Theses for a doctoral thesis (PhD)

ANALYSIS OF HUNGARIAN AND FOREIGN PIG PRICES TO ASSESS THE IMPACT OF INTEGRATION

Tamás Marczin

Theme leader:

Prof. Dr. Péter Balogh

university teacher

UNIVERSITY OF DEBRECEN

Károly Ihrig Business and Management Sciences

Doctoral School

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1. THE BACKGROUND, OBJECTIVES AND THE DESCRIPTION OF THE RESEARCH HYPOTHESES

I first started my research in 2015, when I was interested in what could be the breakthrough points and the basis for the development of competitiveness of the hungarian pig sector, mainly by modelling economic indicators. Subsequently, my further research extended the analysis of the topic by statistical analysis of time series data. This gave me a broader picture of the problems, and therefore the opportunities, facing the domestic sector.

During the doctoral studies, literature research showed that global economic trends in the world indicate that globalization and market competition have affected all sectors in recent decades BRUNELLE et al. (2014), with the result that the food industry is trying to serve the growing population through the continuous development of intensive production and sectoral concentrations. In the case of the modernisations that have taken place, it is clear that the final products are in most cases uniform, high in volume, undergo a cost-efficient production process and, in addition, are of relatively high quality (VAN KERNEBEEK et al, 2016). In addition to the above, a smaller segment can be delineated, which is mainly a group of products of high quality and good distinctiveness (DAVOLI - BRAGLIA, 2007). The challenge has also reached the pig industry, if you look at the main pig producing countries, there has been a huge concentration in the last decade. In the case of China, the increase in protein demand has led to a 26.6% increase in pork production in 10 years, and the number of large-scale pig farms producing 10,000 fatteners per year has increased by 145%, supporting the previous hypothesis (ZHAO et al,2022). At the European level, the shift in production is relatively more specific, as producers are less confronted with population growth. But high feed prices, the emergence of environmental standards and thus rising costs of production require an increase in efficiency and volume (ROCADEMBOSCH et al., 2016).The best example of this development is Spain. Recognising that production can only be successful if all actors are involved in an efficient cooperation by organising the product chain from the top down, they have become the leading pig producing country in Europe in a few decades (FAOSTAT, 2023). Today, they have developed different models to promote cost-efficient production (NADAL-ROIG et al., 2019).

In contrast, Hungary continues to experience sectoral fragmentation, which is reflected in its competitiveness disadvantage. Therefore, it was obvious that the main objective of this paper was to compare European practices with the domestic sector and to explore the success of the domestic market leader organisation in terms of time series analysis and efficiency aspects.

On the basis of the results obtained, my aim was to highlight the specificities and characteristics of each European market, and thus to identify the impact of the high degree of product path organisation and the size of the stock on the success of each sector.

Objectives of the research

- My research objective is to compare the pig sectors of the major pig producing countries in the European Union and the Hungarian pig sector, with a special focus on the integration development of the product trajectories of these countries.
- My research objective is to create a database of weekly sales prices per kilogram in several countries and Hungary, based on a complex predefined framework
- Based on the database created, I aimed to investigate the relationship between integration and free market pork sales prices. Can it be confirmed that the price fluctuations in the Integration were much smaller than those of its competitors, especially when the market was characterised by drastic price reductions.
- Demonstrate the competitive advantage of pig production in Hungary in a cooperative system
- My aim is to present a complex picture of pig production in Europe based on literature and primary data, contrasting it with the specificities of our country and thus making suggestions for improvements to increase the efficiency of the domestic sector.

My research questions all fall under the heading of sectoral competitiveness. In this context, they are grouped around integration and organisation in the pig sector. On this basis, I formulated the respective hypotheses for the thesis:

H1: The high level of market and sector organisation and the high volume of uniform stocks leads to a reduced exposure to market disturbances.

H2: The influence of the German (ZMP) price on the sales prices of the European continental market is of decisive importance.

H3: For the domestic pig sector, producers who are not members of a producer group have a significantly higher exposure to market supply and demand effects than pig farmers in the Integration, in terms of purchase prices.

H4: From an efficiency point of view, the higher selling price and the planned joint purchasing by the Integration member due to its higher organisation may make it more efficient than other market participants.

H5: The lack of organisation in the sector is an important obstacle to improving the competitiveness of the domestic pig sector.

2. LITERATURE REVIEW

In the literature review, my aim was to present almost all aspects of the pig sector, starting from the world market perspective and taking into account the Hungarian situation. First, I will present the development of world pig production. This will give an idea of how the current poles of the world market were created and which countries have a decisive influence today. I will then present the history of the development of the European market. The importance of this longer-term literature review can be seen in the fact that in this case I am already looking at a pig farming region which will later form an integral part of the research. In the case of Hungary, too, a historical overview is an important task in the processing of scientific sources, since it is only by knowing this that we can really understand the current developments in Hungarian pig farming. In addition to the above, when examining the literature, considerable attention had to be paid to the events of the last 4-5 years, as these factors (ASF, COVID-19, Russian-Ukrainian war), which influenced economic processes, may be of crucial importance, especially from the point of view of time series analysis. In addition to the trends and development history of the pig sector, it is also necessary to look at integration and price analysis from an international and domestic perspective, as this research can help to draw conclusions later on.

2.1. Pig farming in the world

Globally, the evolution of pork production has been mixed. In the case of China, the 20th century was characterised by backyard production, mainly comprising farms with a few sows, slaughtered locally and mainly to meet domestic demand. This trend was transformed by the Industrial Revolution of 1978 ZHONGMIN (2015), which brought agriculture into the industrial mainstream, resulting in the emergence of larger farms producing a more uniform commodity base for marketing.

By the turn of the millennium, this trend had changed, as industrial development and increased demand had transformed the population's eating habits. From then on, protein-based sources of nutrition formed a significant part of the daily diet. In addition, a wealthy class has emerged in China today, which, in addition to luxury consumer goods, has shown a significant increase in demand for quality in food, including meat products. WHITNALL – PITTS (2019) shows that global meat consumption has increased by 58% in 20 years to 2018. In addition, as the population grows, this value will continue to increase. In this context, it is worth highlighting that the share of each meat type in the demand indicators is also changing. According to FAOSTAT (2023), the world pig population was 975 million head, of which 46% were Chinese

pigs. Based on this, we can conclude that today, China has a huge influence on the world market for pork. Thus, any impact on its domestic market will have a downward or upward effect on the world and European pig sector after a few weeks.

Another important region of development is the South American continent. Within this, Brazil in particular is worth highlighting. As mentioned earlier in the case of China, there has been a steady development, which is mainly reflected in the growth of exports (VILAS-BOAS et al., 2022). In the case of Brazil, an important advantage is that the development of soy production has also led to improvements in feed efficiency, and in addition, in the case of exports, the combined transport of individual products, especially to Europe, can be achieved, thus also optimising cost efficiency and environmental requirements and transport. In the case of the Americas, it is also important to mention North America, following SATO et.al. (2017), where the role of quality and animal welfare has long been a feature, and the continent's livestock population has been growing at a steady, slow rate.

In the case of Europe, we can speak of a very diverse sector in the light of world pig production AUGÉRE-GRANIER (2020), and the above statement can be approached from many different angles. In terms of farming methods, almost all factors are specific to each Member State, with super-intensive farms and backyard farming also being a feature.

As for the challenges of the future, different regions face different challenges, but in general, population growth is one of the main drivers for world pig production RAUW et.al. (2020), and the implication of the above finding is that future directions are being shaped. In its analysis, it identifies two directions. One of them is the one that has been the subject of several literatures and theses and supports the findings, which focuses on the need to achieve a high level of input-output, thus creating a sustainable intensification.

In the second option, the objective is to reduce input-output and select regionally appropriate animal species.

2.2. Pig farming in Europe

The European pig industry has developed enormously in recent centuries. GENUNG (1940), the development of European agriculture in modern times was determined by the effects of the world war. At that time, market channels were closed and production began to decline due to shortages of raw materials and labour, to an extent that was already reflected in food shortages. BRASSLEY et al. (2016) also concur with the earlier literature. It can be said that after the Second World War, Western European agriculture started to modernise. Previously, the predominant farm size was the family farm, which focused mainly on manual labour and produced relatively small quantities. However, food shortages and the destruction of production units and the loss of human resources encouraged farmers to make improvements. This led to a single market and continuous modernisation of the sectors over a period of 15 years.

