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The phenomenon of cyclical fluctuations on the pork market - global perspective

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1. Introduction

Variations of basic macroeconomic variables such as gross domestic product, consumption and investment, the size and structure of employment, price levels etc. are an integral feature of any market economy. These fluctuations may be the result of factors of an accidental nature of changes related to the seasonality of the seasons or the effect of mechanism shaping the business cycle. An important place in economic research deals with periodic oscillations, that involve repeated every few years periods of boom and recession. They define economic prosperity in the long term and for this reason it is important to identify the causes and consequences of such movements. Knowledge of regularities is the basis of creating the state stabilization policy, and at the microeconomic perspective it serves for economic operators as a source of more rational decision. The issue of fluctuations is of particular importance in the agricultural sector, because although its share in national income is falling along with the development of the world economy, it still plays a key role from the point of view of consumers and food producers, as well as

state intervention. Besides, agriculture is the industry in which the fluctuations of economic aggregates are very clear. This sensitivity to changes in the economic situation of agriculture is rooted in cyclical variability of weather, the nature of the adjustment process, as well as the peculiar characteristics of the sector. One could mention the lower elasticity of demand for food, with a large share of the random component shaping the volume of supply, the limited mobility of factors of production, lack of substitutes and long payback period of capital.

A specific mechanism of fluctuations exists on the pork market. The issue of hog cycle was repeatedly raised in the literature, and the first advanced scientific works date back to the 30s of twentieth century. Then the „cobweb theorem" was made known in economic theory, which became the basis for explaining the phenomenon of regular oscillations of supply and prices of pork (Ezekiel 1938, pp. 255-280; Coase, Fowler 1937, pp. 55–82). Because of changes in external conditions (technological progress, the development of market institutions, processes of integration and globalization of the economy) concept presented by M. Ezekiel was not entirely explaining this mechanism, other studies of the cyclical nature of the pig sector began to develop. Further works used, among others, correlation analysis between prices and meat production (Shepherd 1950, pp. 31-32), linear and nonlinear models (eg. Harlow 1960; Shonkwiler, Spreen 1986, pp. 227–233; Holt, Craig 1999) or chaos theory and theory of price expectations (Chavas 1999, pp. 19–37). The talk about the causes of periodic fluctuations in price and supply of pigs and transformation of phenomenon continues today. If we assume that hog cycle is present in today's economy due to the biological nature of production and delays in adjusting supply to prices, it is certain that it changed its character under the influence of structural changes that are taking place in agriculture in global and regional scale. This causes that previously identified mechanisms of cyclical fluctuations may be inadequate to prove the mechanism and it could be difficult today to predict changes in the meat market accurately.

Therefore, the aim of publication was to find answers to the question about today's hog cycle, its ts characteristics and morphology. The hypothesis was that known in the economy since the second half of the nineteenth century hog cycle is also a typical phenomenon in the contemporary economy. State intervention and the development of market institutions have not eliminated cyclical fluctuations, but only mitigated the negative effects of the process. It is also claimed that cyclical supply changes of pig meat are not synchronized between countries. Fluctuations in production are country-specific and are influenced by local conditions related to farm production resources, demand for meat, the

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state intervention and institutional arrangements. While in the case of pork prices there is a characteristic broad convergence of cycle between countries. Development of world trade exchange and economic integration of groups of countries lead to uniformity of cyclical changes in prices.

The study included the world economy and selected countries with the largest share in the global production and/or foreign trade. These countries are: China, United States, EU countries - Germany, Spain, France, Denmark, Poland, the Netherlands, Belgium and Italy, and also Russia and Brazil. Altogether they form approx. 90% of the world supply and almost as much in demand for pork, their participation in the trade is also similar. Thus, the trends in the above-mentioned variables significantly determine the global situation on the pork market. The time range of empirical analysis (analyzing fluctuations in supply and prices) concerned the period 1991-2012. Adopting such a time horizon it is possible to isolate 5-6 complete cycles, making it possible to define the basic characteristics of the pig cycle phenomenon in modern economies. For the isolation of cyclical fluctuations indexes with the variable basis (previous year = 100) and multiplicative models were applied with the form $\hat{y} = f(t) \square c(t)$, where $\hat{y}$ – level of occurrence in the period t; $f(t)$ – function value calculated on the base of the trend in the period t; $c(t)$ – function value of cyclical fluctuations in the period t. The calculation was based on data from the statistical bases of Food and Agriculture Organization of the United Nations (FAO), the Organization for Economic Cooperation and Development (OECD), Eurostat, as well as Internet databases of sectoral organizations and institutions working in the field of agriculture and meat market. This article is a synthesis of a wider research of one of the co-authors, published in the monograph "Hog cycle in the light of changes on the global pig meat market" (Stępień 2015).

