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# MARKET VERSUS AGRICULTURE IN POLAND – MACROECONOMIC RELATIONS OF INCOMES, PRICES AND PRODUCTIVITY IN TERMS OF THE SUSTAINABLE DEVELOPMENT PARADIGM

Bazyli CZYŻEWSKI, Adam MAJCHRZAK

*Department of Education and Personnel Development, Faculty of Economics, Poznań University of Economics and Business, al. Niepodległości 10, 61-875 Poznań, Poland*

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**Abstract.** In the article macroeconomic relations of prices, productivity and incomes in Polish agriculture in the context of changes in the EU Common Agricultural Policy were studied. The authors have developed a macroeconomic model which explains these relations and confirms the occurrence of market failures in agriculture in Poland. The developed model proves the existence of a puzzling exchangeable relation between the real productivity of production factors in agriculture, and agricultural incomes, under conditions of adaptive expectations. It also proves that it is price scissors, not the efficiency of production, that have a dominating influence on incomes in the sector. The authors propose the hypothesis that correction of market mechanisms by government intervention in agriculture is an objective necessity. However, direct subsidies (area payments) do not have a correcting role, but reinforce King's effect.

**Keywords:** agricultural incomes, prices, productivity, market failures, sustainable development, expectations.

**JEL Classification:** E02, Q01, Q18, Q21, Q28.

## Introduction

Agriculture is changing. In the paradigm of sustainable agriculture (Wallace 1994), which is promoted by the EU, land provides new utilities, which are of the nature of public goods (Varian 1993; Kallhoff 2014). Not only is European agriculture responsible for providing food and material to be further processed, but it also occupies around 40% of the land. As a consequence it has a huge impact on the condition of the environment in rural areas, as well as on possibilities of using the environment (Baldock *et al.* 2010; Hvid 2015). It is a specific feature of public goods related to agriculture and rural areas that they can be an external effect of "regular" agricultural production, a purposive effect or a common supply

Corresponding author Bazyli Czyżewski
E-mail: *b.czyzewski@ue.poznan.pl*

that belongs to society. At the highest level of generalization, the following should be treated as such goods: water, air, biological diversity, landscape, and food safety. By definition, all of these goods are common or merit goods (Wilkin 2010; Buckwell 2009). While in the literature public goods provided by agriculture are identified with external effects of agricultural activity, this approach is too "narrow", because some of them may be the result of purposeful activity aimed at producing them (Brelik 2004), or in some cases be the result of refraining from a specific activity. As was said above, agriculture and rural areas are the key elements creating public goods based on the natural environment (Yang *et al*. 2014). However, as a result of the multifunctional model of agriculture, different forms of public goods are provided. A. Vatn includes among these not only environmental aspects (landscape, biodiversity, pollution, recreation, cultural heritage, food safety), but also protection of food supplies (food security) and aspects connected with the rural lifestyle (settlement models, tradition and culture, local economic and social activities) (Vatn 2001; Fałkowski 2010).

Consequently, the problem of market failures in agriculture should be approached in a different way. These failures are inevitable in the model of sustainable agriculture, because, in principle, the market does not evaluate public goods. Certain instruments of the Common Agricultural Policy, financed from taxes paid by EU communities, nonetheless constitute an attempt at such evaluation (Smędzik-Ambroży, Guth 2016). The question also arises of whether, by paying a higher price for organic products, we are not partially paying for the supply of public goods? If this is acknowledged, then we should reconsider the claim that market prices may only valuate private goods (Czyżewski, Matuszczak 2016). The mechanisms shaping prices and incomes in agriculture, including the 17th-century King's Law (Heberton 1967), should also be reconsidered. According to King, incomes in agriculture decrease when production grows, and increase when production decreases. The effect is related to the low price elasticity of demand for agricultural products, and so far it has been considered a phenomenon typical of raw material markets. This is probably why there exist very few articles on the subject in the world literature, a situation which ought to be remedied. The product of agriculture is changing – as was stated above, it is no longer an ordinary raw material, but a kind of public good. If we assume that public goods include products of agriculture, then what is the price elasticity of demand for them? Assuming that public goods include, among others, safe food (with health-improving properties), unspoiled natural environment, landscape, tradition and rural culture, these goods have one common feature: they satisfy higher needs. Consequently, the price elasticity of demand for these goods should not be low. In other words, the flexibility of prices (a reciprocal of the price elasticity coefficient) cannot be high. Thus, irrespective of whether the price of these goods is included in taxes or in market prices, demand for products of sustainable agriculture should be more sensitive (elastic) to price fluctuations. A second premise is the studies on food demand saturation in Poland (and in the other "new" Member States, the EU12), which point to very low demand saturation and its high income elasticity in categories of basic food products (Świetlik 2014a, 2014b; Gałązka 2013).

In this light, how should the occurrence of the 17th-century King's effect be interpreted, if the effect still exists? In the authors' view, firstly, the macroeconomic dependencies of prices, incomes and production in agriculture should be reinvestigated in the context of the new paradigm. Secondly, if King's effect occurs despite the new conditions, it results from market failures, i.e. a situation where the food industry aims to apply monopoly rents and dictates prices to suppliers of raw materials, who are financially much weaker. Agricultural policy, promoting the sustainable agriculture model in the EU, cannot be indifferent to King's effect, because under these conditions it has no theoretical justification in terms of demand.