The Treaty of Rome was the most important basis for this recovery. The Treaty was pushed for by 6 European countries, with others joining. As part of this cooperation, the first looser integration of the relevant countries of Europe was established. This organisation brought with it an economic boom and the introduction of new directives. This led to an increase in production and a period of peace. The success of the measure is illustrated by the fact that the founding countries are 200% richer (in purchasing power parity terms) than at the time of its creation. The successful development of the countries of the European Economic Community was also helped by the introduction of the Common Agricultural Policy PATTERSON (1997), which was so successful in introducing development and changes in attitudes that it was well received by producers and farmers, despite the fact that the number of farms in Germany, for example, was in decline. The thesis by LINSTEN et al. (2018) also reflects the fact that agricultural development has progressed from initial developments to the point where countries have become self-sufficient and then, in the 1970s and 1980s, were able to achieve a measurable export performance.

Pig production has also been significantly affected by these measures. The aid received was used by farmers to increase efficiency in line with the terms of the contract. Building on this experience, the Western European countries opted for further concentration in the pig sector, as this made market conditions more predictable and ensured the marketability of the single commodity base.

Literature also confirms that this structure ensures efficiency and economic stability OUDEN et al. (1996); SCHULZE et al. (2007); BAUM et al. (2008). The success of these vertical

integrations was greatly facilitated by the bottom-up form of organisation, as producers had a stake in meeting the needs of the end-user.

Several studies and analyses have looked at the Danish pig sector as a good practice and a sector with a high degree of coordination, and STRANDSKOV (2018) showed that the competitiveness of the Danish pig sector can be attributed to the fact that at least 43 mergers and acquisitions have taken place since the 1960s. These have mainly taken place through cooperatives. Today, the Danish pig sector is highly competitive and export-oriented, based on the fact that it is grouped in three large integrations (CROWN, 2001).

Germany is another prime example of organisation and thus market influence in the pig sector. In the first instance, the high volume and the price-setting role that this has led to has been reinforced.

In the above section, it is important to highlight the Spanish pig sector, which has now become the dominant one in Europe. In this case, too, the role of vertical organisation has been emphasised, making it a highly efficient producer country, covering the entire product chain. This was based on the fact that pig farming was started in less fertile areas of the country, which allowed for a more efficient management of both volume and environmental reservations.

In recent years, the European pig sector has faced challenges alongside its development, one of which was the introduction of the 2013 sow welfare regulations, which subsequently led to an increase in costs and hence in sales prices (MC GLONE, 2013; MARCZIN, 2018). This increase was followed by a downward phase in sales prices, due to the conflict between Crimea and Russia. As a result, the European Union and then Russia imposed economic sanctions on each other (KHOLODILIN - NETSUNAYEV, 2016). The big loser of the sanctions was agriculture. The period that followed was mainly one of structural change. The new generations' lifestyles, expectations and needs are challenging both for producers and for the industry (IU – XIAO (2015); MOLINA-MARONE et al. (2017); COLLINS – SMITH (2022), which has increased the role of sustainability in pig production, and the disposal and processing of slurry is a continuing challenge in Western European countries.

2.3. Pig farming in Hungary

Agriculture in the Eastern Bloc countries was characterised by a technical and productivity disadvantage in the early period. Following the example of the Western countries, the socialist bloc also established its own economic community in 1949. GERŐCS – PINKASZ (2017)

describes the specificities of the market, noting that one of the objectives was to reduce the import requirements of each country and to improve the availability of technology. One important feature of the CSTO was that socialist countries could export through it in a relatively protected market environment. VARGA (2018) shows that the basis for change was set in motion by the review processes formulated in 1963. However, it was the introduction of the New Economic Mechanism in early 1968 that brought about the really far-reaching change.

Within the modernisation of agriculture, the development of the pig sector started in 1970. According to the research of PANYOR (2017), from that year we can speak of a food economy, which looks at agriculture as a whole from a global perspective and applies the concept of "agribusiness".

It also highlights the impact of the modernisation imposed as part of the mechanism. This is illustrated by the fact that the ratio between the number of cows and the number of pigs since the 1960s is an indication of more efficient production. A relatively specific form of integration was also created as part of the programme. The model was a kind of vertical integration based on backyard farms. In many cases, these farms had between 80 and 100 pigs at a time BENET (2011), so they played an important role in the success of the pig sector by integrating into the cooperative farms. Furthermore, the establishment and concentration of meat companies in the county was an important part of the supply chain, which made the meat sector large-scale MOHÁCSI (1996 b).

In addition to the development, the sector showed further quantitative growth in the 1980's PÉRCSI - NAGY (2017), but this growth rate was not followed by the development trends of the previous decade (ANTAL, 1999). It can be concluded that agriculture was particularly capital-poor in that decade, which was compounded by the delay in the legislative processes related to the regime change. Recognising this handicap, the Ministry of Labour decided to promote sectoral concentration in view of the challenges and the previous sectoral model. The instrument for this was FVM Decree 85./2002 (IX.18.).

The sector saw in the accession to the European Union a new opportunity to overcome the competitive disadvantage following the change of regime, but contrary to these expectations, the agricultural sector has not caught up.

Nowadays, the hungarian pig sector continues to face market disruptions, as evidenced by GERGELY et al. (2019), which shows that pork consumption is declining, but still accounts for 8.2% of the GDP of agriculture in 2018, while livestock production accounted for 24%.

2.4. The present and future of pig farming

It has already been mentioned in the previous chapters that the pig sector has been confronted with several influencing factors over the decades of its development, which have continuously affected its predictability and successful production. However, looking at the present, agriculture is facing unprecedented challenges.

Today's consumers are aware of the origin of meat, the health hazards associated with its consumption DANG – TRAN (2020), the perception of each type of meat and the role of marketing in the consumer's circle. Furthermore, the consumption of meat and the knowledge of meat consumption, especially among younger generations, differ greatly from that of older generations (TØNNESEN - GRUNERT, 2021). This fact adds to the previous assumption that the role of intensive production, modernisation and quality assurance is being enhanced.

From a risk analysis point of view, we have to consider three main challenges: African swine fever, the COVID-19 pandemic and, mainly at European level, the Russian-Ukrainian war.

African swine fever is not considered an unknown infectious disease in Europe. For the domestic pig sector, it is important to highlight the outbreak in the Romanian feral pig population BOKLUND et al. (2020), which caused almost immediate market disruption in our country, which was reflected in a significant change in sales prices.

Following the eastern region of Europe, the impact of African swine fever was also felt on the global market. In August 2018, China officially announced positive cases in several provinces with domestic pig populations. Due to the rapid spread of the outbreak, culls have started. Several studies have concluded MASON-D'CROZ et al. (2020); YOU et al. (2021) that the economic impact of African swine fever in China is huge, with significant implications for the global pig industry.

In addition, the main market players have sought to regain export licences. In the case of China, following the 2018 outturn, a significant development has started, aiming at self-sufficiency. In Europe, the first positive case in Germany was the first announcement of a new price and market influence. SAUTER-LOUIS et al. (2021), in spite of the initial rapid action, confirms the less successful prevention, as does RENAUDEAU – DOURMAND (2022) in his analysis that the German pig sector has a strong influence on the European market, both in terms of herd and economic terms. Thus, the impact of this infection was immediately felt.

The above problem was overshadowed by the year 2019-2020, as an outbreak of COVID-19 was officially announced in China in December 2019 (CIOTTI et al., 2020). As a result, agriculture and food supply chains faced immediate market disruptions (SICHE, 2020).

By the beginning of 2020, the pandemic was increasingly threatening the European continent. In March of that year, positive cases were recorded in several countries and the number of infected people in Italy continued to rise. In the wake of the outbreak, both demand and labour supply were problematic, with ELLEBY et al. (2020) finding that meat prices fell by an average of 8-17% over the period and agricultural growth slowed.