2. The essence of hog cycle – literature review

Discussing the issue of pig cycle one should take into account the nature of competition in a market economy. Spontaneous reactions of a large number of farms producing livestock independently of each other, on their own account and risk, must cause the frequent disparities. Reactions to the prices from previous period lead each time to the formation for different market conditions and the characteristic for each of these situations are continuous deviations of the equilibrium in either direction (Pohorille 1972). Despite research on cyclical pig production ongoing for many years one common concept has not been created and we can distinguish two theories. One is looking for sources of cycle

in external factors and the direct reason of the fluctuations is considered as an unstable profitability of farming caused by changes in prices of animal feed and pork meat, inadequate government policy, external factors such as natural disasters or wars, etc. (Shepherd 1942). According to the second, cyclical reasons must be sought in the essence of the cycle (Breimyer 1959). In this case hog cycle is included in so-called special cycles, having their own mechanism, independent of the mechanism of cyclical changes in the economy, although there may be links with other markets, eg. grain market.

Followers of the autonomous nature of the pig cycle indicate many of the features that distinguish it from the general economic cycles. These include in particular the counter direction of price and production course as opposed to economic fluctuations, which are parallel. Fluctuations on the pig market are primarily objective, because they result from such causes as: high fertility of sows, low price and income elasticity of demand for meat, the volatility of livestock and fodder prices, the length of time needed to reach the biological maturity of animals and the length of the investment period. Waving of pigs supply is the result of delayed effects of production in relation to the moment of decision-making, because of technological difficulties in adjusting the size of breeding to changes in demand. Finally, another approach assumes that cyclical changes are the effect of both internal factors and external (Reddy 1999). Mechanism of volatility stems from the essence of the cycle, but it needs external factor (eg. poor harvest) to run it.

In addition, cyclical changes are the result of false expectations of producers in relation to the prices and expected profits in a situation of insufficient information market. Biological and technological reasons for the time lag in supply and imperfect predictions of farmers lead to continuous disproportion between the expected and realized level of production. Accordingly, the definitive source of cyclical changes lies not only in the external factors and internal mechanism, but also in the subjective disposition of the producer and his psyche. It should be added that the farms have virtually no possibility to stop the process of breeding or regulate supply by increasing or reducing the production (except the intensity and duration of fattening).

A synthetic approach of aforementioned concept allows to formulate general conclusions. Pig farming is one of the corn-absorbent directions of livestock production, hence the changes in the pig population have a significant impact on the increase or decrease in the demand for feed grain. Increasing population of pigs means higher demand for grain, which in turn leads to an increase in its prices, thereby increasing feed costs. At the same time, under the influence of an

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increase in supply, prices of pork are going down. The result is a deterioration in the relation between livestock prices and feed prices, which leads to a decline in the profitability of farming. Farmers limit reproduction, selling sows and piglets or increasing the slaughter of fattening pigs. This leads to an increase in the supply of livestock on the market and causes a further decrease in prices. As a result, a few months later, there is a breakdown of the supply of finishers. Appearing excess of demand over supply causes a rapid increase in livestock prices and improving relations between livestock prices and feed prices (which decrease as a result of lower demand), which is the impulse to increase production (Kozłowski 1964, pp. 123-125). This means the beginning of another cycle. One could note therefore the time coincidence of "price hole" and "pig hill". It is the more pronounced the higher the price sensitivity to changes in the supply of pigs.

