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Procurement Price Change Outcomes for Producer & Processor along Supply Chain

Agnieszka Bezat-Jarzębowska, Włodzimierz Rembisz

Institute of Agricultural and Food Economics – National Research Institute (IAFE-NRI)

bezat@ierigz.waw.pl, rembisz@ierigz.waw.pl

Abstract

The article focuses on the issue of changes in prices received and paid to an agricultural producer and agri-food processor as a source of changes in the profitability of production. The same purchase price for the first is the price received, for the second price paid. The same movement of the price, i.e. its decrease or increase, is also a source of changes in the profitability of production for both entities. However, its mechanism is different. The description of this mechanism for the agricultural producer and food processor is the subject of the remark in this article. Profitability is, as it is known, the basis of the objective function of both entities. Their own analytical reasoning which captures the essence of this mechanism has been derived. Production profitability ratios for both entities are the basis of the approach. These profitability ratios are determined by the production efficiency indexes and the relations of price received and paid. Understanding of the concept is helpful for explaining the sources of price risk for an agricultural producer and agri-food processor.

In addition to derivation of analytical formulas describing the mechanism of changes in profitability, which is the main goal adopted in the article, this was subjected to initial empirical illustration, to confirm the correctness of reasoning, in particular to confirm the relationship between indicators adopted in the paper. An empirical analysis of price risk was not the goal.

Keywords: profitability, price risk, agricultural producer, agri-food processor, efficiency

Outline of the problem

In the relationship agricultural producer – agri-food processor, the same price movement (procurement prices) has different effects on their revenues. This is related to the risk of prices received for an agricultural producer or paid to an agri-food processor. An expression of this is also the sensitivity of revenues of both producers to changes in the price of the same product (procurement price). Therefore, the question of whether this sensitivity is the same or different arises. It can be assumed that the effects of the same price change are different for the revenues of both producers. For an agricultural producer, a drop in the procurement price is an obvious decrease in revenue, if it is not compensated by increased revenue from the increase in sales. For an agri-food processor, this drop in the procurement price should in principle have an impact on the increase in revenues and, of course, a decrease in production costs. In an opposite situation, the increase in procurement prices in principle means the increase in revenues, unless it is neutralised by the decrease in procurement. For the processor, it should hypothetically mean a decrease in revenues and, of course, profitability of production. Of course, the scale and significance of these reactions, i.e. the sensitivity of the revenues of both entities in the agri-food chain, is conditioned by the price elasticity of food demand and other factors, which is accepted in this reasoning on the *ceteris paribus* principle. It also depends on the extent to which the procurement market (market of agricultural products) and the market of final agri-food products are in competitive balance. For example, to what extent the processor can transfer the effects of increase in the price paid (also increase in unit costs) to the final recipient, that is, the consumer. It is important to what extent agricultural producers and processors are able to improve production efficiency to neutralise unfavourable changes in prices. It is a whole complex of relations and conditions which determine flexibility in terms of changes in production efficiency, which of course we leave aside. We can only accept that in a given period, relatively short one, these possibilities of improving production efficiency are very limited. Therefore, we can assume that this variable is relatively constant and express it on the *ceteris paribus* principle. Other conditions are also important, e.g. legal regulations, which is classified as *ceteris paribus* as well.

Obviously, in the case of both discussed entities their expectations as to the level and direction of changes in procurement prices are opposing. In relation to these expectations, both entities design their behaviour. As a result, they adapt to the actual changes in the procurement price on the basis of a certain levelling of mutual benefits. Of course, the basis is own income and its maximisation. The market is a place to agree on these different expectations.[1]

Reference literature

It is hard to find direct references to the approach proposed in this article in literature. Nevertheless, many authors raise the issue of the procurement price in relation to the agri-food market. Prices of agricultural products are a point of interest of many authors. As Klank (2008) points

[1] In a sense, to agree on prices; this is explained by the Hurwicz mechanism design.

out, among many economic conditions affecting the state of Polish agriculture, the most important ones include prices of agricultural products. As argued by Tomek and Robinson (2001), prices determine to a large extent the level of profitability of agricultural production, the possibilities of accumulation, the standard of living of producers and consumers, as well as the possibilities and volume of export. It is important that the prices of agricultural products are usually characterised by greater volatility than the prices of products of non-agricultural origin (Woś, 1996), and one of important reasons which affects their volatility is the biological nature of agricultural production. Low elasticity of demand for food is also significant, especially in developed countries, which is conducive to overproduction, especially in the situation of bumper crop (Płonka and Musiał 2017). Currently, in the global market economy, the price level is significantly influenced by the growing demand for agricultural products, created by highly populated developing countries, but also by speculations on markets, especially futures market (Grzelak 2013).