URSACHY et al. (2021) analyzed a very important issue. Within the meat industry, the working conditions of slaughterhouse workers (low temperature, high humidity, little natural light) meant an increased risk of infection during the pandemic, so in addition to a high level of food safety, ensuring the ability of workers to work and thus maintaining production became important.

In the case of our country, the spread of the pandemic also negatively affected the food industry and agriculture. MEZEI – GOMBKÖTŐ (2022) magazine article, within the framework of a comprehensive analysis, came to the conclusion that in the initial period the virus had an effect of increasing demand on the food and chemical goods market. The individual supply chains were able to operate less efficiently from the perspective of the food industry.

After the ASF and the impact of COVID-19, the sector was confident that market conditions would settle down, investment security and planability would return to the previous level, however, at the beginning of 2022, economic conditions and agricultural productivity were affected by another global economic problem. The Russian-Ukrainian conflict turned into a war in February 2022, which affected the world economy almost immediately. CSÁKI (2021) magazine article, it can be concluded in the short term that the importance of Russian and Ukrainian grain is very high in European agriculture. The study by POÓR et al. (2022) also highlights that, in addition to feed costs, energy prices also began to increase. By the end of the year, compared to previous data, the price of natural gas and electricity rose 5-7 times, which seriously affected plants producing at lower efficiency, and the cost level of meat processors also increased unexpectedly.

2.5. Price analysis and integration

VAIL WAUGH (1964) book, it can be established that agricultural analysis methods go back more than 100 years, and already around the time of the First World War, statisticians were concerned with the description of market events, which was initially limited to the analysis of consumption.

PALASKAS (1995) in his analysis came to the conclusion that in the seven countries of the EU, if we examine the transmission of prices, we can see that producer prices differ from consumer prices in the short term, but this difference always turns into a longer-term equilibrium state .

Based on the research of MILLER – HAYENGA (2001), changes in wholesale prices are asymmetrically transmitted to retail prices in relatively low-frequency cycles, which does not support search costs and other high-frequency explanations. On the other hand, the wholesale price of pork adapts asymmetrically to changes in agricultural prices with all frequency LIU et al. (2019) Expanded the scope of examination of pork prices. According to them, in today's economic environment, forecasting sales prices is an important task for the management of individual production companies to make the right decision. According to their experience, pork prices follow a non-stationary, non-linear, pseudo-periodic time series that changes due to potential growth, cyclical fluctuations and errors. With the right model, the cyclicality and fluctuation of individual agricultural products can be predicted with a low error factor, which is the basis of process-based planning.

MARSH (2007) examined individual levels of production, starting with grain production, and his results supported the previous ones, or the supply of fodder and production, thereby serving consumers, show a close connection. Furthermore, prices are correlated.

Investigating at the European level, several studies elaborated the topic of the related chapter. TLUCZAK (2022) mentions in his analysis that, in connection with climatic conditions, the feed market has a strong influence on the selling price of pigs.

Studies related to the domestic sector also often dealt with the development of prices and the measurement of efficiency. KOVÁCS – BALOGH (2011) looked for the answer to the question of how well previous sales prices follow values located later in the time series.

Historical overview of the Hungarian price analysis methodology SÜVEGES (2018) in the field of price statistics. In the course of his investigation, he mentions that when analyzing the price

of pigs, it is necessary to take into account the individual data collection methods and accessories, in order to be able to make accurate measurements.

From an integration point of view, conceptual demarcation is important in the first instance. Vertical integration is the most common form of integration in agriculture, and within that, in the pig sector. FERTŐ (1996)'s analysis formulates a wider conceptual circle through vertical coordination.

SZENTIRMAY – GERGELY (2005) magazine article, it can be said that vertical organization can now be considered common mainly in the food industry. If we specifically examine the integration of the pig sector in the world, we can divide vertical integration into two parts. One possibility, in accordance with the above statement, is the integration organized from above. NEMES – VARGA (2015) co-authors also speak about this form of vertical integration

Another possibility is organized integration from below. In this case, the producers are more interested in the success of the process and take a big role in it. In addition to the above, another form of integration is horizontal integration, which plays an important role in pig farming in our country (MARCZIN, 2016).

Looking at it from a global perspective, integration has appeared in several pig-producing countries over the years. As mentioned in the previous sections of the chapter, China has undergone enormous development, and its further growth can be ensured by sectoral coordination.

The research sees the management of these challenges in the integration of the supply chain, since the effective exchange of information between the individual participants ensures successful operation (ALHO, 2015).

Analyzing integration at the European level, it can again be said that we can talk about a broad sector. In the case of studies related to pig breeding, we can almost always come across examples from the Danish pig sector. KNUDSEN - HANSEN (2008) analysis highlights that one of the great competitive advantages of Danish pig farming is the market coordination achieved in cooperative ownership.

If we examine today's pig farming, Spain can also be considered an important example from the point of view of vertical integration. Several studies focused on the concentration of the country's pork sector PEREZ et al. (2010); CHEN (2012); HORILLO et al. (2022). According

to their findings, in order for the Spanish pork sector to be able to function effectively, it is important to establish a top-down organized sector system and market channels.

In terms of integration, Hungary is currently in a special situation if we take into account pig farming. MARCZIN 2018) study, it can be said that the level of pig sector integration in Hungary is around 40%. POPP - POTORI (2006) analysis already established that the rate of cooperation between the grain producing and consuming sectors is low, which does not ensure the proper functioning of the value chains.

3. PRESENTATION OF THE DATABASE AND USED METHODS

The doctoral dissertation is characterized by both primary and secondary research. Before conducting the research, the available relevant literature was analyzed. In connection with this, I reviewed journal articles, books, publications and databases belonging to international and domestic literature.

The primary research was based on the creation of the database. On the one hand, the research dataset was based on a comprehensive time series, which aggregates the weekly sales prices going back 13 years. I considered it appropriate to start the length of the given time period from 2010, since Integration received the recognition of the Qualified Producer group in this year, so the relevance of the data can be considered higher compared to previous periods. Data collection began in 2018, when T=441 data were recorded. For the preparation of the doctoral dissertation, the data series was expanded to include several relevant countries, and the data of the time series is also meant for the period between week 8 of 2010 and week 9 of 2023 (T= 685). The data was collected based on the databases of the Agricultural Research Institute.

The countries included in the study were selected on the basis of several criteria, such as sector size, development of integration, and their role in the European pork market. Based on this, the countries included in the research are: Germany, the Netherlands, Spain, Denmark, Poland, Austria, Hungary, as well as the European average, for comparison. Based on the above, the data series provided by the producer group starts from the week of 08. 2010 and lasts until the week of 9. 2023. (T=685). It also contains weekly data, and in terms of price range, it can be compared with the relevant values of the above-mentioned countries and the Hungarian pork market. The integration data comes from the internal records of the given producer group and is available to all members of the cooperative.

During the dissertation, the following methods were used:

I used various statistical and statistical programs to analyze the data. I performed the volatility analysis and RMSE analysis with the Excel 2016 program. The price transmission calculations were performed with the ’inpute TS’, ’apt’ package of the R program. Furthermore, I used the Excel 2016 program for the efficiency analysis.

My goal was to obtain the statistical indicators of the 9 markets presented during the primary data collection in the first round, and then to compare them with each other in order to get an answer as to how well the deviations in trends follow one another. How the previously mentioned market-influencing processes can be seen in the weekly sales rates of individual markets. After that, with more complex statistical analyses, I will examine the effect of market size and integration development on the role of price tracking and market exposure.

Variation of coefficient

The given coefficient measures the variability of a series. In this case, the measurement units will disappear, so the resulting indicator will be completely independent of the basic measurement units (HERVÉ, 2010).

$$V_r = CV = \frac{\sum_{i=1}^{n} \frac{\sqrt{x_i - x_{átlag}}}{n-1}}{\frac{\sum x_i}{n}} = \frac{s}{\bar{x}}$$

Volatility

ANDERSEN et al. (2006) it can be said that, in general, volatility refers to fluctuations observed in the case of a given phenomenon within a period of time. From an economic point of view, this proposition can be formulated in such a way that we can use it to describe the variability of the random component of the time series without a metric.

