments at a very high level of technology, but on the contrary there are farms of traditional and hardly modern techniques of farming. Changes in the effectiveness of plant production can take place slowly, because they require a social re-construction in Polish agriculture. Moreover, the increase of effectiveness in the crops production will require the abandonment of the agricultural use of the poorest soils constituting about 30% of the surface of arable lands in Poland.

Only after attaining the appropriate technological level and abandonment of the poorest soils it will be possible to use the crop-generation potential of new varieties in the whole-agricultural sector, and not only in a small number of the best farms.

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