Due to the increasing volatility of agricultural prices, both producers and food processing enterprises show a strong risk exposure. Broll, Welzel and Wong (2013) argue that this is related to the conditions of agricultural production – climate change, international barriers and trade restrictions, food safety standards and quality requirements, growing public interest in environmental and other issues. Wang and Barrett, in the context of increased price volatility, note the difficulties (larger compared to the products of other branches) with the storage and warehousing of food processing products (Wang and Barrett, 2007). Czyżewski and Stępień (2011), indicate that the agricultural sector is confronted with a considerable risk of variations in supply and prices due to the specific production factor, which is land factor.

The article focuses on the sensitivity of revenues of food chain entities to changes in the prices of the same product as a source of changes in revenues and profitability of production. The same procurement price for the former is the price received, for the latter the price paid. The same movement of this price, i.e. its decrease or increase, is also a source of changes in the profitability of production for both entities. However, its mechanism is different. The description of this mechanism for an agricultural producer and a food processor is the subject of attention in this article. Profitability of production is, as we know, the basis for the implementation of the objective function of both entities. Own analytical record which captures the essence of this mechanism has been derived. The bases of the approach are the production profitability indicators for both entities. These profitability indicators are determined by the production efficiency indicator and the relations between prices received and prices paid.

Assumptions for the analysis

In the article, we refer to these issues in analytical terms. We assume that in the conditions of competitive market balance and with given production efficiency in the short term, the reduction in profitability occurs in the case of an agricultural producer as a result of a decrease in revenue

resulting from a decrease in the price received.[2] In the case of a processor, the increase in the price paid[3] may lead to a decrease in revenue. In both cases, we are dealing with sensitivity of revenues to the same change in the procurement price. The level of this sensitivity is different because the intensity of the relationship between the procurement price and this revenue is different. At the agricultural producer, this relationship is direct, and at the processor indirect. Both at the agricultural producer and at the agri-food processor these processes focus on the profitability of production. Therefore, the coefficient of profitability for both entities is crucial. Hence, in further reasoning and in the analytical approach derived, this coefficient, i.e. profitability coefficient, is the obvious starting point for explaining the reaction of revenues to changes in the procurement price. Profitability is, as we know, the basis for the implementation of the objective function of both entities, i.e. maximisation of income and profit. Hence, its significance for the description of the mechanism of revenue sensitivity to changes in the procurement price of an agricultural producer and an agri-food processor.

In addition to deriving analytical formulas describing the mechanism of changes in the coefficient of production profitability, which is the main goal adopted in the article, a preliminary empirical illustration was performed to confirm the correctness of reasoning. It is the first approach to this issue, hence both the analytical and empirical approach may generate discussions and require additions. An empirical analysis of the price risk was not the goal.

How are the procurement prices determined?

The most important variable in our analysis is, of course, the procurement price, i.e. the price received by an agricultural producer and the price paid by an agricultural producer. We put it as: P^O, P^P. In a simple way, their changes affect the sales volume of an agricultural producer and the purchase volume of an agri-food processor. It results directly from the regulatory market mechanism and the essence of the profitability indicator as the relation of revenues to costs.[4] We have a simple mechanism for both entities on both sides of the market. On the one hand, the increase in procurement price increases the supply or sale of products (because it increases revenues) of the agricultural producer. On the other hand, it reduces the demand for these products (i.e. procurement) because it increases costs. As a result, we have:

$$\frac{\Delta Y^S}{\Delta P^O} > 0 \quad \text{for the producer} \quad \text{and} \quad \frac{\Delta Y^P}{\Delta P^P} < 0 \quad \text{for the processor} \tag{1}$$

where:

P^O – price obtained/received by agricultural producer (procurement price),

P^P – price paid by agri-food processor,

Y^S – sold production (sales volume),

Y^P – purchased production (purchase volume),

[2] This is the procurement price, and of course its unexpected drop means a drop in profitability (with other conditions unchanged, including given efficiency).

[3] The prices paid are the procurement prices of agricultural products used as a raw material in processing, their unexpected increase means a drop in profitability (of course with *ceteris paribus*).

[4] We show records of profitability coefficients in the next point of consideration.

