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THE ISSUE OF STABILITY OF REVENUE
IN PIG PRODUCTION IN POLAND

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Abstract

Pig production is subject to fluctuations due to the pig cycle. These fluctuations cause that the supply of pork is either excessively high or too low in relation to a given demand assumed on the ceteris paribus principle. In the former case, the prices of pork, especially livestock, are high, and in the latter, they are low. As a result, the revenue of agricultural producers changes accordingly. It can be assumed that the negative revenue effects of the decrease in purchase prices are compensated by the positive effects of higher sales of porkers. Therefore, it is assumed that the volatility of revenues should be lower than that of both components.

The purpose of this article is to verify this view, which can be regarded as a hypothesis. To be more exact, the paper attempts to answer the question whether there is volatility or relative stability of revenues in the pig market. This issue is important not only for the producers, but also for the agricultural policy. Using simple statistical methods, the authors evaluate the variability of revenues between 2005 and 2020, i.e. after Poland's accession to the European Union. Recognizing that this was not a homogeneous period, the research also involved the revenues in two sub-periods, i.e. 2005-2012 and 2013-2020.

The adopted assumption and the research hypothesis about the relative stability of revenue due to a certain interchangeability of the price level and the purchase volume were only quite incomplete for the period 2005-2012. For period 2013-2020, the analysis of charts, coefficients of variation and correlation gave different results that did not allow for confirming the assumption and hypothesis.

Keywords: purchase price of pigs, pig cycle, King effect.

JEL codes: Q11, Q13, E32.

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Introduction

In agricultural practice and policy, stability of revenue is an important issue. This concerns the revenue of agricultural producers, particularly in a given market for agricultural produce. Revenue is a reference point for profitability coefficients. The structure and, so to speak, morphology of this coefficient has been discussed elsewhere (Rembisz and Zawadzka, 2017). The problem we refer to in this article is the issue of stability of revenue. We consider this issue on the basis of theoretical and formal premises, and we verify the assumptions derived therefrom empirically. In formulating the assumptions and hypothesis, we take into account the importance of such patterns as the King effect and the cobweb model. The assumption of a certain interchangeability of purchase (sale) volume and purchase prices, i.e. negatively correlated changes in supply and purchase prices (Hamulczuk, 2006; Hudson, 2007; Rembisz, 2020; Zawadzka, 2013) is important in these patterns. This indicates the possibility of certain stabilization of revenue which is, as already mentioned, a product of purchase volume and price level.

Therefore, the article poses a question whether we are dealing with volatility, or relative stability of revenue in relation to the market and pig production. This line of production is among those most closely linked to the market; it is subject to the laws and patterns of the market. Theoretically and empirically documented dependencies are known as the pig cycle (Małkowski, 1998; Małkowski and Zawadzka, 1995). This pattern undoubtedly has an impact on the issue of stability of revenue, because in the period of good profitability, often connected with high pig prices, farmers produce more porkers, which are slaughtered in the period when their levels are low. Thus, their increased quantity takes on the role of a factor compensating for revenue; conversely, reduced production in the period when purchase prices are low contributes to the price increase, which automatically makes up for deficiencies in revenue resulting from low supply of porkers. However, relative stability of revenue does not mean its constancy, but only lower variability in comparison with the variability of prices and purchase of porkers.

On the basis of all these premises, we conclude that revenue should be relatively stable if we assume a negative correlation between the level of supply and the purchase price, resulting from the patterns referred to in the literature. We will prove it in the following theoretical and formal analysis. However, the reality may be different. This does not mean that the assumptions and formal inference are wrong. Without addressing this, it can only be noted that the power of the connection may be different, which is not captured in the theoretical analysis. It is also possible that there may be additional variables beyond those included in the formal reasoning, i.e. purchase volume and price level. There may also be other unmeasurable determinants (Hamulczuk, 2006). We do not attempt to explain them. We assume them on the *ceteris paribus* principle.

Thus, in this article we make two alternative assumptions, which can be regarded as hypotheses. The first one concerning a relative stability and the second one regarding relative volatility of production revenue in the pig market. This is connected with an assumption, also in an alternative approach, about relative inter-

changeability of the price level and purchase volume or lack thereof[1]. To achieve the research objective, we adopt an analytical and statistical approach based on conventional indices of variability. An additional objective is to examine the usefulness of the approach proposed in the article to explain the actual situation in the pig market. We limit the analysis only to the framework set in the analytical and theoretical approach and resulting from the statistical method.

References in the literature

In the literature, it is difficult to find direct references to the specific issue of stability of revenue from a given line of production. However, there are some studies that address similar issues. One of them is an article describing the King effect as a phenomenon of compensating a decrease in revenue due to lower production by the effect of increasing revenue due to higher prices (Krawczak and Rembisz, 2018). Additionally, there are analyses of revenue in the context of the influence of the price level and the purchase volume of animal products, which were conducted in the first years after Poland's accession to the European Union (Zawadzka, 2005, 2006, 2007, 2008). The problem of income stabilization, as well as agricultural revenue in a broader context, is addressed by Soliwoda, Kulawik, and Góral (2016). To some indirect extent, as the basis of the goal function of agricultural producers, theoretical references to this issue can be found in the work of Drummond and Goodwin (2011) as well as Hamulczuk, Gędek, Klimkowski and Stańko (2012). In the context of purchase price volatility, references are made to the price cobweb model and revenue volatility in the work of Shepherd (1963), Tomek and Kaiser (2014), and Tomek and Robinson (2001).