On the basis of analysis of the input-output matrix of a given sector, it is possible to assess the structure of economic rent flows in a given year and changes in their values over time. If the values of outlays and products are deflated by the suitable price indices, it will be possible to evaluate changes in real productivity (Sulmicki 1959). Higher real productivity of a sector, for instance resulting from technical or organizational innovations, should bring additional and proportional benefits to the owners of means of production in the industry, and lower productivity should bring a residual loss. If this is not the case, it leads to "surplus drainage" (Czyżewski, Kryszak 2015). This means that a sector does not increase its surplus (income) despite real productivity growth. Meanwhile other sectors gain profits that are not justified by changes in real productivity, but are caused only by nominal variables. The aforementioned mechanism has been observed by the authors in Polish agriculture based on historical data, leading to the conclusion that a state intervention in agriculture is not only a pure political rent while it shall also correct the market failures of public goods and information asymmetry (Czyżewski 2013a, 2013b; Czyżewski, Brelik 2014)

The purpose of this article is to study the macroeconomic relations of prices, productivity and incomes in Polish agriculture in the context of changes that have occurred in the European Common Agricultural Policy since the 1990s. The authors have developed a macroeconomic model which explains these relations and describes the mechanism behind market failures in agriculture in Poland (and probably in other countries as well). The authors claim that the occurrence of King's effect is such a failure, as a result of adaptive expectations in agriculture, and of the information asymmetry between agriculture and its market environment. Both reasons have not hitherto been taken into consideration in models of the functioning of agricultural markets. The authors address the question of whether CAP subsidies adjust these failures, and to what degree they streamline the functioning of the market. The authors propose the hypothesis that the correction of market mechanisms in agriculture by state intervention is an objective necessity. However, direct subsidies (area payments) do not have a correcting role, but reinforce King's effect.

## 1. Theoretical dependencies of incomes, prices and productivity in agriculture – an attempt to give an analytical form of the income function

On the basis of historical data (see Table 1), inspiring dependencies may be observed: an exchangeable relation of income growth rate (surpluses) in agriculture with productivity delayed by one year, and proportional changes in incomes and the agricultural raw materials price gap index in Poland. This is particularly visible in the local maxima and minima of business cycles in agriculture (see in Table 1).

Table 1. Indices of prices, incomes and productivity of factors in Polish agriculture, 1996–2013

| Variables | 96 | 97 | 98 | 99↓[1] | 00 | 01 | 02↓ | 03 | 04↑ | 05 | 06 | 07↑ | 08 | 09↓ | 10 | 11↑ | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Operating surplus index $t$–1 = 100 (without subsidies)[2] | 111 | 105 | 100 | 73 | 111 | 126 | 78 | 93 | 125 | 83 | 104 | 146 | 74 | 99 | 125 | 139 | 102 | 109 |
| Lagged productivity index in constant prices $t$–1 = 0, one period lag[3] | 95 | 95 | 107 | 116 | 110 | 97 | 106 | 105 | 99 | 105 | 102 | 92 | 98 | 106 | 110 | 95 | 95 | 103 |
| Price indices of agricultural goods output $t$–1 = 100[4] | 122 | 110 | 98 | 95 | 116 | 104 | 93 | 102 | 109 | 98 | 108 | 115 | 97 | 93 | 111 | 119 | 104 | – |
| Price gap[5] | 96 | 96 | 91 | 92 | 103 | 97 | 91 | 97 | 103 | 96 | 102 | 108 | 91 | 96 | 110 | 108 | 98 | 99 |

*Note:* [1]Local minimum or maximum of business cycle in agriculture in Poland (IRG 2014); [2] See methodology in Table 2; [3] See methodology in Table 2; [4] Price indices of agricultural products – agricultural goods output, including fruits and vegetables; [5] Relation between the price index of products sold by individual farms and the price index of products bought at individual farms in Poland (inflation rate included).
*Source:* EUROSTAT (2014); GUS (2014).

On the basis of the above data it may be assumed that price expectations in Polish agriculture are of an adaptive nature, taking the following form:

$$p_t^e = p_{t-1}^e + \lambda(p_{t-1} - p_{t-1}^e), \text{ where } \lambda \in (0,1), \quad (1)$$

where: $p_t^e$ – expected prices within the period $t$; $p_{t-1}^e$ – expected prices within the period $t$–1; $P_{t-1}$ – prices within the period $t$–1; λ – parameter.