As a result, the level of the balance price for both entities is fixed mechanically on the market: P^X.

This price level is set according to the Ricardo and Walras traditions. It also results from the mechanism of agreement of benefits of both sides, which was the contribution of Hurwicz. If their bases of procurement price for both entities are similar, i.e. bases related to the profitability of production, or the relation between revenues and costs. At the same time, as we have already pointed out, at the producers, they are directly related to revenues and at the processors to costs. Hence, of course, the expectations as to the amount and direction of changes in the procurement price are different, the results of which are shown in (1). For both entities, the objective variable as to which "they must agree" is the market balance price: P^X.

An advantageous situation for the agricultural producer is when the admissible (planned) procurement price will be lower than the "objective" market balance price, that is: $P^O \leq P^X$. And opposite for the agri-food processors, i.e. when the admissible (planned) procurement price will be higher than the market balance price, that is: $P^P \geq P^X$. Then, as it seems, both parties have the benefits allowing to conclude a transaction. Then, admitting inequalities arise as a result of which the balance price is established because it is beneficial for both parties. Admitting inequalities illustrating equal benefits of the producer and the processor can be defined as follows:

$$P^O - P^X = P^X - P^P \tag{2}$$

As a result, the balance price the procurement price accepted in the transaction by the producer and the processor is set.

Revenue and profitability at the agricultural producer

Simplified production profitability indicator (marked as: π^O) for the agricultural producer can be put as:

$$\pi^O = \frac{Y^S \cdot P^O}{N^P \cdot P_N^P} \tag{3}$$

After finding the logarithm for this quotient and reducing it to the linear equation and calculating the logarithmic derivatives, i.e. the growth rates, we have:

$$\ln \pi^O = \ln(Y^S \cdot P^O) - \ln(N^P \cdot P_N^P) \tag{4}$$

and:

$$r^O = \frac{\Delta \pi^O}{\pi^O} = \left(\frac{\Delta Y^S}{Y^S} + \frac{\Delta P^O}{P^O}\right) - \left(\frac{\Delta N^P}{N^P} + \frac{\Delta P_N^P}{P_N^P}\right) = \left(\frac{\Delta Y^S}{Y^S} - \frac{\Delta N^P}{N^P}\right) - \left(\frac{\Delta P_N^P}{P_N^P} - \frac{\Delta P^O}{P^O}\right) \tag{5}$$

where:

Y^S – sold production / agricultural product sold, P^O – as above, price received (procurement price), the most important variable in this analysis, N^P – purchased input for agricultural production, P_N^P – prices paid for this input, r^o – the rate of changes in the profitability of production at agricultural producer level.

Of course, the condition for improving the profitability of production is, first, for the following inequality to be satisfied:

$$\left\{\left(\frac{\partial Y^S}{Y^S}+\frac{\partial P^O}{P^O}\right)>\left(\frac{\partial N^Z}{N^Z}+\frac{\partial P_N^P}{P_N^P}\right)\right\}\Rightarrow r^O>0 \tag{6}$$

that is, the rate of increase in revenue compensated for the rate of increase in costs. The rate of increase in the profitability of production is the most important economic indicator for the agricultural producer, also any other. This rate of changes in profitability, as shown in (4), is determined by the relation between the rate of increase in revenue and the rate of change in the cost of using the input.

According to the sentence and purpose of the article, let us first deal with the rate of changes in revenue, which is the most obvious for the producer.[5] It consists of the rate of increase in the production (sold) and the rate of changes (decrease/increase in prices). We put this as:[6]

$$r^O=\frac{\partial Y^S}{Y^S}+\frac{\partial P^O}{P^O}=\frac{\partial(Y^S.P^O)}{Y^S.P^O} \tag{7}$$

The isolation of the rate of increase in sold production: $\frac{\partial Y^S}{Y^S}$ and the rate of changes in prices received (procurement prices): $\frac{\partial P^O}{P^O}$ is in line with the practical and intuitive approach and is important, e.g., for price risk management. At a given rate of income of an agricultural producer, determined in advance by demand restrictions, there may be substitution between these two sources shaping revenues:

$$\pm\frac{\partial Y}{Y}\Leftrightarrow\pm\frac{\partial P^O}{P^O} \tag{8}$$

This is important for the market neutralisation of profitability changes as the basis for price risk in agriculture, which is a reference to the King effect known in agricultural economics.[7] For a given production volume, we have that the rate of increase in revenues (r^O) is entirely dependent on changes in prices received:

$$r^O=\frac{\partial(Y\cdot P^O)}{Y\cdot P^O}\Leftarrow\pm\frac{\partial P^O}{P^O} \tag{9}$$

Therefore, of course, the carrier of risk are the drops in prices received, i.e.:

$$\frac{\partial P^O}{P^O}<0. \tag{10}$$

However, the drop in the price received does not necessarily lead to a deterioration in the profitability of production, i.e. a negative rate of change in the profitability of production: $r^O<0$.