Theoretical and formal assumption

We assume that the revenue of porker producers is the product of the purchase price level and the purchase volume[2]. This definition was used (Rembisz and Zawadzka, 2017) when discussing the production profitability index. It may be presented as the quotient of revenue to the expenditure incurred in the following equation:

$$op_y \approx \frac{R}{N} = \frac{y \cdot p_y}{n \cdot p_n}$$

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[1] This can be related to the question of the occurrence of natural hedging, natural price risk reduction. Then, it is said that due to the interchangeability of the price level and purchase volume, revenue is relatively stabilized. Relatively, there is no notion of absolute stability; there may always be another point of reference. In this article, we do not refer to the issue of price risk, although if the hypothesis of relative stability of revenue is confirmed, it could mean that natural hedging occurs.

[2] Purchase volume represents about 82-92% of production, depending on the basis of reference. Until 2016, purchase (calculated by Statistics Poland together with live animal imports) was referred to domestic production (balanced by foreign trade). This means that domestic production consists of industrial slaughter plus on-farm slaughter and live animal exports. This total is reduced by live animal imports. As long as imports of piglets and weaners were relatively small, their impact on production was marginal. As imports increased, the disparity grew. Therefore, from 2016 onwards, Statistics Poland began to refer purchase to industrial production, i.e. calculated together with live animal imports, or total production, which, aside from the additionally mentioned components, also includes slaughter on demand.

dividing it into two coefficients: the production efficiency coefficient (essentially the grazing efficiency coefficient); $ef = \frac{y}{n}$ and the price relationship coefficient: $p_{yn} = \frac{p_y}{p_n}$, where: p_y – purchase price; p_n – expenditure price (mainly feed), for a given period (t) and for variables greater than zero.

The article deals only with the numerator of this formula, namely revenue. In a formal sense, revenue is a function of the volume of sales (purchase) and the price level received (purchase price)[3] which can be seen in the following equation:

$$R = f(y, p_y)$$

for the given periods (t), it can also be expressed analytically as follows:

$$R(t) = y(t) \cdot p_y(t)$$

It is clear that changes in revenue depend on changes in both the production volume and resulting purchase volume and the purchase price level, thus from the function we have a complete differential which is as follows:

$$dR = \frac{\partial R}{\partial y} \cdot \Delta y + \frac{\partial R}{\partial p_y} \cdot \Delta p_y$$

The value of dR[4] represents the total increase (decrease) in revenue from the two sources included in this formula. The first source, i.e. $\frac{\partial R}{\partial y} \cdot \Delta y$, represents the increase (decrease) in revenue due to the increase (decrease) in sales (purchase) volume. Whereby: $(\frac{\partial R}{\partial y} \frac{1}{t})$ illustrates the effect of a minimum[5] unit increase (decrease) in purchase volume on revenue, while the change: Δy denotes the specific growth (decrease) in purchase volume at a given time (t). The second source is the increase (decrease) in revenue due to the increase (decrease) in the purchase price level: $\frac{\partial R}{\partial p_y} \cdot \Delta p_y$. The $\frac{\partial R}{\partial p_y} \cdot \frac{1}{t}$ quotient illustrates the effect of an increase (decrease) in the purchase price level on the value of revenue, while Δp_y is the specific increase (decrease) in the purchase price in a given period (t).

If we accept the assumption of income stability, i.e. its invariability in time, the complete differential of the above function should be equal to (close to) zero:

$$dR(t) \cong 0$$

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[3] In econometric terms, the linear analytical form of this function could be approximated and estimated for this function, for example: $R = a \cdot y + b \cdot p_y + \xi$ for the time series (t,..) or the power law after logarithmization: $lnR = alny + blnp_y + lnu$. We assume that although these two variables are independently shaped, there is a correlation between them to some extent, as we show next, hence we do not undertake to give an analytical form to this function or to approximate and estimate its parameters.

[4] Complete differential.

[5] This is related to the assumption of continuity of the assumed revenue function with respect to the price and purchase volume.

Therefore, the influence of the price level and purchase volume on the value of revenue and its changes should offset each other[6]. The position of the price level and purchase volume must be opposite, i.e. alternate[7]. In simplified terms, this should follow the pattern:
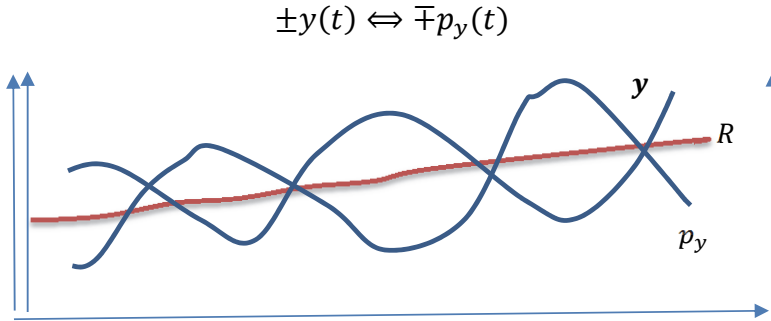
$$\pm y(t) \Longleftrightarrow \mp p_y(t)$$

Fig. 1. Hypothetical contours of the interchangeability of purchase price and volume and revenue constancy[8].
Source: own study.