The analysis of the given indicator can be considered very important from an economic point of view, the seasonality of the agricultural sector, its exposure to nature and the production with biological organisms cause continuous change. This fact can also be seen in the price of the finished product to be sold in several cases. CHAVAS – LI (2019) analysis also states that high price fluctuations lead to instability, which, in the case of a producer, threatens financial security and the success of investments in the long term.

Depending on the time frame and data we are examining, we have to use different volatility models. LEDERBURG – SCHMITZ (2012) it can be established that if we take the sales prices

of a sector, then we are talking about historical data, since in the previous case we fit a model to weekly sales prices. We apply the given model with regard to a certain price level. In this case, the standard deviation, logarithmic price and variation coefficient are the focus of the investigation. The respective values give the standard deviation of the sample as a function of the sample mean.

Accordingly, among the volatility models, the use of the historical model is justified, which is supported by the analysis of (TOTHOVA, 2011). Due to the peculiarities of the pig sector, the inclusion of logarithmic price returns is necessary to conduct the study. Its formula is:

$$u_i = Log\left(\frac{prices\ in\ t\ period}{prices\ in\ previous\ period}\right) = Log\left(\frac{Pt}{Pt-1}\right)$$

In this case, P shows the weekly sales prices in the formula, and the ui value gives us an approximation of the price change expressed as a weekly percentage.

After fitting the formula to the data series, the fluctuation of the successive factors can be calculated for the entire time series.

The reported returns are then squared. Our basic assumption is that the average of the log returns (expected value) is 0, so the variance formula is modified according to the formula below:

$$Variance = \sigma^2 = \frac{1}{T}\sum_{t=1}^{T} u^2$$

Since the data collection took place on a weekly basis, the calculation is completed with the formula that appears, in this case 52 represents the weeks.

$$Aprice\ change\ adjusted\ for\ date\ series\%(Log\ render^2)$$
$$= 52 * weekly\ price\ change\%^2$$

By adding the correction to the model, the complete analysis can be performed. In the case of the 9 sales markets, due to the more comprehensive results, a moving average-based analysis was performed. Moving averages were modeled in 12-, 24-, and 52-week windows.

$$Moving\ average\ of\ price\ volatility(n) = \sqrt{\frac{1}{n}\sum_{t=1}^{n} u^2}$$

Among the components of the above formula, n shows the moving averages for different time windows. Or, instead of the entire t period, we calculated only n periods, which we then moved as a constant time window throughout the entire time span.

From the point of view of the above-mentioned aspects and the peculiarities of price analysis, it is necessary to use the following formula for the precise examination of the coefficient of variation MARCZIN (2018b), which is supplemented by a moving average and moving standard deviation. The necessity of this is shown in the fact that we can fit the above formula to the time series, and then "scroll to the end" on it, so we can make a projection for a month or even a current year. In this case, I chose the 12-week projection.

$$CV\% = \frac{standard\ deviation\ of\ the\ first\ 12\ factors}{mean\ of\ the\ first\ 12\ factors}$$

Several types of rules are accepted in the interpretation of the coefficient of variation, but in general it can be highlighted that the time series is homogeneous, i.e. free of market disturbances, if the value of the relative standard deviation varies below 10%.

Root Mean Square Error

According to the study by CHAI – DRAXLER (2014), RMSE is mainly used for forecasting purposes, by applying it to a given data set, it can be determined how calculable the relevant data are. During the analysis of pig market prices, the necessity of the given methodology was shown in the fact that we can demonstrate the seasonal variation of the given examination period in relation to the prognosis.

In the case of the study, due to the model fitting criteria and to avoid measurement distortion, the time range was reduced to the period between week 1 of 2018 and week 52 of 2022. From a sectoral point of view and taking into account economic trends, this decision can also be considered favorable, since the effects of the COVID-19 pandemic and the Russo-Ukrainian war were also felt here in the ASF.

The first step was to calculate the monthly average of the prices, as the model can calculate properly with this breakdown. After that, the real and predicted value became calculable. By combining these data, we obtain residual values, which can also be interpreted as forecast errors. An important feature of the methodology is that it focuses on accuracy, has a positive value and a minimum value of 0. From a market analysis point of view, we can therefore say

that the smaller the value, the more accurate the estimate, so the level of market disturbances can be considered low.

The above analysis could be run in two aspects. On the one hand, with the method of polynomial trends, the essence of which is that the forecast is made for the entire time band, in this case it gives the model a higher RMSE value. The other option is moving average-based analysis, when we fit a moving average to a 3-month timeframe. Due to the shorter time span, this methodology shows a lower RMSE value, and the forecast can more accurately follow the real database.

Price transmission

In the case of the given methodology, the data covered the period between the 1st week of 2010 and the 5th week of 2021 (T=577). The selection of the data series (countries), as mentioned earlier, was done with diversification in mind, as this way we can get a comprehensive picture of the influence of the markets on each other and the advantages and disadvantages of the market size data. In this case, it can be said that the German ZMP price can be considered decisive in establishing the sales price of several European countries.

When choosing the methodology of the present study, I looked for an analysis option that can examine the short-term and long-term mutual influence between time series, for which cointegration and asymmetric harm distribution as well as correlation-based clustering can be considered ideal.

Cointegration and asymmetric price transmission analysis

ENGLE - GRANGER (1987) showed that the linear combination of two non-stationary (non-stable in time) time series results in some cases in a stationary (stable in time) time series. This is called cointegration. In such a case, the two time series do not deviate from the established long-term equilibrium in the long run. With the help of cointegration, we can set up an Error Correction Model (ECM), which examines short- and long-term effects in one model. In this model, in case of a deviation from the long-term equilibrium state, the correction is shown by the same parameter even if the deviation is negative or positive. This automatically assumes symmetrical correction. The description of the Asymmetric Error Correction Model (AECM) is based on the following MEYER - VON CRAMON – TAUBADEL (2004); FREY - MANERA (2007):

$$\Delta y_t = \sum_{h=1}^{r} \beta_h \Delta y_{t-h} + \sum_{i=0}^{s} \alpha_i^+ \Delta x_{t-i}^+ + \sum_{j=0}^{q} \alpha_j^- \Delta x_{t-j}^- + \lambda^+ ECT^+ + \lambda^- ECT^- + \epsilon_t$$

Where ECT=(y_(t-1)-θx_(t-1)). The model can have many prescriptions, here we present a general prescription that can vary depending on the specific testing needs. This model divides the error correction term (ECM) into negative 〖ECT〗^- and positive 〖ECT〗^+ terms, which thus already shows whether there is a deviation in the convergence process (ie whether there is a case of asymmetric price transmission). I calculated the model using the 'apt' package of the R program (SUN, 2020). If λ^+≠λ^- then the convergence process is different, depending on the direction of the deviation from the equilibrium position. Not only the error correction term, but also the lagged terms of the explanatory variables can be divided into negative and positive terms, if the research requires it (FREY - MANERA, 2007a).

Efficiency analysis

In addition to the previously presented statistical indicators, it is also important to present the operational role of the given sales prices during the thesis. Because in the case of an operating business, maintaining liquidity is crucial for efficient operation within the year. CHEN et al., (2009); VIKTOROVNA – NICKOALEVNA (2019) also highlighted in their analysis that in the modern economic environment, such an examination is essential in the life of a company.

Based on my analyses, it has already been proven that in the case of liquidity it is not possible to determine exactly when a period leading to insolvency will occur, as this is influenced by the current economic situation, the negotiation of world politics and many other components that are a simulation does not allow running the model. This finding was confirmed by consultation with several producers and by key players in the sector.

However, through calculations based on efficiency indicators, we can get an idea of how successfully a given plant can finance its costs, and in the future, how well it can implement investments and operate successfully. In this phase of the investigation, I selected the markets that form the basis of the analysis, because in the case of European pig-farming countries, the related data may differ in relation to the cost structure, the use of feed raw materials is different, and due to the different data provision, the data cannot be compared correctly. Thus, the efficiency analysis was limited to Hungary, where I was curious about the profitability of the two market channels mentioned earlier.