Let us begin with the case where λ is 0, and state intervention in agriculture does not occur. Here a farmer evaluates, in the period $t$, the change in the technical productivity of a holding (e.g. yield per hectare of utilized agricultural land) as compared to the previous year, disregarding price changes. In the language of economics we would say that the farmer, defining the value of a relation of production to input, applies fixed prices from the previous year. In the event of increasing technical productivity, he makes an economically justified decision to increase production in the following season, which should theoretically result in increased income (operating surplus). Unfortunately, expectations in the environment of the agricultural market are more rational. The increase in agricultural production resulting from higher efficiency is properly anticipated. Under conditions of low price elasticity of demand for agricultural raw materials, this results in lower incomes from sale. This is a delayed King's effect. In the following seasons, farmers adjust their evaluation of their farms' technical productivity with an error resulting from price expectations, but in view of the continued asymmetry of information (adaptive expectations in agriculture against rational expectations in its market environment), every increase in agricultural productivity is exploited by the market environment by way of a drainage of rents. Nonetheless, marginal drops in revenue become smaller (and approach zero) as a result of the aforementioned price expectation adaptation process. Despite the fact that the price elasticity of supply in agriculture is low, the possibility of substituting remunerated employment with a farmer's family's work (especially when there is hidden unemployment in agriculture), as well as the possibility of limiting consumption in a household, are the factors absorbing income drops. Another factor contributing to the slower decrease in incomes is the possibility of exporting surpluses of agricultural raw materials to regions with lower supply (under conditions of a global food deficit). In contrast, the market's reaction to lower technical efficiency and consequent lower production in agriculture is the opposite, and results in delayed growth in revenue (analogously, the main reason is the rigidity of demand for agricultural raw materials at the stage of processing). In this case, however, marginal growth of revenue is much higher, because of "food consumption compulsion" and the political dimension of the problem of food self-sufficiency and food security. In other words, the market reacts more dynamically to a deficit of food products than to a surplus.

The authors have concluded that the dependencies described above are best represented by a hyperbolic function, where incomes are negatively correlated with the real productivity of agriculture, with a one-year delay. It should be borne in mind, however, that the prices of means of production and inflation (i.e. interest rates, which determine costs of credit and exchange rates, are related to inflation) also have an effect on changes in incomes in agriculture. The dynamics of these variables are well reflected by a price gap index, calculated as the ratio of the prices of products sold at private agricultural farms to the prices of products purchased by those farms (including consumption). Taking all these factors into consideration, the authors propose the following analytical form of a macroeconomic function of incomes (surplus) in agriculture:

$$S = \mu + \delta \frac{1}{(AO_{t-1} \div AI_{t-1})} + \varphi(\frac{AP_0}{AP_i}), \tag{2}$$

where: $S$ – economic surplus rate (index, $t$–1 = 100) without subsidies; $\frac{AO_{t-1}}{AI_{t-1}}$ – productivity of inputs in agriculture in constant prices (index, $t$–1 = 0) from previous period (one period lag); $AO$ – agricultural output index (constant prices, $t$–1 = 100); $AI$ – agricultural input index (constant prices, $t$–1 = 100); $(\frac{AP_0}{AP_i})$ – price gap; $AP_0$ – index of prices of products sold by private farms ($t$–1 = 100); $AP_i$ – index of prices of goods and services purchased by private farms ($t$–1 = 100) ; $\mu$, $\delta$, $\varphi$ – parameters.

The above function is of a macroeconomic nature and describes what the authors consider to be universal mechanisms shaping economic surplus in an agricultural sector dominated by individual farms and in a situation where agricultural interventionism does not occur. The strength of the aforementioned relations depends, however, on the resources of own work and hidden unemployment in agriculture, the possibility of exporting agricultural raw materials, the degree of information asymmetry in the relationship of agriculture with its market environment, and the coefficients of price elasticity of demand for agricultural products and of their supply (it is assumed that these are respectively smaller than –1 and 1).

## 2. Methodology

The authors estimated the parameters of the above functions on the basis of statistical data from EUROSTAT and GUS (annual data from 1996–2013). The details of variable determination and the structure of time series are presented in Table 2.

Table 2. Sources of statistical data and methodology for determining the variables

| Variables | Source of data | Description |
|---|---|---|
| Economic surplus rate (income of agriculture industry) | EUROSTAT (2014a, 2014b). Supply and Use tables – values at current prices, annual data from Poland extracted October 2014. *S* – version without subsidies – the data comes from NA in the years 1994–1997 and 2004, and from EAA in 1998–2003 and 2005–2013. $S_{sub}$ – version with all subsidies – the data comes from NA in the years 1994–1997 and from EAA in 1998–2003 and 2005–2013; 2004* – replaced by the maximum value from the 1994–2013 time series. $S_{sout}$ – version with output subsidies only – as above. | The index of economic surplus (residual income in agriculture industry according to NACE, at national level), $t$–1 = 100, was extracted as a value at current prices. In the first version, *S*, all subsidies are deducted. The second version ($S_{sub}$) includes total subsidies to agriculture. The third version ($S_{sout}$) includes only output subsidies, which means market intervention and Rural Development Programs including investment support (direct payments to producers, i.e. area payments are deducted) |
| Productivity | EUROSTAT (2014a, 2014b). Supply and Use tables: – values at current prices, – price indices of total agricultural goods output and input (annual data), extracted October 2014 Time series 1994–2012; the data comes from NA for the years 1994–1997, and from EAA for 1998–2012. | The lagged index of inputs productivity ($t$–1 = 100, one period lag) was calculated as a ratio of two indices in constant prices ($t$–1 = 100): *Index of agricultural output without subsidies* and *Inputs index* (including: *total intermediate consumption + compensation of employees*). Price indices of agricultural output and of means of agricultural production were used as deflators. The explanatory variable is productivity from the previous period. |
| Price gap | GUS (2014). Time series 1994–2013 | The price gap index ($t$–1 = 100) was calculated as a ratio of two price indices: *Index of sold agricultural products at private farms* and *Index of purchased goods and services at private farms*, to reflect both changes in prices of means of agricultural production and the inflation rate. This is the methodology used by GUS. |
| Subsidies | EUROSTAT (2014a). Values at current prices | The index of total subsidies ($t$–1 = 100) is calculated using the sum of *output subsidies* and *producer subsidies* (according to EAA "*other subsidies on production*"). |

*Note:* *2004 was the year of Poland's accession to the EU, and rates of subsidies in agriculture rose by hundreds of percent. Replacement was necessary because such high values could strongly influence the model, artificially increasing $R^2$.
*Source:* own study.