Purchase volumes and purchase price levels should be sine and cosine alternating, as illustrated in Figure 1 hypothetically.

This would provide a good, although imprecise, basis for the hypothesis of relative stability of revenue in the pig market with some interchangeability of the price level and the purchase volume[9]. We will use this method in the empirical part. Under the same analytical assumption, we will also present a separate graph showing the purchase price level and purchase volume in relation to the amount of revenue. This is an important part of assumption and hypothesis verification.

Statistical approach

We will verify this assumption using simple statistics for reliable empirical data. In the convention of standard deviation to the mean and coefficient of variation, in view of the above analytical assumption, it would be necessary to assume that the coefficient of variation for the revenue level will be close to zero, or at least lower than for the purchase price level and purchase volume. The latter seems to be more realistic for verification of the assumptions made above. In order to con-

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[6] According to the transformation: $\pm \frac{\partial R}{\partial y} \cdot \Delta y = \mp \frac{\partial R}{\partial p_y} \cdot \Delta p_y$. This should be related to the assumption about the interchangeability of changes in the purchase price and purchase volume, i.e.: $\pm \frac{\partial y}{y} = \mp \frac{\partial p_y}{p_y}$.

[7] It can be assumed to be according to the assumptions of the pig cycle, and with reference to the King effect.

[8] On the vertical axes in the respective scales: price level, purchase volume on the left and revenue amount on the right.

[9] In the hypothetical figure, illustrating the hypothesis, the interchangeability of prices and purchase volume are related to the trend as an assumption that structural conditions lead to increasing revenue, however, the trend is not a basis for examining coefficients of variation of prices and purchase, and correlations between them.

firm the assumptions made and the hypothesis formulated, it can be expected that the standard deviation, and most importantly, the coefficient of variation will be correspondingly higher for the purchase price level and purchase volume than for the revenue level. In the empirical analysis, we assumed the statistics of standard deviation and coefficient of variation as presented in the following equation[10]:

$$s = \sqrt{s^2}$$

$$s^2 = \frac{1}{n} \sum_{j=1}^{n} (x_j - \overline{x})^2$$

The coefficient of variation is determined by the following formula:

$$V = \frac{S}{\overline{x}} \cdot 100\%$$

where: V – indicates the coefficient of variation, s – the standard deviation, x – the arithmetic mean of the variable values (purchase prices: p_y, purchase volumes: y and revenue: R).

According to our assumption and the resulting hypothesis, we believe that the initial and sub-hypothesis will be positively verified when the following relations are met:

$$V(p_y) > V(R) \quad \text{and} \quad V(y) > V(R)$$

For the same analyzed periods (t) and in their time sequence. This means that the coefficients of variation for the price level and the purchase volume should be higher than the statistics for the revenue level. This would satisfy the requirements for meeting the theoretical assumptions. If these inequalities occurred, it would be a sufficient condition for positive verification of these assumptions. It is desirable, also in the context of the King effect and the pig cycle and the hypothetical Figure 1, that there be interchangeability in the formation of purchase prices and purchase volume. Using the same statistics, it would therefore be beneficial if for (*t*) (*t+n*), there were a reasonably objectively expressed relation[11]:

$$\pm V(p_y) \approx \mp V(y), \quad \text{and} \quad V(R) \approx 0$$

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[10] The primary measure of variability is the standard deviation, which tells us about the variability, or in other words, whether the spread of results around the mean is large or small. A measure similar to the standard deviation is the coefficient of variation. Both measures are classified as measures of dispersion and have a similar interpretation. What differs is their use. The standard deviation is a measure of the variation of one trait. The coefficient of variation can be used to compare different traits. The standard deviation is the square root of the variance, and the variance is the arithmetic mean of the squares of the deviations of the trait values from the mean. A high value of the coefficient means high variability of the trait and indicates heterogeneity of the studied population; a low value indicates low variability of the trait and homogeneity of the studied population. The coefficient of variation is a quotient of the standard deviation and arithmetic mean. The value of the coefficient is expressed as a percentage, and its interpretation depends on the size of the coefficient. It is assumed that: < 25% – low variability, (25-45%) – average variability, (45-100%) – high variability, > 100% – very high variability.

[11] To a limited extent, a similar message is conveyed by the following equation: $\pm s(p_y) \approx \mp s(y)$.

Meeting the latter condition would almost fully satisfy the requirements for positive verification of the hypothesis of relative revenue stability under the assumption of relative interchangeability of price level and purchase volume – preferably mutual and even symmetrical, in line with the assumptions of the pig cycle and the bases of the King effect. The only issue is the degree of correlation of these variables, which will be addressed in the empirical analysis. The low correlation of both the purchase price level and purchase volume with the amount of revenue may indicate confirmation of the hypothesis, while a high correlation index may indicate the opposite. To confirm the hypothesis, the purchase price level and the amount of revenue, as well as purchase volumes and the amount of revenue (purchase value) should be independent from each other, as can be seen in Figure 1. A certain stabilization of the market could be indicated by statistics decreasing from period to period, both in terms of the standard deviation and coefficient of variation, which we will verify.