When setting up the basic calculation model, I assumed that we are examining a modern farm in 2023, where we produce final products for sale with 1000 sows. The natural indicators of the given plant are presented in *Table 1*.

Table 1: **The natural indicators of the farm on which the calculation is based**

Megnevezés	***Mértékegység***	
Sows	*piece*	*1000*
Number of selected piglets per sow	*piece/year*	*30,63*
Sow rotator	-	*2,35*
Childhood average	*pig/birth*	*13,97*
Battery death	*%*	*2,47*
Total fattening material	*piece*	*29873,439*
Fattening pig death	*%*	*2,33*
Number of gainers available for sale	*piece*	*29177,38787*
Average weight of a fattening pig	*kg*	*108,52*
Total marketable live weight	*thousand kg*	*3 166 330,13*
FCR	*kg/kg*	*2,64*
Average daily weight gain	*kg/day*	*0,82*
Sow culling in the first year	*%*	*45,3*
Number of workers in the sow farm and the battery	*piece*	*5*
Number of workers in the fattening plant	*piece*	*5*

Forrás: Saját adatgyűjtés és kalkuláció, 2023

After the foundation was established, the operating factors characteristic of the two markets had to be differentiated.

In the first calculation model, I took the farm of a producer who sells his pigs on the Hungarian free market. In this case, acquiring the market is his or his management's task, with approximately 28,400 fattening pigs appearing in the sector annually. In connection with this, the purchase of input materials is also limited to the plant, so the level of discounts is low and the exposure is also higher.

In the second model, I bought a plant operating under the umbrella of Integration. In this case, sales prices are proven to be higher compared to free market prices, as the integration enters the

market with 700,000 pigs per year, so it can exert influence on the processors, and the uniform, large amount of goods base generates additional income. In the first case, the input material side can be calculated at the same rate as for free market players.

However, since joint cooperative procurement is under development, the construction of an additional model is justified, where animal health costs can be reduced by up to 20% and feed costs by up to 10%. This suggestion was also supported by the management of Integration based on its own previous calculations. In addition, an additional cost item is the operating cost contribution, which is HUF 400 per pig.

To evaluate the obtained results, the following operational indicators are justified:

$$Production\ value = Sales\ revenue\ of\ main\ product + Sales\ revenue\ of\ secondary\ product + Subsidies$$

$$Direct\ production\ costs = Total\ direct\ costs$$

$$Net\ income = Production\ value - Production\ cost$$

$$Kdirect\ cost\ ratio\ profitability\ (\%) = (Net\ income)/(Direct\ production\ cost) * 100$$

$$Cost\ ratio\ profitability\ (\%) = (Net\ income)/(Production\ cost) * 100$$

$$Cost\ ratio\ profitability\ (\%) = (Net\ income)/(Production\ cost) * 100$$

$$cost\ level\ (\%) = (Production\ cost)/(Production\ value) * 100$$

$$Prime\ cost = (Production\ cost * 1000)/(Total\ ripenable\ weight\ (kg))$$

$$EBITDA = Net\ income + Depreciation$$

$$EBITDA\ margin = EBITDA/(Total\ revenue)$$

The EBIDTA value describes a company's operating performance by not taking into account cost factors that may distort the company's actual operating quality (ALCLADLE et al., 2013).

4. MAIN FINDINGS OF THE DISSERTATION

Volatility

The results of the volatility analysis were as follows:

In the case of Hungary, it can be clearly seen that the 12-week period shows more significant differences in the case of individual time windows, after which the extent of the differences decreases with time. It can be said that mainly in the initial period, however, during almost the entire time series, the increase in volatility can be linked to a decrease in some sales price. Price increases mainly induce a decrease in volatility. This tendency appears mainly in the case of the smaller sector, which is sensitive to external influences.

In the case of Germany, as expected, the swings appear to be relatively low in a significant part of the time series, which can be traced back to the market-determining role and the large-volume stock. Compared to the previous figure, the question may arise as to what is the reason for the jump in companies in 2010. Presumably, the effect of the 3-year pig cycle and the increase in feed prices during this period may have played a role. In addition, the other outstanding period in this case is also a consequence of the appearance of the pandemic in Europe and the increase in input prices and uncertainty caused by the war.

The time series of the Netherlands can be said to be largely predictable and free of major outbursts, but there are very significant fluctuations in three cases. In the first case, a significant swing was experienced at the beginning of 2013. The reason for this is the environmental protection and sow regulation system introduced during this period, which can be strongly felt in the case of a country with pig sales and significant breeding. In the second case, the effect of the COVID-19 pandemic and the ASF infection reported in Germany appear, and the effect of the war can also be clearly perceived in the given figure.

On the basis of Spain's volatility diagram, it can be concluded that the previous suggestion is also confirmed by the analysis, since the degree of swings is lower compared to the previous ones. Examining the years, a larger jump usually occurs in the first quarter of the year, which mainly occurs due to the Easter and spring seasons, and the quick market reaction shows that the increase in the volatility value appears in the event of price increases, which can be measured in extra profit. It is an interesting fact that the appearance of the COVID-19 pandemic in Europe cannot be significantly detected in the current timeline. This may be due to the fact

that the infection wave has appeared less frequently in the given country. However, the impact of the war, as in all cases, affects the data obtained here as well.

Compared to previous charts, Denmark shows a completely different picture here. During the vast majority of the period, we experience a relatively low swing level, however, jumps also occur in unexpected places. One of these will happen at the end of 2014. In the case of Denmark, it can be said that in addition to the high level of integration, the level of export is also significant in the field of live animals and meat. During this period, this market segment was greatly affected by the Russian embargo, which also applied to pork products. The other significant jump can be traced back to similar reasons. Brexit happened in 2020. One of Denmark's key export partners is the United Kingdom, so the market uncertainty experienced in this period is reflected in the analysis.

Based on the trends in Poland, it can also be concluded that the first quarter is characterized by seasonality within a year. In 2010, there is a significant jump, which is due to the previously mentioned increase in feed prices, and then in 2012, we experience a higher value, which is a consequence of the sow and environmental regulations. It can be clearly seen that the impact of COVID-19 is more moderate here as well, but the extent of the war's market influence is strong.

In the case of Austria, the jumps at the beginning of the previously experienced time series are also visible. It is an interesting fact that, in this case, the increase in volatility values is more likely to occur in the 2nd or 3rd year. quarter. The reason for this may be the more closed internal market, on which the decline in summer breeding performance is more evident. Despite the expected results, the impact of the pandemic is less perceptible, despite the fact that in the case of Austria, the emergence of infections received a strong response, which was offset by significant restrictions in the service industry. The impact of the war can also be measured here, but it is lower compared to, for example, Hungary.

In the case of the European average, we can mainly get an answer to what are the trends that characterize the pig farming of the entire continent. The increase in feed prices at the beginning of the time series and the market uncertainty caused by sector provisions affected the entire sector. An important fact is the significant jump in 2016, which can be traced back to the effect of the embargoes applied to Russia. In this case, due to a joint effect with the 3-year pig cycle, the European pig sector collapsed. Further spikes can be seen from 2019-2020. In this case, the emergence of the pandemic situation can be considered the cause. Finally, as expected, the war significantly affects the industry of the entire continent.

We can also experience the usual tendencies in the case of Integration. In 2010, dioxin contamination in the feed sector had an impact on price volatility. The reason for the significant jump in 2019 is the earlier appearance of the ASF. The integration already had export markets in this period, the limitations of which resulted in strong uncertainty in sales prices. After that, the pandemic effect also appears in the figure. Integration was able to deal with this problem by opening new export markets. At the end of the time series, the effect of the war can also be seen in this case.

Relative variance analysis

Based on the results obtained, it can be said that the trends of specific markets are relatively similar. In 2010, we can see a small difference in the case of Germany (ZMP), which can be traced back to the effect of the dioxin scandal, but even then the indicator remains homogeneous. In other cases, the trends follow each other. As of 2019, we are experiencing heterogeneous market characteristics, which in this case were also due to the emergence of ASF and COVID-19. In addition, it is important to emphasize that the impact of the war, which already shows us a highly volatile market, in all three cases.