Next, subsidies under agricultural policy, divided into "production subsidies" and "farmer subsidies" (area payments), according to the EAA classification, were included in the function. The following analytical forms of functions with subsidies were calculated:

$$S_{sub} = \mu + \delta \frac{1}{(AO_{t-1} \div AI_{t-1})} + \varphi(\frac{AP_0}{AP_i}) + \alpha D; \tag{3}$$

$$S_{sub} = \mu + \delta \frac{1}{(AO_{t-1} \div AI_{t-1})} + \varphi(\frac{AP_0}{AP_i}) + \alpha D_{out} + \gamma D_{prod}; \tag{4}$$

$$S_{sout} = \mu + \delta \frac{1}{(AO_{t-1} \div AI_{t-1})} + \varphi(\frac{AP_0}{AP_i}) + \alpha D_{out}, \tag{5}$$

where: $S_{sub}$ – economic surplus rate with total subsidies (index, $t$–1 = 100); $S_{sout}$ – economic surplus rate with output subsidies only (index, $t$–1 = 100); $D$ – total subsidies rate (index, $t$–1 = 100); $D_{out}$ – output subsides rate (index, $t$–1 = 100); $D_{prod}$ – producer subsidies rate (index, $t$–1 = 100); α, γ – parameters; other symbols – as in formula 1).

In Eq. (5), only production subsidies (in the form of a growth rate) were considered, as farmer subsidies turned out to be statistically insignificant and considerably lowered the degree of function matching.

Methods of non-linear estimation (Gauss-Newton) and linear regression (y = 1/x transformation type, least squares method) were used to estimate the function parameters. Then standardized B coefficients and partial and semi-partial correlation coefficients were calculated to evaluate the relative input of individual variables in different function variants. DW (Durbin-Watson) statistics were also estimated, to determine the risk of serial correlation – there is no serial correlation in models 2) and 5), DW tests for model 3) and 4) are inconclusive, however these models are less important for conclusions because of insignificant "producer subsidies rate" variable. The normality of the distribution of residuals was positively checked.

## 3. Results

On the basis of the graph (Fig. 1) of the variables from Eq. (2), it may be stated that there is a high probability of positive correlation of "price gap" and negative correlation of real productivity of production factors (one-year delayed, in fixed prices from the previous year) with the surplus index. The graph also suggests that the variables do not share a common trend and that the risk of spurious regression is small, which is confirmed by stationarity tests (the risk of spurious regression is lower owing to the fact that the variables are expressed in the form of growth rates and indices).

The above observations were confirmed following the estimation of the parameters of **function 2**, which turned out to be quite well adjusted to the series of data (R2 = 0.8, all variables were statistically significant, α = 0.05, standard estimation error < 10%) – see Table 3.

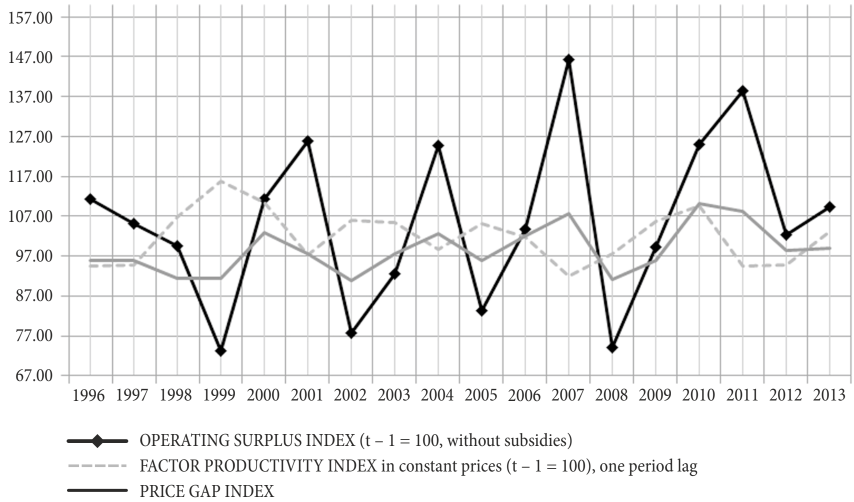


Fig. 1. Surplus rate in agriculture in Poland and its macroeconomic determinants

*Note:* *The PRICE GAP INDEX is the ratio between the price index of products sold by individual farms and the price index of goods and services purchased at private farms in Poland (the inflation rate is included).

*Source:* EUROSTAT (2014a, 2014b); GUS (2014).