Data, research period, and market features

In order to verify the assumptions and hypothesis empirically, we have used empirical data of the monthly levels of pork livestock purchase price and purchase volume from Statistics Poland's Statistical Bulletins from 2005-2020. The years 2005-2020 constitute the research period, covering 16 years after Poland's accession to the European Union. It seems that this period is long enough for statistical verification of these assumptions and hypothesis. It was divided into two eight-year sub-periods, 2005-2012 and 2013-2020, recognizing that they were not homogeneous. An important feature of the market, distinguishing the second research sub-period on substantive and statistical grounds, was the import of piglets and weaners, which undoubtedly had an impact on changes in the production volume, and therefore the purchase volume. It emerged in 2004 and since then it has been growing very rapidly. Although, in the first period, the growth rate of imports was faster than in the second period, nevertheless the absolute volume of imports in the first period remained relatively small compared to the second period. In a slightly shorter period, i.e. 2006-2012, piglet and weaner imports increased from 240 to 3,424 thousand, i.e. 14-fold. In 2012, the final year of the period, they accounted for 21.6% of slaughters. Between 2013 and 2019, these imports increased from 5,139 to 6,979 thousand heads, i.e. by 36%. As a result, in 2019 they accounted for 48.0% of domestic pig slaughters and 33.0% of industrial slaughters. The impact of imports on production was so large that the 27.5% decline in average annual population between 2013 and 2020 compared to the average annual population between 2005 and 2012 was accompanied by a decline in production and consumption of about 5%. Undoubtedly, it must have influenced the analytically outlined relations, distorting interchangeability of the price level and purchase volume, or flattening or shifting them[12].

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[12] This is a separate problem requiring a separate study; in this paper it constitutes the background for the analysis in relation to the assumptions made.

The average level of purchase price of pigs in the whole analyzed period amounted to 4.59 PLN/kg, including 4.22 PLN/kg in 2005-2012 and 4.96 PLN/kg in 2013-2020.

The increase in the price level by 17% resulted, among others, from the depreciation of PLN against EUR[13], increase in the price level of Polish porkers, expressed in euro, as well as the prices of porkers in the European Union[14].

Basic empirical verification

The starting point for verification of the assumptions and hypothesis, using the statistics and empirical data used are the values summarized in Table 1. Referring directly to the assumption and hypothesis, we have compared in particular periods the values of the coefficients of variation of the purchase price levels to the amount of revenue, and the coefficient of variation of purchase volume to the amount of revenue, according to: $V(p_y) > V(R)$ oraz $V(y) > V(R)$[15].

Table 1

Descriptive statistics of pig purchase price, volume, and value

Statistics	Price of pigs	Purchase	Purchase value	PLN exchange rate to EUR
2005-2020				
Mean	4.29	115.68	498.90	0.28
Standard deviation	0.68	15.10	100.72	0.25
Coefficient of variation	15.75	13.06	20.19	0.09
2005-2012				
Mean	4.29	110.19	459.63	4.02
Standard deviation	0.64	11.53	39.39	3.90
Coefficient of variation	15.01	10.47	8.70	4.26
2013-2020				
Mean	4.97	121.17	599.14	6.96
Standard deviation	0.48	15.85	363.97	6.48
Coefficient of variation	9.67	13.08	15.18	2.17

Source: own study based on data from Statistics Poland.

The comparison of the values of these coefficients of variation is not quite in accordance with the assumptions and hypothesis. First of all, it concerns the whole analyzed period. The coefficient of variation of revenue is higher in value, irrespective of the fact that its value is high, than in the case of the level of purchase

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[13] Exchange rate data are given in the last column of Table 1 as a reference.

[14] Since Poland's accession to the European Union, pig prices in Poland have been influenced not only by supply and demand in the Polish market, but by supply and demand in the entire European Union, i.e. by the average price in the EU and the PLN/EUR exchange rate.

[15] We did not intend to determine the impact of price and purchase variability on revenue variability, as, for example, in the Malmquist index (MI).

prices and purchase volume. Relations between these coefficients between 2012 and 2020 follow the same pattern. Only for the period 2005-2012 the relations between these coefficients are arranged according to the assumptions and hypothesis, i.e. according to the formula quoted[16]. For this period (2005-2012) the variability of the purchase price levels is also greater than that of the purchase volume. The same applies to the whole research period (2005-2020). It may indicate a certain dislocation or instability of the market[17]. This is also confirmed by the fact that we do not observe a decrease in the value of the analyzed coefficients in time; although, to some extent, it relates to the purchase prices, especially taking into account the recent period of 2012-2020[18]. Nevertheless, there is no clear trend towards certain stabilization of this market.