In the case of data from Spain, Denmark and Poland, the relationship between the individual data series is relatively similar. From 2014, Spain shows outliers. The reason for this may be the natural cycle within the year, compounded by the embargo introduced during this period, which causes prices to be less harmonious in the case of an export-oriented market. In the future, Poland shows variable values. This may be due to the smaller market size. Furthermore, the effects of war may be more pronounced due to the territorial proximity. It can also be said here that at the beginning of 2022, the value of the coefficient of variation will become highly variable. It is an interesting fact that Denmark follows this trend less, the reason for this being exports to the United Kingdom and Eastern markets.

For Austria, the European average and the Integration curve, we can say that we see a relatively balanced and homogeneous time series for the majority of the time period. One of the biggest jumps can be seen in 2016, when we can say that the European pork sector almost collapsed due to the market influence of the embargo. For this reason, the indicator immediately takes on a heterogeneous value. Another outlier can be seen in 2019. This is due to the emergence of ASF infection. In the case of Integration, the higher value is a consequence of the fact that it works on the basis of annual contracts, so it must follow the corresponding agreements.

Root Mean Square Error

After the time-series-based representation, which mainly examined the trends and market economic influencing factors, I prepared the deviation error sums calculated by the polynomial model, which are presented in Table 2.

Based on the table, it can be said that the market with the smallest error value was Denmark. This fact agrees with the findings of the literature. After that, I took Denmark as a base, compared to this, the market with the second smallest error amount was the Integration market with a 41.58% higher value, which proves the success of the cooperative approach. The Netherlands showed a similarly low value, so here too it can be said that sharp jumps are characterized by quick recovery. Austria and Hungary showed a similar RMSE value compared to the base with a difference of 50-60%. Spain's significant deviation is a relatively unexpected figure, but this may be due to its strong presence on the world market.

Table 2: **Error sums of the polynomial RMSE test for the given markets**

Country	RMSE polinomial	Difference
HUN	28,971	53,34%
GER	34,727	83,81%
NED	27,127	43,58%
SPA	45,157	139,01%
DEN	18,893	0,00%
POL	35,590	88,37%
AUT	30,647	62,21%
EU átlag	29,267	54,91%
Integráció	26,748	41,58%

Source: Own editing based on the internal register data of AKI and Integration, 2023

After examining the deviation curves, I present the calculated results of the RMSE values and the comparison of the individual markets in the case of the moving average-based model as well. This is illustrated in Table 3.

As in the previous results, in this case too, Denmark's mature was outstanding. It is clear that the comprehensive integration of the supply chain and the interest of the producers in the success of the trade lead to the fact that the planning of sales prices, even in the case of the moving average-based model, is particularly accurate compared to other markets. The second value was given by the EU average with a difference of 45%, but it can be highlighted here that this value rather reflects the economic events affecting all relevant countries due to the

continent's market. This is followed by the value of Integration and the Netherlands, which deviates from the base by 55%, so the effect of the organized approach appears here as well. Austria and Hungary represent over 60%. Germany and Poland show a value of around 70%. And Spain 109%, which can also be traced back to the high level of exports here.

Table 3: **The error sums of the moving average-based RMSE test for the given markets**

Country	RMSE moving average	Difference
HUN	18,922	61,54%
GER	20,198	72,43%
NED	18,131	54,79%
SPA	24,505	109,20%
DEN	11,713	0,00%
POL	20,304	73,34%
AUT	19,558	66,97%
EU átlag	17,064	45,68%
Integráció	18,160	55,04%

Source: Own editing based on the internal register data of AKI and Integration, 2023

Price transmission

During the test of asymmetric convergence, the obtained results showed that there was asymmetric price transmission in three cases compared to the weekly sales prices in Germany. The three markets in question were Hungary, Denmark and Poland. In the case of the markets of the other countries, the lack of significance can be explained by the fact that their structure and the design of their market channels differ from the factors directly influenced by Germany.

In the case of paired studies, only the data series of countries showing asymmetric price transmission were included in the comparison. In the case of the Germany-Hungary pair, we can say that the t-1 delay showed significance. Furthermore, ECT (t-1)+ demonstrated rearrangement.

The next pair to be investigated was the German-Denmark market. In this case, we can say that the significance can also be experienced in the case of t-1, t-2, t-3 delays.

The last pair to be examined was the case of Germany-Poland. Regarding this comparison, we can say that there was significance in the case of t-1 and t-2 delays, the adjustment of Polish prices to German prices was observed in a negative direction.

Efficiency analysis

After the calculations assuming individual operating models, by comparing the efficiency indicators, the economic advantage of the producer who is a member of the Integration, in the existing horizontal form and in the cooperation based on joint procurement to be established in the future, compared to the producer operating on the free market, became more appreciable.

The comparison is presented in Table 4.

Table 4: **Comparison of efficiency indicators**

Designation	M.e.	Domestic market	Integration	Member of Integration, joint procurement
Production value	ezer Ft	2 327 632,15	2 349 246,52	2 349 246,52
Direct production cost	ezer Ft	2 277 767,15	2 289 438,10	2 124 447,57
Coverage amount	**ezer Ft**	**49 865,00**	**59 808,42**	**224 798,95**
General cost	ezer Ft	29 536,91	29 536,91	29 536,91
Production cost	ezer Ft	2 307 304,06	2 318 975,01	2 153 984,48
Net income	**ezer Ft**	**20 328,09**	**30 271,51**	**195 262,04**
Direct cost proportional profitability	%	0,89%	1,32%	9,19%
Cost-proportionate profitability	%	0,88%	1,31%	9,07%
Income level	%	100,88%	101,31%	109,07%
Cost level	%	99,13%	98,71%	91,69%
Total cost (fattening)	Ft/kg	747,24	751,02	697,59
EBITDA	**ezer Ft**	**191 276,12**	**201 219,53**	**366 210,06**
EBITDA Margin	%	8,67%	9,04%	16,44%

Source: Own data collection and calculation, 2023

On the basis of the comparison table, it can be stated that the exposure of the free market producer is proven, since in his case only his own produced fattening animals are the basis of the negotiation and fully accept the role of price in relation to trade. Thus, in such a hectic period, where prices are constantly changing, production is only just paying off mainly due to the existence of support, however, in the case of a deferred payment or an increase in feed

prices, it leads to immediate insolvency, which can eat up the current year's profit by using factoring or working capital loans. On the other hand, the net income of the producer joining the Integration is 30% higher. In its case, it was already mentioned that the reason for this is the large integrated stock, which ensures a higher purchase price for trade. The reason for this is that the pigs delivered on the basis of uniform annual contracts have a significant positive influence on the efficiency of the processing plant. Of course, only by calculating the sales price difference, it can be said that in the current economic situation, the given plant also produces a low profit. However, it is important to emphasize that in this case, the guaranteed 14-day payment deadline appears as an advantage that cannot be directly measured in money, which in practice means that the plant does not have to use external sources to overcome possible liquidity problems. Thus, the net income is not reduced by such an economic event.

On the basis of the joint procurement, a very important previous conclusion is confirmed. It can be said that in Hungary, individual agricultural enterprises very rarely carry out their own cost analysis and their efficiency improvement opportunities based on input materials. Even though the table clearly shows that in the case of a pig farm of this size, 10% feed costs and 20% savings are cost-proportional indicators from 1.3%, 9% increases to a value of around , which means that the plant is profitable even without subsidies. It also measurably reduces the cost per kilogram, which is the basis of efficiency and continuous liquidity.

Overall, it can be said that the necessity of increasing integration in Hungary is well proven by the efficiency analysis. In the previous chapters, it was mentioned several times that due to the size of our country, it can minimally influence the market prices. So the reduction of the purchase price of the main cost factors of the successful sector. Which is only possible if we buy a product base of such an extent that we have a strong bargaining position, this and it is only possible through cooperation, and thus we can successfully enter the world market with Hungarian pork.

5. CONCLUSIONS AND RECOMMENDATIONS

During my research, I examined the effect of pig sector integration and herd size from the point of view of changes in sales prices, as well as the influence of sector organization on efficiency. Based on my results, in the case of my hypotheses, I can draw the following conclusion:

H1: A high level of market and sectoral organization and a large volume of uniform stock cause a moderate exposure to market disturbances.