To conclude, the mechanism of hog cycle can be explained by the fact that the function of livestock supply has a different form than function of livestock demand (Woś 1998, p. 182). These functions are as follows:

The supply function $S_t = F_i$ (hog price$_t$/feed price delayed by 18 ÷ 24 months)
The demand function $D_t = f$ (the hog price in the same month)

Thus, there is a delay in response relative to the cause of an average of 18 to 24 months. This delay is the fact that pig production cannot suddenly increase or decrease. It must be taken into account the fattening period, the period to increase the herd of sows and their farrowing. In addition, a certain amount of time is needed to transform a market stimulus (in the form of price changes) into a production decision. This gives a total period of approximately 18-24 months, corresponding to half the length of one cycle, ie. the length of the phase of growth or decline. Therefore, the overall length of the pig cycle is 3 to 4 years. If you take into account that the irregular changes in the grain harvest generally do not coincide with the cyclical changes in pigs population fluctuations in the prices of both products are inevitable.

3. Cyclical fluctuations of pork meat supply and prices in a global scale

In this chapter Author will try to analyze the hog cycle in some 12 countries around the world. The selection of these countries was deliberate, and the criterion was the participation in the global supply of pork. As indicated in Table 1, the state with the highest number of head and pork production is China. Their share in the global stock in 2012 reached nearly 50%. Subsequently, there were the following: the EU was a region (over 12% share), USA (almost 7%), Brazil (4%) and Russia (less

than 2%). At the same time it is worth noting that among the surveyed economies the share in the total world livestock have raised in China, the United States and Brazil, while in the EU and Russia there was a decline in the share.

Table 1. The pig livestock (million pcs.) and the pork production (thous. tons) in selected countries in the world in 1990 and 2012

Country	1990		2012		1990	2012
	Live-stock	Share in world livestock	Livestock	Share in world livestock	Produc-tion	Produc-tion
China	353,8	41,6%	471,9	48,8%	23559,5	50003,6
EU*, including:	121,5	14,3%	119,1	12,4%	14814,0	18757,8
- Belgium	6,4	0,8%	6,4	0,7%	784,0	1150,0
- Denmark	9,3	1,1%	12,3	1,3%	1208,5	1669,0
- France	12,3	1,4%	13,8	1,4%	1726,8	2179,9
- Spain	16,9	2,0%	25,3	2,6%	1788,8	3466,3
- Netherlands	13,7	1,6%	12,2	1,3%	1661,4	1331,7
- Germany	34,2	4,0%	28,1	2,9%	4457,0	5474,0
- Poland	19,5	2,3%	11,6	1,2%	1854,5	1836,0
- Italy	9,3	1,1%	9,4	1,0%	1333,1	1650,8
USA	53,8	6,3%	66,4	6,9%	6964,0	10555,2
Brazil	18,9	2,2%	38,8	4,0%	1050,0	3464,5
Russian Fed.	43,6	5,1%	17,3	1,8%	3429,1	2559,5

*EU – eight biggest producer of porkmeat.

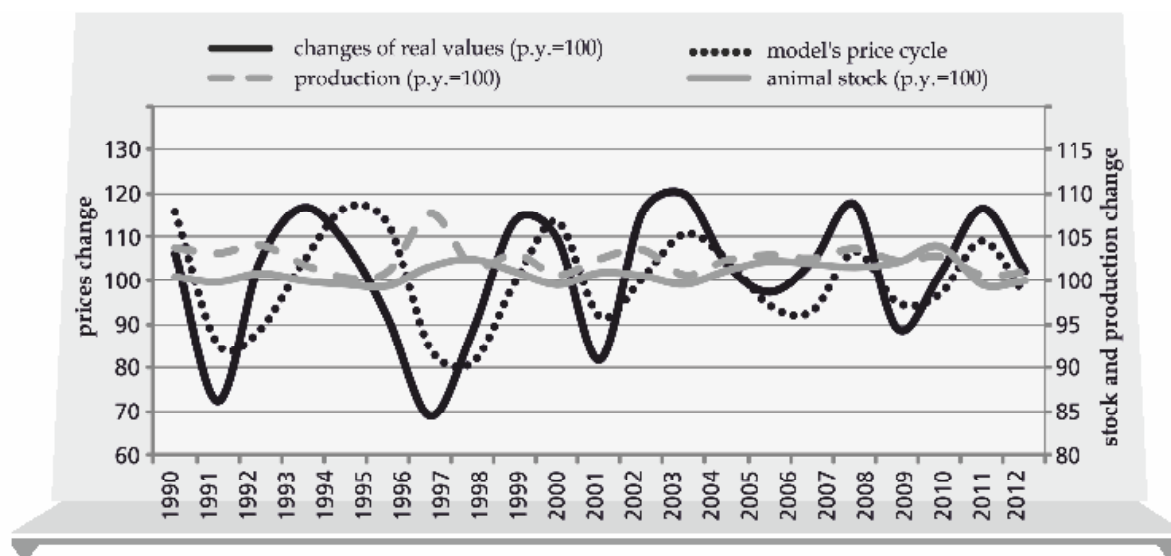**Source:** own study on the basis of FAO 2015 and Eurostat 2015