For the period 2005-2012 it may be assumed, on the basis of relations between the coefficients of variation, that there is some alternation between the analyzed variables, i.e. price level and purchase volume, as in the assumptions. The coefficient of revenue variation for this period is lower than in the case of the variables shaping it. Between 2013 and 2020, the values of the coefficient of variation for price level, purchase volume, and revenue are contrary to the assumptions. This probably results from the influence of pig prices in the European Union and the PLN/EUR exchange rate on Polish pig prices and farmers' revenue. The relatively low volatility of the exchange rate between 2013 and 2020 (Table 1) could, on the one hand, drive a reduction in the variability of purchase prices, but on the other hand, high and constantly increasing imports affected the coefficient of variation of purchase, and thus also purchase values. Therefore, this period is characterized by a lower value of the analyzed coefficient for purchase price than for purchase volume, and a visible link between the latter and revenue. It may be assumed that revenue changed mainly under the influence of the purchase volume.

In the analysis, the values of standard deviations are less important to confirm our assumptions, as they cannot be directly compared with each other, taking into account the level of purchase price and volume and the level of revenue. However, they provide some information, when we analyze them over time for a given variable: separately for price level, purchase volume, and revenue. Taking into account the level of purchase prices, we can see, for example, that interestingly, this indicator slightly decreased in the two analyzed periods. It may indicate that price risk in this market is slightly decreasing, as we have noticed before. This observation is also confirmed by the indicators of the deviation of the twelve-month centered moving average from the trend line. From 2005-2012, price fluctuations ranged from -12.9 to 22.3%, so the difference between the lowest and highest point was 9.4 percentage points. In the second period, i.e. from 2013-2020, fluctuations took place in the range of -14.0 to 20.3%, so in this case, the difference between the extreme deviations was 6.3 percentage points. Certain stabilization of the standard

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[16] For this period, it is probably also in accordance with the mentioned market patterns (King effect, pig cycle).

[17] It may be associated with growing exposure to market risk in pig production.

[18] This, in turn, may indicate a decreasing price risk tendency.

deviation over time can be observed for the purchase volume. By contrast, changes in the standard deviation over time (for the analyzed periods) for the amount of revenue are completely irregular, which indicates market volatility, and the influence of other factors and conditions apart from these two variables in the formation of revenue. This also distorts the inference regarding the assumptions and hypothesis. A final comment relates to the layout of all the statistics shown (Table 1).

Interchangeability of the price level and purchase volume

Verifying the underlying assumption about interchangeability of the purchase price levels and purchase volumes, and even a certain symmetry in it, is crucial for the hypothesis made. The basis is visualization of this interchangeability for monthly data. The presented graphs of the price level and purchase volume (Fig. 2) may constitute the basis for empirical confirmation of the assumption about their alternation. It is both a graphical illustration and confirmation of the basis of the King effect. It also reflects the pattern called the pig cycle[19]. It is confirmed and presented in greater detail in Figure 3, where price levels and purchase volumes for data cleansed[20] of seasonal and random fluctuations are shown, quite close to sine and cosine shapes. If so, it may also provide a graphical indication to confirm the assumption of relative stability of revenue. However, we do not address this issue in this part of the analysis.
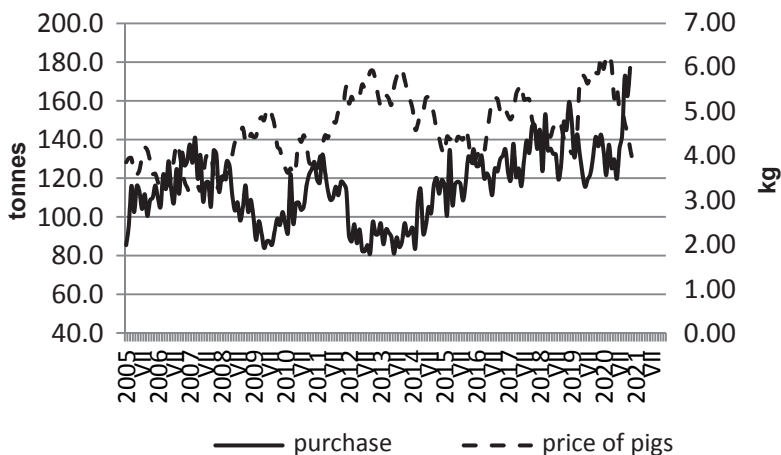

Fig. 2. Monthly levels of pig prices and purchase volume (actual data).

Source: own study based on data from Statistics Poland.

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[19] According to J. Małkowski (1998), the term pig cycle refers to the fluctuations in the population and production of pigs included in the so-called "special cycles, i.e. cycles which have their own mechanism". These fluctuations cause the supply of pork to be either excessively high or too low. In the former case, the prices of pork, and especially of live pork, fall, and in the latter case, they rise. Thus, prices are always in an inverse cycle to supply.

[20] The cleansing was done using a twelve-month centered moving average.
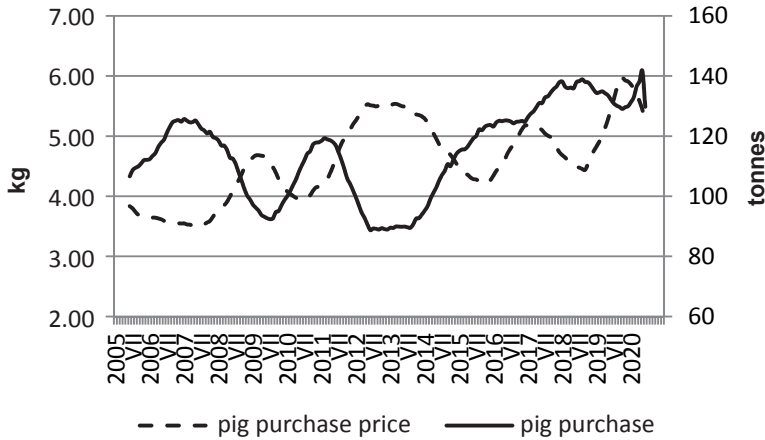

Fig. 3. Monthly purchase volume and price level of pigs (random and seasonal fluctuations eliminated).