[5] It also results directly from the objective function of the agricultural producer in which, as we know, revenue is compared to the costs of using production factors.

[6] The share which these two indicators, i.e. the rate of increase in production and the rate of changes in price, have in shaping the rate of changes in revenue of an agricultural producer is also important, namely: $\mathrm{r_Y}=\frac{\partial \mathrm{Y}}{\mathrm{Y}}:\frac{\partial(\mathrm{Y}\cdot\mathrm{P^O})}{\mathrm{Y}\cdot\mathrm{P^O}}$ and $\mathrm{r_{P^O}}=\frac{\partial \mathrm{P^O}}{\mathrm{P^O}}:\frac{\partial(\mathrm{Y}\cdot\mathrm{P^O})}{\mathrm{Y}\cdot\mathrm{P^O}}$. For: $r_Y+r_{P^O}=1$ or $\mathrm{r_Y}+\mathrm{r_{P^O}}=100\%$. The level of the correlation indicator between the decrease in prices received: $\frac{\partial \mathrm{P^O}}{\mathrm{P^O}}<0$, and the increase in production: $\frac{\partial \mathrm{Y}}{\mathrm{Y}}>0$ or the scale of mutual compensation between these two indicators is of importance to revealing the effects of price risk.
Usually, the relationship, including the correlation, between them is high, and the directions of changes in these rates of increase in production or prices compensate each other to a large extent. These indicators are recently analysed in the OECD materials. According to the OECD report on risk management in agriculture, the scale of coverage or cross-compensation between price decrease and yield increase for farms in Great Britain was 75%, 36% in Italy, 25% in Spain, 72% in Australia, 55% in Canada. It is also pointed out that "data show that price variability from markets is larger than production variability from weather risks," while changes in prices and yields are significantly correlated (OECD, 2017).

[7] In a sense, the content of the previous footnote is a reference to this.

Revenue and profitability at the agri-food processor

Also in the case of the agri-food processor, the concept of profitability (marked as: π^P) will be limited to the relation between revenues (the product of final food products sold and prices received for them) and the cost of purchased agricultural raw materials (the product of purchased agricultural raw materials and their prices paid, or procurement prices) with the remaining conditions unchanged; then we have the following relation:

$$\pi^P = \frac{Q^S \cdot P_P^O}{Y^P \cdot P^P} \tag{11}$$

Thus, the indicator of changes in profitability for the agri-food processor is as follows:

$$r^P = \left(\frac{\Delta Q^S}{Q^S} + \frac{\Delta P_P^O}{P_P^O}\right) - \left(\frac{\Delta Y^P}{Y^P} + \frac{\Delta P^P}{P^P}\right) = \left(\frac{\Delta Q^S}{Q^S} - \frac{\Delta Y^P}{Y^P}\right) - \left(\frac{\Delta P^P}{P^P} - \frac{\Delta P_P^O}{P_P^O}\right) \tag{12}$$

where:

Q^S – sold products, Y^P – input to production / agricultural products, P_P^O – price received for the final food product, P^P – as before, price paid for an agricultural product as a raw material, i.e. the procurement price we are interested in, r^P – the rate of changes in the profitability of production at agri-food processor level.

The interpretation of the first part of the right side of the above formula is obvious. The increase in prices paid (procurement) at a given rate of increase in procurement means an increase in production costs:

$$\left(\frac{\Delta Y^P}{Y^P} + \frac{\Delta P^P}{P^P}\right) > 0. \tag{13}$$

With permanent revenues:[8]

$$\left(\frac{\Delta Q^S}{Q^S} + \frac{\Delta P_P^O}{P_P^O}\right) = 0, \tag{14}$$

As a result, we have a drop in the profitability of production at the processor level. This occurs at the rate equal to the increase in procurement prices: $\frac{\Delta P^P}{P^P} > 0$.