Table 3. Estimation of model 2 parameters

| | | | | | | |
|---|---|---|---|---|---|---|
| **Results of linear regression:**<br>Dependent variable Surplus rate Multiple R = .89792338 F = 31.21296<br>R^2= .80626640 df = 2.15<br>No. of cases 18 Adjusted R^2= .78043526 p = .000005<br>Standard estimation error: .098774523<br>Absolute term: -2.669836177 Std. error: .4882201 t( 15) = -5.469 p = .0001<br>DW: 2.28; dl = 1,04607 du = 1,53525; inconclusive range: 2,46447-2,92570<br>**no serial correlation**<br>**Non-linear estimation – Gauss-Newton method:**<br>Model: $Y=a+b*(1/X_1)+c*X_2$<br>Dependent variable: Surplus rate Independent variables: 2<br>Loss function: least squares<br>Final value: .1463461<br>Share of explained variance: .8062664 R =.89792338 | | | | | | |
| | Standardized coeff. b 'BETA' | St. error: | Coeff. b | St. error: | t(15) | p level |
| Absolute term | | | –2.66984 | 0.488220 | –5.46851 | 0.000065 |
| Price gap | 0.760145 | 0.116861 | 2.68316 | 0.412496 | 6.50470 | 0.000010 |
| Productivity of inputs (trans. 1/X) | 0.332646 | 0.116861 | 1.09756 | 0.385580 | 2.84651 | 0.012253 |

*Source:* Calculations performed using StatSoft *STATISTICA* software.

The function obtained has the following form:

$$S = -2.67 + 1.1\frac{1}{(AO_{t-1} \div AI_{t-1})} + 2.68(\frac{AP_0}{AP_i}). \quad (6)$$

Table 4. Partial and semi-partial correlations for variables from Eq. (2)

| | BETA | Part. | Semip.[1] | Tolerance | R-square | t(15) | p level |
|---|---|---|---|---|---|---|---|
| Price gap | 0.760145 | 0.859227 | 0.739238 | 0.945748 | 0.054252 | 6.504704 | 0.000010 |
| Productivity of inputs (trans. 1/X) | 0.332646 | 0.592219 | 0.323497 | 0.945748 | 0.054252 | 2.846514 | 0.012253 |

*Note:* [1]The difference between semi-partial and partial correlation is that in the case of semi-partial correlation, we refer a part of the $X_1$ variable (without that part of $X_1$ which, together with other $X_i$ predictors, is correlated with the Y variable) to the "entire" Y variable (it thus reflects the "lone" influence of X on Y). In partial correlation, we refer the $X_1$ variable to a part of the Y variable (the part which is not explained by other $X_i$ variables). It therefore informs us about the size of the influence that a particular variable has on the dependent variable, but only that part of its variance which has not yet been explained by other analyzed predictors.

*Source:* Calculations performed using StatSoft *STATISTICA* software.

The interpretation of the hyperbolic dependency of productivity and income proves, for $\delta = 1.1$ under the *ceteris paribus* condition, that an increase in the real productivity of agriculture by 10% in the previous period leads to a decrease in the income rate, also by 10% (see Table 3 and 10), and that the rate of these decreases is slowing. On the other hand, it means that only a relatively high acceleration of productivity increase against the previous year, i.e. exceeding 10% a year, results in negative income growth rate in a subsequent period, under the *ceteris paribus* condition. By contrast, the average rate of productivity changes throughout the year is only 1.8% in the analysed period (geometrical mean). A macroeconomic evaluation of these phenomena is presented later in this paper. It should be borne in mind, however, that we are presently considering the variant without agricultural policy subsidies.

The estimation of **model 3** parameters leads to interesting conclusions concerning the influence of intervention on market mechanisms in Polish agriculture (see Table 5).

Table 5. Estimation of model 3 parameters

**Results of linear regression:**
Dependent variable Surplus rate with subsidies Multiple R = .90841153 F = 17.31107
R^2= .82521150 df = 3.11
No. of cases 15 Adjusted R^2= .77754191 p = .000178
Standard estimation error: .084483648
Absolute term: -2.024911587 Std. error: .4531413 t( 11) = -4.469 p = .0009
DW: 2.305912 dl=0,81396 du=1,75014; inconclusive range: 2,24986-3,18604
**inconclusive solution**

**Non-linear estimation – Gauss-Newton method:**
Model: $Y=a+b*(1/X_1)+c*X_2+d*X_3$
Dependent variable: Surplus rate Independent variables: 3
Loss function: least squares
Final value:.07851235
Share of explained variance: .8252115 R =.90841153

| | Standardized coeff. b 'BETA' | St. error: | Coeff. b | St. error: | t(11) | p level |
|---|---|---|---|---|---|---|
| Absolute term | | | –2.02491 | 0.453141 | –4.46861 | 0.000949 |
| Price gap | 0.589584 | 0.136297 | 1.71630 | 0.396764 | 4.32575 | 0.001203 |
| Subsidies rate | 0.389991 | 0.130303 | 0.49036 | 0.163838 | 2.99295 | 0.012233 |
| Productivity of inputs (trans. 1/X) | 0.306458 | 0.132049 | 0.86470 | 0.372587 | 2.32080 | 0.040521 |

*Source:* Calculations performed using StatSoft *STATISTICA* software.