Source: as in Fig. 2.

We will not discuss individual years and periods. However, it can be inferred that periods of low purchase volume correspond quite proportionally to periods of high purchase price level. However, it can also be noticed that low purchase volumes correspond to relatively higher price levels, which is indicated by the sections between the lowest and the highest points on the graph lines. These sections *de facto* illustrate the state of imbalance in the market. It also indicates lower flexibility of the purchase volume than of the purchase price level in the given situation of imbalance, which seems to be in accordance with the market patterns.

Purchase price level and revenue amount

The curves illustrating the purchase volume and the purchase price level refer to the curve illustrating the purchase value, which is assumed to be the approximate revenue value. In order to verify the hypothesis, it is important that changes in the purchase price level be larger than changes in the purchase value and relatively independent. A visualization of the levels of purchase prices and purchase values is provided in Figures 4 and 5. The graphs or contours of the quantities juxtaposed are very similar, especially for the raw data.

In terms of our assumption and hypothesis, this is not good news. It means that the assumptions made are not confirmed. According to the formal and theoretical analysis, the contour of the purchase price level should be as above a sine-wave, and the graph of the revenue is almost a straight line. There is no relation in which the levels of the purchase price are sinusoidal and the revenue is more level or even close to a straight line, both for untreated and treated data. On the contrary, the graphs of purchase price and value levels are quite similar in shape and course for almost the whole analyzed period. The correlation coefficient between the purchase price level and the purchase value in the whole analyzed period, as the average from particular years, is R=0.64. The link between purchase price level and

revenue amount (purchase value) decreased in the analyzed sub-periods. For 2005--2012, it is 0.64, and for 2013-2020, it is 0.46.

It means that a stronger link between price level and revenue was observed in previous years, i.e. directly after Poland's accession to the European Union. This was probably due to the high volatility of the PLN/EUR exchange rate (Table 1). Then, however, as shown in Figure 6, the exchange rate was neutral in relation to purchase prices. Considering only the analysis with regard to the variables included here, it can be assumed that these observations may indicate a high exposure of production to price risk, and thus the dependence of revenue on prices, as shown in Figures 4 and 5, is deepened. Therefore, it is difficult to consider this as a confirmation of the assumption and hypothesis made. The level of the purchase price, its changes, does not catalyze relative revenue stability. However, some symptoms can be seen, considering only the graphs in the figures analyzed, in the period 2011-2016.
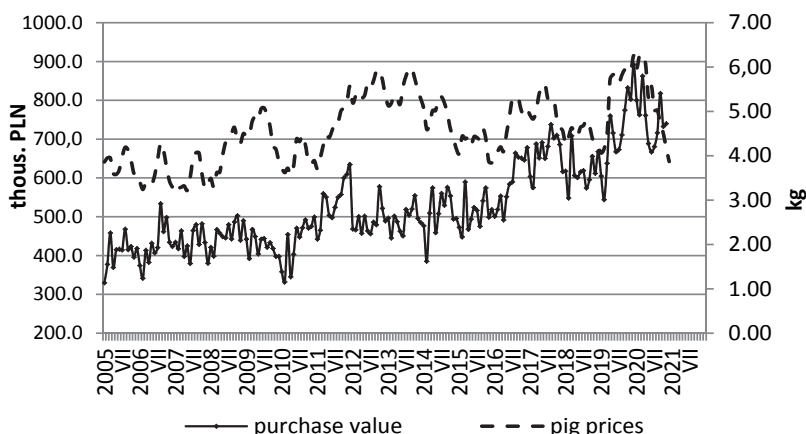

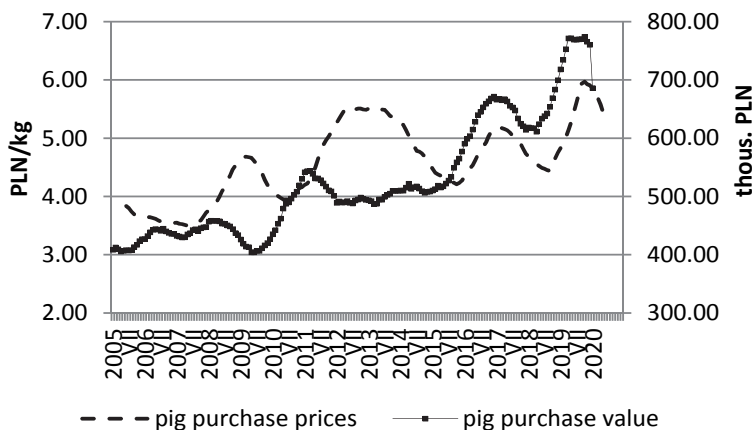*Fig. 4.* Purchase price level and purchase value (actual data).
Source: as in Fig. 2.