My first hypothesis is answered by the results of the volatility test and RMSE modeling. The results of the volatility test show that markets that have reached a high level of organization and that also have a uniform size of stocks are less exposed to market swings. Furthermore, it is a very important conclusion that the growth of the volatility curve in their case mainly occurs during the period of price increase. This fact shows us that the respective markets can immediately take advantage of a possible increase in demand or price increase, and can react almost weekly, and can also maintain the higher sales price. On the other hand, the volatility curve of smaller organized markets shows spikes mainly in the event of a price drop, which supports the role of price acceptors and the influence of larger market participants. In the case of Integration in Hungary, the above proposition is also confirmed, according to which the increase in volatility values can be paralleled by the price increase, which results in a higher sales price and thus a higher profit.

In the case of RMSE values, most of the obtained results agree with the literature and also follow previous suggestions. Based on this, the model error values of markets with higher organization are lower than those of their more fragmented counterparts. The best example of this is the value of Denmark, which stands out among all. Compared to the results expected based on the literature and previous research, the error sums of Germany, Spain and Hungary can be considered different. The reason for this is the volatility analysis and the specifics of the markets.

In the case of the results in Germany, it can be said that the outstanding value can be traced back to the fact that, in addition to the European market, it also appears on the world market with significant exports, which is why it quickly follows the supply and demand conditions in China and the Far East. Based on this, it can be concluded that in the case of export markets, it can react very quickly to price increases due to its size and organization, which can mean extra income for the players in the product line. It should be noted that the ASF infection in Germany in 2020 radically changed this situation: since then, German prices have largely reflected

internal supply and demand conditions. In the future, this will certainly transform the EU's pork pricing system. German dominance will weaken.

The outstanding values of the sector in Spain can also be traced back to similar reasons. It has the largest pig population in the Union, which is characterized by full sector integration. For these reasons, it is now beginning to separate from the European pig sector. Here, too, it must be emphasized that it follows global market trends and price changes immediately, especially in terms of price increases, so it is able to realize higher profits. It makes good use of its geographical features and historical traditions in its exports. Due to the size of its pig herd, it plays an important role in the global pork trade, carrying out significant exports to the Far East and some Latin American countries.

In the case of Hungary, the results of the statistical analysis show values that are typically similar to those of the leading competitors. This is an apparent contradiction, since the organization of the Hungarian pig sector is significantly lower than that of the previously examined countries. Examining the sector, it can be seen that, apart from minor or major fluctuations, the demand and supply in Hungary is relatively balanced, it completely covers internal consumption and, in addition, live pigs and pork are also exported. The Hungarian pig population accounts for barely 2% of the European pig population, which is why it fully follows European trends. In addition, Hungary is economically a very open country, which is why it cannot develop an internal market integration similar to that of Austria. We can say that the dominant retail chains in the Hungarian food trade are foreign-owned, mainly belonging to German parent companies. The meat trade in the internal markets of the Union has become unified and liberalized at such a level that individual supermarket chains can realize cross-country price optimization with regard to the procurement prices of meat. One of the best examples of this is the widespread use of ZMP price tracking among Hungarian slaughterhouses. In addition, it is important to emphasize that the statements and statistics only take into account the base prices from the point of view of the sales price. In the case of Western European countries, a premium of HUF 30-50/kg can be added to this base value in terms of the final price. In the case of our country, the culture of premiumization related to quality has not developed, so only a fraction of the above premiums is received even after the producer's outstanding pig.

Based on the above, **I retain my first hypothesis (H1).**

H2: The influence of the German (ZMP) price in the sales prices of the continent's market is of decisive importance.

In the case of my second hypothesis, the decision was based on the price transmission study. It can be said that, based on the literature, the German base price (ZMP) is monitored by all major European countries. However, the results of the conducted investigation showed that only the time series showing the markets of Hungary, Denmark and Poland is organically connected to the price in Germany. In the other examined countries, the German base price is also taken into account, however, the formation of the final, weekly base price is adjusted based on local supply and demand. Here too, Spain can be singled out, which was already selected during the prerequisite examination. In this case, too, the explanation is provided by the significant role of pork in the global trade. Based on this, we can state that the European effect of the ZMP base price is weakening due to the continuous decrease of the German pig population and the appearance of the ASF in Germany. It is used as a reference point in the pricing system of individual countries, but is largely corrected by local conditions (supply-demand conditions, export opportunities).

Based on this, **I reject my second hypothesis (H2).**

H3: In the case of the domestic pig sector, the non-producer group, the producers acting as members, are significantly more exposed to the supply and demand effects of the market than the pig farmers producing in the Integration, in terms of purchase prices.

In addition to the previous analyses, the time series analyzes carried out during the doctoral thesis also attempted to compare the Hungarian market channels. In doing so, among the results of the methodologies that take into account market volatility, I mainly tried to compare the prices of the domestic free market and the prices of the Integration, since in this way the organized sales and the producer carrying out their own sales can face each other in the same economic environment. In the case of the volatility analysis, it can be established that the member of the non-producer group plays a continuous price-accepting role, and its market fluctuations mainly occur in connection with price reductions. On the other hand, the Integration time series shows spikes mainly when the management of the producer group reacts to the improvement in demand conditions with a higher sales price, thus achieving a higher profit.

The RMSE analysis also showed that the free market producer can expect a 5-10% higher estimation error in the predictability of his prices. In the Integration, sales are carried out full-

time by professionals who have much more market information compared to non-cooperative members and can use this during their price negotiations. The above proves that well-organized sales and the introduction of a large, homogeneous product base into the market are also reflected in the predictability of the purchase prices.

Based on the results, **I accept my third hypothesis (H3).**

H4: From an efficiency point of view, a member of the Integration can operate more effectively compared to other market players due to the higher sales price resulting from the organization and the planned joint procurement.

It can be said that, in addition to the better market predictability established in the case of the previous hypothesis, the plant operating as a member of the Integration can turn the higher sales price into additional profit on an annual basis. In the event that you only focus strictly on sales prices, we can achieve HUF 10 million higher net income in the case of a pig farm with 1,000 sows. The potential emerging in the development of joint procurement is much more obvious. Here, too, it can be said that an organization with 106 members is already in demand on the input materials market, which can be measured in significant discounts. Based on the literature and the results, it can be said that feed is the most significant cost item in the life of animal breeding sectors. In this way, a discount related to it can increase our cost, and thus our net income, to an enormous extent. In this case, we can say that a 10% feed cost saving for every kilogram produced is a HUF 50 advantage compared to competitors on the free market. Thus, the cost-proportional profitability increases eightfold in this case.

Based on these, **I accept my fourth hypothesis (H4).**

H5: An important inhibiting factor for improving the competitiveness of the domestic pork sector is sectoral disorganization.

In the course of the doctoral thesis, it was established that the sectoral organization in pig farming can be considered vital from the point of view of efficient production. The best example of this is Danish pig farming. Based on the analyzes carried out, it can be considered outstanding in all indicators, so that its stock shows a value of around 10 million pieces. Thanks to the results of cooperation covering the entire product range, the Danish pork sector has achieved a level of efficiency that is capable of outstanding export performance and the distribution of a product that has become known worldwide. Based on the results of the dissertation, the sector of Spain can also be highlighted, in which the expected values were not met, but this precisely

leads to the conclusion that the given sector has undergone such a development in the last 8 years that it is already positioned more in the direction of the world market, and in addition, due to its size, any can react to market events.

From a domestic point of view, the results of the examined integration have been proven, thereby highlighting the importance of the previously mentioned organization. On the other hand, in the case of a producer operating on the free market, there is a continuous competitive disadvantage from both the input and output side, since he cannot establish a significant bargaining position with his issued quantity of a few tens of thousands. Thus, even in the case of a particularly modern, natural indicators and technologically outstanding pig farm, we can say that the high-quality end product is useless if we are at a constant competitive disadvantage in the external economic environment. Overcoming this competitive disadvantage is only possible through sectoral cooperation.