The model assumes the following form:

$$S_{sub} = -2.02 + 0.86\frac{1}{(AO_{t-1} \div AI_{t-1})} + 1.71(\frac{AP_0}{AP_i}) + 0.49D. \quad (7)$$

On the basis of standardized Beta coefficients and partial and semi-partial correlations, we concluded that price scissors continue to play a dominating role in explaining the changes in agricultural incomes, followed by subsidies (with a contribution smaller by approximately one third) and, similarly, productivity of production factors. This shows that agricultural intervention under CAP lowers market risk only by an insignificant amount, while price gap and real productivity of production factors explain over one half of income volatility in agriculture. Interestingly, however, the parameter analysed above with the "productivity" variable, in the model with subsidies, is lower than 1 (it is approximately 0.86 – see Table 5). This means that an increase in the real productivity of factors by 10% is accompanied by a decrease in incomes by almost 8%, *ceteris paribus* (in the model without subsidies, the decrease was 10%), which suggests a relaxation of King's effect (marginal falls in income per unit productivity growth are smaller). On the other hand, it means that any acceleration in productivity growth compared to the previous year results in a negative income growth rate in the subsequent period, under the *ceteris paribus* condition (see Table 10), which reinforces the negative market effect.

Table 6. Partial and semi-partial correlations for variables from Eq. (3)

| | BETA | Part. | Semip. | Tolerance | R-square | t(11) | p level |
|---|---|---|---|---|---|---|---|
| Price gap | 0.589584 | 0.793587 | 0.545282 | 0.855363 | 0.144637 | 4.325746 | 0.001203 |
| Subsidies | 0.389991 | 0.669953 | 0.377277 | 0.935859 | 0.064141 | 2.992954 | 0.012233 |
| Productivity of inputs (trans. 1/X) | 0.306458 | 0.573323 | 0.292548 | 0.911282 | 0.088718 | 2.320798 | 0.040521 |

*Source:* Calculations performed using StatSoft *STATISTICA* software.

Estimation of the parameters of models 4 and 5, in which subsidies are divided into production support (including PROW – Polish Rural Development Plan) and direct payments (mainly area payments), brings new information in addition to the mechanisms described above. The models assume the following form:

$$S_{sub} = -2.24 + 0.87\frac{1}{(AO_{t-1} \div AI_{t-1})} + 1.99(\frac{AP_0}{AP_i}) + 0.31D_{out} + 0.14D_{prod}; \quad (8)$$

$$S_{sout} = -2.72 + 0.95\frac{1}{(AO_{t-1} \div AI_{t-1})} + 2.5(\frac{AP_0}{AP_i}) + 0.33D_{out}. \quad (9)$$

In **model 4**, the influence of direct support on income changes turned out to be statistically insignificant (see Table 7). **Model 5** was therefore estimated, including only subsidies supporting production. Of all the models, model 5 was adjusted best, with $R^2 = 0.89$, standard estimation error 7% – see Table 8 (linear and non-linear estimation using the Gauss–Newton method gave the same results).

Table 7. Estimation of model 4 parameters

**Results of linear regression:**
Dependent variable Surplus rate with subsidies Multiple R = ,93835705 F = 18,42295
R^2= ,88051395 df = 4,10
No. of cases 15 Adjusted R^2= ,83271953 p = ,000132
Standard estimation error: ,073260718
Absolute term: -2,249651496 Std. error: ,4212026 t( 10) = -5,341 p = ,0003
DW: 2,36 - **inconclusive solution**

**Non-linear estimation – Gauss-Newton method:**
Model: $Y=a + b*(1/X_1)+c*X_2+d*X_4+e*X_5$
Dependent variable: Surplus rate with subsidies Independent variables: 4
Loss function: least squares
Final value:.05367133
Share of explained variance: .88051395 R =.93835705

| | Standardized coeff. b "BETA" | St. error: | Coeff. b | St. error: | t(11) | p level |
|---|---|---|---|---|---|---|
| Absolute term | | | –2.24965 | 0.421203 | –5.34102 | 0.000328 |
| Productivity of inputs (trans. 1/X) | 0.307943 | 0.114717 | 0.86889 | 0.323683 | 2.68438 | 0.022920 |
| Price gap | 0.684413 | 0.129319 | 1.99235 | 0.376451 | 5.29245 | 0.000351 |
| Output subsidies rate | 0.398801 | 0.114340 | 0.30500 | 0.087448 | 3.48785 | 0.005844 |
| Producer subsidies rate | 0.146833 | 0.125754 | 0.13858 | 0.118687 | 1.16762 | 0.270047 |

*Source:* Calculations performed using StatSoft *STATISTICA* software.

Table 8. Estimation of model 5 parameters

**Results of linear regression:**
Dependent variable Surplus rate with output subsidies only Multiple R = .94442806
F = 30.26647
R^2= .89194437 df = 3.11
No. of cases 15 Adjusted R^2 = .86247465 p = .000013
Standard estimation error: .072608780
Absolute term: -2.722340860 Std. error: .4100040 t( 11) = -6.640 p = .0000
DW: 2.05; dl=1,04607 du=1,53525; inconclusive range: 2,24986 - 3,18604
**no serial correlation**

| | Standardized coeff. b "BETA" | St. error: | Coeff. b | St. error: | t(11) | p level |
|---|---|---|---|---|---|---|
| Absolute term | | | –2.72234 | 0.410004 | –6.63979 | 0.000037 |
| Price gap | 0.784885 | 0.104708 | 2.49748 | 0.333180 | 7.49590 | 0.000012 |
| Output subsidies | 0.396173 | 0.100475 | 0.33119 | 0.083995 | 3.94300 | 0.002300 |
| Productivity of inputs (trans. 1/X) | 0.309274 | 0.103888 | 0.95386 | 0.320413 | 2.97698 | 0.012587 |

*Source:* Calculations performed using StatSoft STATISTICA software.