Fig. 5. Monthly prices and purchase value of pigs after eliminating seasonal and random fluctuations.
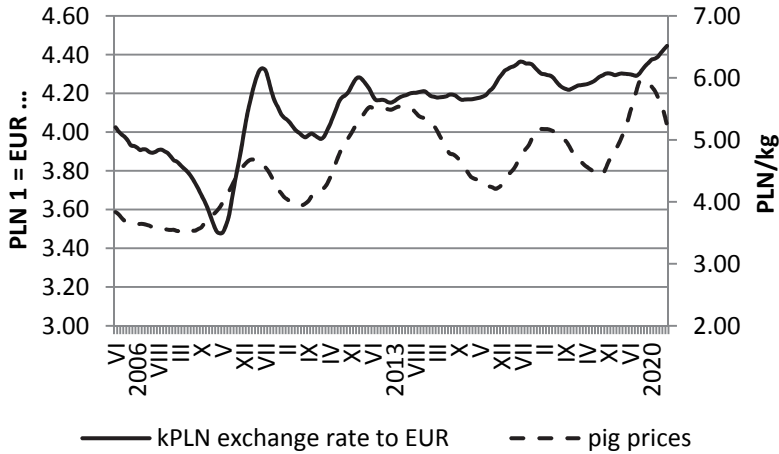Source: as in Fig. 2.

Fig. 6. Monthly purchase prices of pigs after eliminating seasonal and random fluctuations and the PLN/EUR exchange rate.

Source: own study based on data from Statistics Poland and the National Bank of Poland (NBP).

Purchase volumes and revenue level

The second source of revenue, according to the approach taken, is the variable purchase volume. A visualization of the relationship between this variable and revenue is shown in Figure 7 (for raw data) and Figure 8 (for data after eliminating seasonal and random fluctuations). From the point of view of verifying the assumption and hypothesis about the relative stability of revenue, analyzing the aforementioned figures, no unequivocal conclusions can be drawn. It is impossible to tell from the graphs whether the link between the purchase volume and the amount of revenue is tightening, which contradicts the assumption and hypothesis, or loosening, which confirms it. Between 2005 and 2012, the analysis of the graphs may indicate the correctness of the assumption and positive verification of the hypothesis; the revenue graph is almost equal to the sinusoidal graph of the purchase volume. In the later period, the situation is the opposite: the shape of both contours, i.e. purchase volume and revenue, is similar. Therefore, we additionally introduce the correlation coefficients. The obtained figures confirm these observations. For the whole analyzed period, R=0.63, so this means *de facto* the rejection of the assumption and hypothesis. However, for 2005-2012, R=0.20, which in turn confirms the assumption and hypothesis. For 2013-2020, the situation is the opposite, because R=0.71. It can be noticed that the influence of the number of purchased porkers on the revenue is increasing. One of the factors is the aforementioned import of piglets. The correlation coefficient between the import of piglets and purchase in 2013-2020 was R=0.97, so it was very high. The correlation coefficient between the import of piglets and pig producers' revenue was also high (R=0.67). Aside from the import of piglets, the scale of production is also considered as a determinant of the relatively high correlation coefficient between purchase and purchase value in the second period. Its influence on revenue is significant.

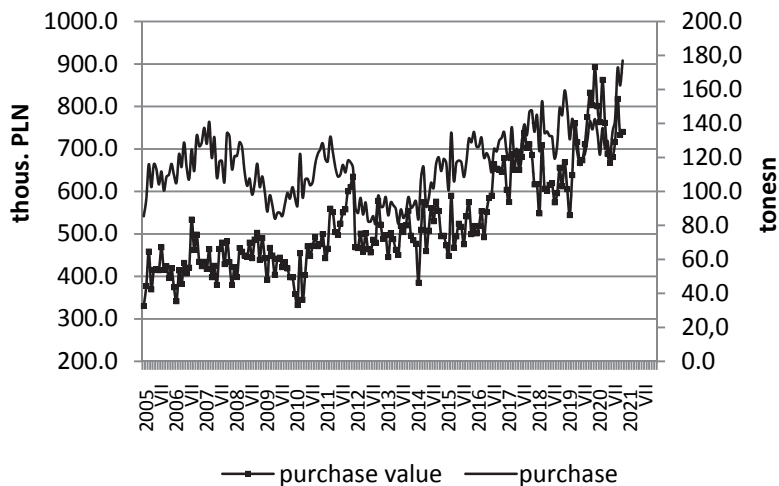Between 2005 and 2016, the number of pigs per one pig farm increased from 25 to 69 pigs[21].