Based on all this, **I accept my fifth hypothesis (H5).**

6. NEW AND NOVEL RESULTS OF THE DISSERTATION

Based on my research, I can formulate the following new and novel results:

1. The finding that Spain's pig industry development and market organization is such that it can appear on the global market in addition to the European market can be considered novel. The efficiency and organization advantage has already been presented in several specialized literature, but it has not yet been analyzed in this form, and the statistical analysis of the relevant flow data is also unique.

2. In the case of the sales prices of the domestic pig sector, several investigations were conducted in a time-series format, however, they mainly compared some other market that typically displays input materials. On the other hand, in this case, the sales prices covered the same product group, thereby comparing major markets in Europe. That way I got an answer to how domestic sales prices compare to competitors.

3. In terms of price analysis and efficiency, I compared the domestic free market and a leading domestic integration, on the basis of which it can be concluded that compared to the 90-97% organization of the competitors, the domestic integration rate of 40% can be considered particularly unfavorable. Producers selling independently are able to achieve worse acceptance prices during their price negotiations, and thus, due to the lower profit, they are limited in implementing their own cost-reducing improvements. Thus, in the long term, they will be at a significant competitive disadvantage compared to their competitors. On the other hand, the interests of the producers gathered in the integration are better enforced, they can get a higher income, and they can also plan to improve their efficiency, and joint procurement can be an additional help for this.

7. PRACTICAL USABILITY OF RESULTS

Before the regime change in Hungary, agriculture was well organized. The subsequent transformation and privatization processes completely overturned the previous vertical integration. In the past 30 years since then, domestic pig farming has been constantly searching for a way forward. Many provisions, studies and researches have been undertaken to solve this problem. In addition, in the production sector, the promotion of an integrated approach and the increase of sectoral concentration can be seen. In the course of these efforts, the mistrust of individual producers was shown in several cases.

I believe that one of the main practical benefits of this thesis is to be found in this. The conducted research reveals the benefits that can be measured in money from the organization of the product path, and also mentions those that cannot be measured in money. Thus, during a critical decision, the given methodology can help to establish its basis through statistical and operational calculations.

Domestic agriculture as a whole and the pig sector are also characterized by the use of established customs, which in many cases lacks statements and cost analysis for the given relevant year, for a longer period of time. From this point of view, the thesis also points out that, in addition to the experience gained in agriculture, it is also important to think that takes into account the economy, since the analysis of our own data can increase our efficiency and competitiveness with minimal time and cost. Furthermore, the best way to utilize the operating capacity and turn it into profit is to join a producer organization, since the management of the given organization has more extensive resources in terms of market information supply.

8. SUMMARY

In my doctoral dissertation, I dealt with the price analysis of the pig sector, paying special attention to the characteristics of each market and how these are related to the organization of the product line and the herd size.

In the case of the agricultural sector in recent years, it can also be stated that globalization and the constantly growing demand for food have greatly transformed the agricultural sector. These changes are also significant in the pig sector. Concentration affected both breeding and final product production. Today, the leading European pig-farming countries have developed comprehensive integrations across the entire product line and across countries, the goal of which is efficient and profit-oriented production. It is now clear that the countries where this sectoral organization did not develop were at a significant competitive disadvantage. Accordingly, one of the main driving forces of my research is what are the factors that contribute to successful pig farming, within which the existence of integration can be considered a key factor.

In my dissertation, I therefore set the goal of a statistical investigation of the sales prices of the European pig sector, and then to carry out efficiency calculations at the level of Hungary.

Another goal of mine was to create a database from the selling prices of pork in the markets of the selected European pig countries and Hungary, which is suitable for running time series analysis methodologies, and thus for examining the predictability and market safety of the individual markets. In the case of Hungary, in addition to the above time series analysis methodologies, I also carried out an efficiency study, thus obtaining an answer to the advantages of integration, which is considered the market leader in Hungary, based on a productive example. After that, I identified the competitiveness problems of the domestic industry.

One of the important points of the doctoral dissertation was the literature review. In this case, I analyzed 180 domestic and international literature sources and professional datasets. In addition, I also reviewed the relevant data lines of the internal register of the leading integration company operating in the domestic pork sector. In the literature review, I presented the pork sector of the world market and the European Union from top to bottom, and I also considered the chronological sequence important, since knowledge of previous periods is essential in many cases to interpret the current situation. After the European literature review, I analyzed the scientific works on Hungary in this perspective.

In addition to the individual pig sectors, I considered it important to process the specialized literature summarizing the integration, as well as to present the previous findings related to the price analysis studies.

When creating the research database, I considered it essential that, in the case of European pig farming, in addition to the leading pig-keeping countries, sectors with a lower size and organization are also included in the study, thus giving a complete picture of the continent's pig sector.

During the time series analysis, the data series presented the sales prices of 685 weeks of capital pigs in the relevant markets.

Based on the time series analysis, it can be concluded that in the case of the analyzed markets, the larger stock size and the high degree of integration showed the equalization of sales prices. The volatility test allows us to conclude that those markets with a higher degree of organization mainly encounter statistical values showing higher market uncertainty when some factor associated with price increases appears on the market. However, with the help of their market power and homogeneous stock, in most cases they can take advantage of this jump and achieve higher profits.

When aggregating the estimation errors, I had to qualify this statement with the fact that outstanding markets such as Germany and Spain show a different picture compared to other European markets. The reason for this is that Spain, in particular, is part of the global market at a level that is already reflected in the results of the statistical indicators.

Based on the tests carried out, Germany's price-influencing role is only partially proven. The movement of prices together appeared mainly in the case of exposed, smaller markets. This can be explained by the fact that the more organized players take the given price into account, but in the creation of the final goods, they also include additional sub-units in addition to the base. In addition, in recent years, due to the ASF infection in Germany, the related export performance has also decreased, which can also be seen in the role of influencing the price.

When analyzing the domestic pig sector, the data of the free market producer and Integration was compared based on statistical and efficiency indicators.

In all cases, the statistical indicators allowed us to conclude that, based on their results, the free market actors are showing an increase in market uncertainty, which is mainly linked to the price drop. This picture is also confirmed by the examination of market predictability, where

compared to the Integration indicator, we get a measurably less favorable value in the case of the free market.

Based on the efficiency analysis, it can also be said that the efficiency indicators of a producer more exposed to market disturbances will be worse than that of its partner producing in Integration. And in the event that a joint procurement is implemented, the cost reduction will reach such a level that the producer of the Integration can produce profitably even without support in the current economic situation.

The results of my thesis highlight that the basis of a competitive pig sector is a high degree of sectoral organization. This has already been recognized by the leading pig farming countries. The best example of this is the case of Denmark, where a high degree of organization concentrates information and data, thereby creating a market that can continuously sell with a more predictable profit, and in addition, its export performance is outstanding compared to its sector size. From a domestic point of view, the acquisition of an integrated approach and the doubling of the current cooperation ratio would be desirable because a stock the size of Hungary can only be successful in domestic market efficiency and exports if this quantity appears on the market as concentrated as possible. It is important for the meat industry to have a uniform, high-quality, relatively large quantity of goods, for which it is even willing to pay a premium price in the long term. This can also improve the competitiveness of the manufacturing industry, and in the long term, a vertical integration between the actors of the product track can develop in Hungary as well. In addition to the above, it can be said in general that one of the breaking points of Hungarian agriculture within the pig sector is the reduction of the cost level and the increase of efficiency. Since they can only have a low influence on sales prices, they can be competitive by reducing the costs used for production. Hungarian agriculture has great opportunities in joint procurement. To this day, the sector is indebted to this, there is very little exemplary cooperation in this area.

I believe that the events of the year 2022 will highlight the dire situation that a worldwide rise in raw material prices can put producers in. With a high level of joint procurement, this price increase can be mitigated to some extent, but it clearly represents a competitive advantage over purchasers outside the organization.

Even in the integration I examined, during the multi-year operation, they mainly concentrated on the organization of sales, the construction of joint procurement only started nowadays, the effects of which will really be appreciated in a few years.

9. PUBLICATIONS MADE ON THE SUBJECT OF THE DISSERTATION

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