Two facts are interesting. Firstly, direct subsidies considerably reduced the influence of "price gap", and consequently of price variables (including marketing prices, prices of means of production and inflation), on income dynamics. After this type of support was excluded from the model, the semi-partial correlation coefficient for the "price gap" variable rose from 0.54 (Table 6) to 0.74 (Table 9) (that is, in model 5, "price gap", without the influence of other independent variables, explain up to 74% of surplus rate volatility in agriculture). The influence of price gaps therefore close to that found in model 2, which excludes all subsidies (Table 4).

Table 9. Partial and semi-partial correlations for variables from Eq. (5)

| | BETA | Part. | Semip. | Tolerance | R-square | t(11) | p level |
|---|---|---|---|---|---|---|---|
| Price gap | 0.784885 | 0.914484 | 0.742936 | 0.895965 | 0.104035 | 7.495904 | 0.000012 |
| Output subsidies | 0.396173 | 0.765274 | 0.390800 | 0.973058 | 0.026942 | 3.943000 | 0.002300 |
| Productivity of inputs (trans. 1/X) | 0.309274 | 0.667975 | 0.295055 | 0.910165 | 0.089835 | 2.976982 | 0.012587 |

*Source:* Calculations performed using StatSoft *STATISTICA* software.

Secondly, in the last evaluated model, the parameter with the "productivity" variable is again closer to 1 (it is about 0.95 – see Table 8). This shows that, in comparison with the model that includes subsidies, there is a larger marginal income change in response to growth in productivity (see Table 10), but this is accompanied by a higher threshold for a positive income growth rate (for models 1, 2 and 4, the threshold was at productivity rates of 10%, –14% and –5% respectively, i.e. these were the maximum productivity change rates for which incomes did not drop, *ceteris paribus*).

Table 10. Simulations of changes in real productivity and incomes on the basis of estimated δ parameters (functions No. 2, 3, 5, under *ceteris paribus* conditions)

| δ = 1.1 | | δ = 0.86 | | δ = 0.95 | |
|---|---|---|---|---|---|
| Lagged productivity index (*t*–1 = 100) | Income index (*t*–1 = 100) | Lagged productivity index (*t*–1 = 100) | Income index (*t*–1 = 100) | Lagged productivity index (*t*–1 = 100) | Income index (*t*–1 = 100) |
| 0.800 | 1.375 | 0.860 | 1.000 | 0.900 | 1.056 |
| 0.900 | 1.222 | 0.900 | 0.956 | 0.950 | 1.000 |
| **1.000** | **1.100** | **1.000** | 0.860 | **1.000** | 0.950 |
| 1.010 | 1.089 | 1.010 | 0.851 | 1.010 | 0.941 |
| 1.020 | 1.078 | 1.020 | 0.843 | 1.020 | 0.931 |
| 1.030 | 1.068 | 1.030 | 0.835 | 1.030 | 0.922 |
| 1.040 | 1.058 | 1.040 | 0.827 | 1.040 | 0.913 |
| 1.050 | 1.048 | 1.050 | 0.819 | 1.050 | 0.905 |
| 1.060 | 1.038 | 1.060 | 0.811 | 1.060 | 0.896 |
| 1.070 | 1.028 | 1.070 | 0.804 | 1.070 | 0.888 |
| 1.080 | 1.019 | 1.080 | 0.796 | 1.080 | 0.880 |
| 1.090 | 1.009 | 1.090 | 0.789 | 1.090 | 0.872 |
| 1.100 | 1.000 | 1.100 | 0.782 | 1.100 | 0.864 |

*Source:* own calculations.

## Conclusions and discussion

Despite the changes taking place in agriculture, King's Law still operates, although its character has changed. King's effect occurs with a delay, as a result of adaptive expectations in agriculture. This is an objective premise of state intervention in agriculture, because the effect should be treated as a market failure, which results from the fact that the market is unable to evaluate public goods (Bonini *et al.* 2015). Nevertheless, promoting an industrial model of agriculture in Poland (Kowalski *et al.* 2011) and pushing the growth of efficiency of production factors "at all costs" mainly serves the food industry, which appropriates the rents from the growing productivity of agriculture. Evolution of the European model of agriculture towards sustainable agriculture is therefore justified (Öhlund *et al.* 2015). The thesis that growth achieved by increasing capital productivity not only causes negative external effects, but also does not guarantee adequate growth of agricultural incomes (Brelik, Grzelak 2011) is thus confirmed. Methods of subsidizing agriculture should nonetheless compensate for market failures, not reinforce the mechanisms of their formation.