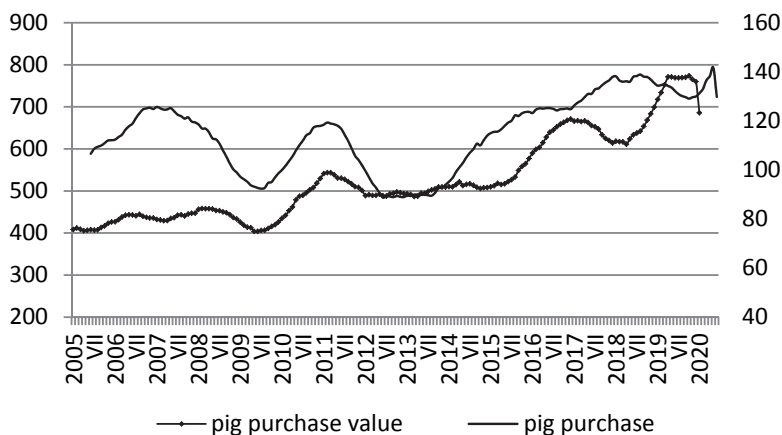*Fig. 7.* Purchase volume and value (revenue).
Source: as in Fig. 2.

Fig. 8. Monthly purchase and purchase value of pigs after eliminating seasonal and random fluctuations.
Source: as in Fig. 2.

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[21] This is not much compared to the concentration of population in other EU countries (e.g. in 2018 in Germany there were 1,175 pigs per farm), but it is still a significant improvement compared to 2005.

Conclusions

Our assumption and the research hypothesis about the relative stability of revenue due to a certain interchangeability of the price level and the purchase volume were only partially confirmed for the period 2005-2012.[22] For the period 2013-2020, the analysis of charts, coefficients of variation and correlation gave different results that did not allow for confirmation of the assumption and hypothesis[23]. In particular, for this period, the variability of revenue was higher than the variables shaping it. For the whole period, the inference is ambiguous and it does not give grounds to accept or unequivocally reject the hypothesis. However, we can certainly speak of interchangeability of the purchase price level and purchase volume. It does not translate into the stabilization of revenue, as other determinants not included in the method, which we provided in the inference, also have an influence[24]. For exploratory purposes, it does not close the way to further research on the validity of the hypothesis of relative revenue stability in the context of interchangeability of the purchase price level and purchase volume.

The analysis and inference were based on comparisons of the values of coefficients of variation of revenue in relation to the purchase price level and purchase volume, as well as comparisons of graphs of these variables and their correlation. This approach was based on certain fundamentals of the pig cycle and the King effect. As a research method, it is a new alternative to the econometric model-based analysis or tabular and descriptive approaches. It is difficult to say whether this method worked well in this analysis as a basis for inference. However, it provides an opportunity to structure the research problem, and it may be useful for market analysis and as a basis for policy inference. It certainly requires refinement. Certain determinants, although they should be reflected in both price and purchase volume, remain beyond the quantitative method. However, they can be supplemented in a qualified analysis.

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[22] Between 2005 and 2012, the prices of pigs showed greater variability than the purchase of pigs. This situation was influenced by the high volatility of the PLN/EUR exchange rate.

[23] Between 2013 and 2020, the variability of revenue was higher than that of prices, as well as of the purchase of pigs. Between 2013 and 2020, the variability of purchase was higher than between 2005 and 2012. It is estimated that this situation was influenced by high and constantly increasing imports of piglets and weaners.

[24] For example, spatial integration of the market may be such a factor, which weakens the interchangeability of price level and purchase volume, or at least reduces the amplitude of it, but this is subject to a separate hypothesis and research topic.

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KWESTIA STABILNOŚCI PRZYCHODÓW
W PRODUKCJI TRZODY CHLEWNEJ W POLSCE

Abstrakt

Produkcja trzody chlewnej podlega wahaniom wynikającym z cyklu świńskiego. Wahania te powodują, że podaż wieprzowiny jest bądź nadmiernie wysoka, bądź zbyt niska w stosunku do danego popytu przyjmowanego na zasadzie ceteris paribus. W pierwszym przypadku ceny wieprzowiny, a zwłaszcza żywca wieprzowego są wysokie, a w drugim niskie. W rezultacie zmieniają się odpowiednio przychody producentów rolnych. Można przyjąć, iż ujemne skutki przychodowe spadku cen skupu są kompensowane przez dodatnie z tytułu większej sprzedaży tuczników. Dlatego uznaje się, że zmienność przychodów powinna być mniejsza niż obu składowych.

Celem niniejszego artykułu jest weryfikacja tego poglądu, co można uznać za hipotezę. W szczególności chodzi o odpowiedź na pytanie, czy na rynku trzody chlewnej mamy do czynienia ze zmiennością czy względną stabilnością przychodów. Kwestia ta jest istotna nie tylko dla samych producentów, ale także dla polityki rolnej. Posługując się prostymi metodami statystycznymi, dokonano oceny zmienności przychodów w latach 2005-2020, czyli po przystąpieniu Polski do Unii Europejskiej. Uznawszy, że nie był to okres jednorodny, przychody oceniono także w dwóch podokresach tych lat, czyli 2005-2012 i 2013-2020.

Stwierdzono, że przyjęte założenie i hipoteza badawcza o względnej stabilności przychodów w związku z pewną przemiennością poziomu ceny i wielkości skupu znalazły jedynie dość niepełne potwierdzenie dla okresu lat 2005-2012. Dla okresu 2013-2020 analiza wykresów, współczynników zmienności oraz korelacji dała inne wyniki, które nie pozwalały na potwierdzenie założenia i hipotezy.

Słowa kluczowe: skup trzody, cykl świński, efekt Kinga.