Indicators of price sensitivity of producer and processor revenues

The relations in the analytical approach derived above were illustrated empirically to confirm the validity of the accepted reasoning. This applies to equation (5) for agricultural producers and (12) for agri-food processors. A regression model was estimated for each of these equations. Linear regression models were used in assessing the relations of change rates therein. The relation between the rates of increase in sold production and the rate of increase in procurement prices was assessed. The selection of models was dependent on the availability of empirical data. In the case of the agricultural producer, the parameters of the model were estimated:

$$r^o = a^R X^O + e, \tag{15}$$

where:

r^o – the rate of increase in the profitability of agricultural production,

[8] Here, too, we assume the conditions of competitive balance, virtually very strong competition and saturation of the market that there is: $\frac{\Delta Q^S}{Y^S} = -\frac{\Delta P_P^O}{P_P^O}$.

X^O – the rate of changes in prices received – $\frac{\Delta P^O}{P^O}$.

For the agri-food processor, the parameters of the model were estimated:

$$r^P = a^P X^P + e \tag{16}$$

where:

r^P – the rate of increase in profitability in agri-food processing,

X^P – the rate of changes in prices paid for agricultural product (raw material for production) – $\frac{\Delta P^P}{P^P}$.

The estimation of the model parameters was preceded by determination of the simple correlation coefficients between individual variables included in equation (15). Table 1 summarises the results obtained.

Table 1. Correlation coefficients between analysed variables (growth rates) – agricultural producer

Marking of the variable	r^o	X^O
r^o (profitability)	1.000	
X^O (prices received)	0.713	1.000

Source: own calculation.

Taking into account the variable depicting the rate of changes in the profitability of agricultural production, it can be noted that it is strongly correlated with the rate of change in prices received (procurement) for a product. This is consistent with the logic of equation (5) and the so-called intuitive reasonable approach. First of all, it confirms the correctness of the adopted analytical approach.

Like in the case of the agricultural producer, the estimation of the model parameters was preceded by determination of the simple correlation coefficients between individual variables included in equation (16). Table 2 summarises the results obtained.

Table 2. Correlation coefficients between analysed variables (growth rates) – agri-food processor

Marking of the variable	r^R	X^P
r^R (profitability)	1.000	
X^P (prices of input)	-0.510	1.000

Source: own calculation.

For the agri-food processor, we note that the variable depicting the rate of changes in profitability is negatively correlated with the rate of changes in prices of input to production, i.e.

agricultural products. This is consistent with the assumptions and logic of the analytical approach derived.

Estimation of parameters of the regression models (for the agricultural producer equation 15 and agri-food processor equation 16) are presented in Table 3. The analysis assumes the significance of coefficients at the level of 0.05.

Table 3. Estimation of linear function coefficients for panel data – agricultural producer

Coefficient	*Value of coef.*	*Stand. error*	*t-Stat*	*p-value*	
a^R	0.924	0.042	22.13	0.000	***
a^P	0.039	0.002	23.22	0.000	***

Source: own calculation.

In the empirical part, we verified the analytical bases of profitability included in the theoretical chapter. In this context, our reasoning axis touched the issue of neutralisation of unfavourable changes in prices paid and received (affecting changes in profitability) by improving efficiency (for the long period which the empirical verifications carried out in the article are relate to). Based on the results presented in Table 3, we can confirm our approach to the mechanism of changes in the profitability of production. In both cases, we are dealing with sensitivity of revenues to the same change in the procurement price. The level of this sensitivity is different because the intensity of the relationship between the procurement price and this revenue is different. At the agricultural producer, this relationship is direct, and at the processor indirect. We see that the profitability of production depends, in the case of the agricultural producer, to a large extent on the prices received for a product. In the case of the agri-food processor, this relationship is small, it can even be said that the change in the price of input to production does not directly affect the rate of changes in profitability of production.

Summary and conclusions

The article shows the essence of the production profitability mechanism as the basis of price risk for an agricultural producer and agri-food processor. The same movement of procurement prices, for one being the price received, for another the price paid, means a different source of changes in profitability (and risk). The key in both cases is adequate compensation for or efficiency neutralisation of unfavourable changes in prices, however possible over longer periods, which was also confirmed by the empirical study.

The validity of presenting the indicators in analytical formulas – based on deductive reasoning – was confirmed by the initial statistical analysis. The obtained estimates of correlation and regression coefficients, although to a different degree and significance, which was conditioned by available data, indicate the relation between production profitability and changes in prices received in the case of an agricultural producer and the lack of direct relation between these variables in the case of an agri-food processors.

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