Direct (decoupled) subsidies considerably reduce the influence of "price gap" on agricultural incomes, and at the same time reinforce King's effect. That is, they make it possible for farmers to sell products far below the costs of their production, a fact of which purchasers of raw materials take advantage. Contemporary production subsidies – the Rural Development Plan from the CAP second pillar – are more effective. The European Union's agricultural policy should aim towards market valorisation of the public goods provided by agriculture, and towards a decrease in the price flexibility of agricultural raw materials at the processing stage (Tomek, Robinson 2001). This can be achieved by, among other things, stimulating integration processes in agriculture, developing organic farming and improving the image of traditional agriculture. A subsidized agricultural insurance system, not area payments, should be used as a counterweight to expanding price gap (Grzelak, Brelik 2011). If we look for optimizing solutions in the new programming period of the CAP (2014–2020), a national flexibility of the pillars should be maximally used in terms of the so called modulation, i.e. shifting of funds from the Ist to IInd pillar. However, it is commonly known that such solution is a very unpopular one in the new member countries of the UE13, while the area payments are being maximised mainly the political reasons.

In the light of the above considerations, it is timely to take a look at available study results concerning the elasticity of demand and supply in agriculture. It is beyond any doubt that the demand for massively produced food is characterized by low price elasticity, though relatively higher in countries with lower per capita income. This dependency is a result of both "forced consumption of food" and a demand barrier in agriculture (Daszkowska 2008). Demand elasticity is also higher in the case of specialist crops and animal production than in the case of products which have been granted institutional support (Tweeten, Zulauf 2008).

As regards the supply of food products, low price elasticity is a characteristic feature here too (Nerlove 1956). It should be borne in mind, however, that globally, farmers continue to adjust their decisions on the allocation of land resources for plant production purposes in response to changes in the prices of agricultural products (Haile *et al.* 2013). This phenomenon gains in significance in view of the increasing foreign investment in the agricultural sector, and the growing demand for biofuels. It is suggested that, because of international integration, which allows the export of surplus production of food products or the import of goods in deficit periods, it is possible to lower the elasticity of supply (Musiał, Wojewodzic 2013). This phenomenon is identifiable today in reference to EU member states. Lower price elasticity of supply has a negative influence on the shaping of rational price expectations in agriculture (they are less rational and more adaptive), particularly under conditions of a declining trend in prices of agricultural products. The authors' analysis fails to bear out the popular thesis that all CAP support instruments (price and market intervention, supporting agricultural incomes direct payments) reduce price volatility (Kiryluk-Dryjska, Baer-Nawrocka 2010), favour greater price predictability and lead to more accurate production-related decisions by farmers (Gerson, Fen 2013). The models developed prove that direct payments reduce the market's influence on farmers' incomes only ostensibly (Rembisz, Sielska 2013; Cunha, Swinbank 2011), because they simultaneously reinforce King's Law.

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**Bazyli CZYŻEWSKI.** PhD, Associate Professor of the Poznań University of Economics and Business, Department of Education and Personnel Development and Investigator in Research Group of Macroeconomics and Agricultural Economics. He received a professor degree (habilitation) in the discipline of economics in 2013. Author or co-author of over 130 scientific publications. He conducts research in the field of institutional economics, economic theory and agricultural economics, concerning i.a. input-output matrices, political rents and the Common Agricultural Policy (CAP) of the UE. Key publications in English: *The Assessment of The Common Agricultural Policy Reform After 2013 From the Point of View of Polish Agriculture* (Bazyli Czyżewski, Sebastian Stępień), Annales Universitatis Apulensis. Series Oeconomica, 2012 Vol. 14(2); *The Regional Structure of CAP Subsidies and Factor Productivity in Agriculture in the EU28 – a Spatial Analysis* (Bazyli Czyżewski, Katarzyna Smędzik), Agricultural Economics (AGRICECON), 2016 in press; *Economic Size of Farms and Adjustments of Total Factor Productivity to The Business Cycle in Polish Agriculture* (Bazyli Czyżewski, Adam Majchrzak), Agricultural Economics (AGRICECON), 2016 in press; *A New Land Rent Theory for Sustainable Agriculture* (B. Czyżewski, A. Matuszczak), Land Use Policy 2016; *Political Rents of European Farmers in The Sustainable Development Paradigm. International, National and Regional Perspective* (Edited by Bazyli Czyżewski), Polish Scientific Publishers PWN.

**Adam MAJCHRZAK.** PhD, Assistant at the Poznań Univeristy of Economics and Business, Department of Economic and Local Government Policy and member of "Institutional sphere in multifunctional rural development" research team. Author or co-author of about 40 scientific publications and expertise in the field of agricultural policy, agricultural structures and agricultural law. Member of Polish Association of Agricultural and Agribusiness Economists. Key publications in English: Czternasty Waldemar, Majchrzak Adam, Changes in Agricultural Land Resources in Conditions of Common Agricultural Policy Evolution [in] Kazimierz Pająk (Ed.) Zones of high productivity and economic growth: selected problems – Toruń: Adam Marszałek, 2011; Majchrzak Adam, Convergence Process of Agricultural Land Structures in the European Union, "Integrated and Sustainable Regional Development", No. 36 – Jelgava 2014; Czyżewski Bazyli, Majchrzak Adam, Regulations for the Polish agricultural land market compared with other EU member states: implications for market efficiency, "Studia Ekonomiczne" 2014, 2.