As a result, the study gave an answer for the question whether known and described almost a century ago pig cycle phenomenon exists in the contemporary world. The answer was not obvious, because today we live in a different reality, in

which the agricultural sector is in contact with previously unknown processes. They are connected with the progressive concentration and specialization of agricultural production, development of vertical and horizontal linkages and cooperation, with the increasing role of environmental factor. Different elements are also macroeconomic factors, regarding global economic downturn, demand for meat, foreign trade, and above all, international integration and globalization. The study showed that despite these changes mechanism of hog cycle is also a typical characteristic of the contemporary economy. Thus the hypothesis was confirmed by research. As for detailed conclusions it can be stated that during the period 1990-2012 the global volume of the number of pigs and pork production increased steadily. This growth was quite regular, but in subsequent years we can observe deviation from the trend line, which is a reflection of cyclical fluctuations. In the process of analysis we received 6 complete cycles of production, with an average length of 3 years and a half. At the same time the volatility in terms of annual growth of the animal stock increased, which was the effect of fluctuations in China (compare figure 1). The participation of this country in the global supply of pork exceeds 50%, thus the situation in the Chinese market determines the cyclical nature of the global population and production (although this relationship is not the case of prices).
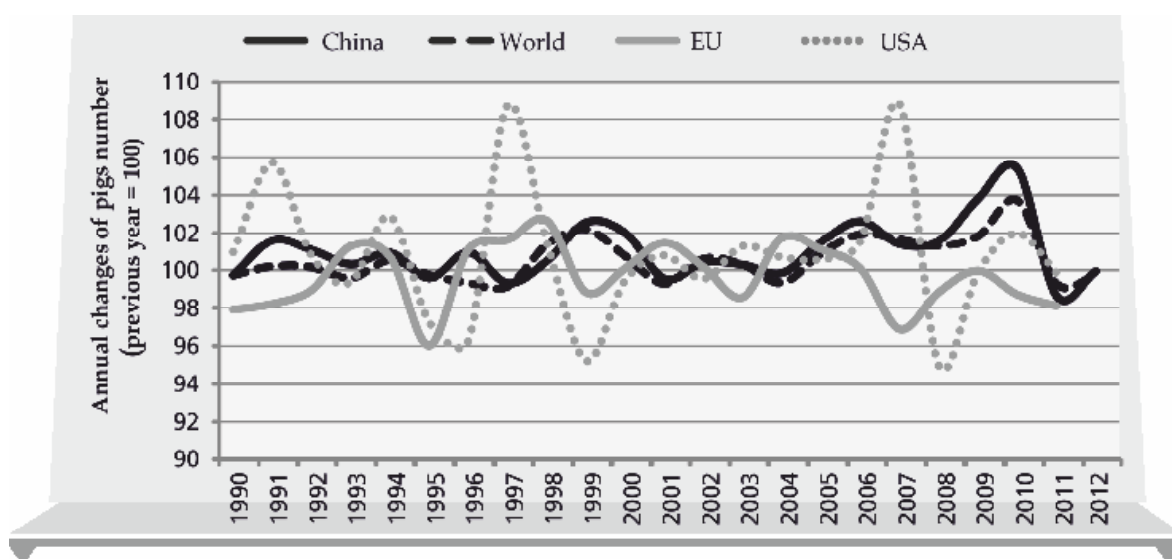
Figure 1. Annual changes of pigs number for China and in a global scale in 1990–2012 on the background of changes in the EU and USA

Source: own study

Figure 2. Changes of pork meat prices (in USD) on the background of changes of pig stock and pork meat production (in carcass weight) in a global scale in 1992-2012

Source: own study on the basis of FAO 2015, OECD 2015 and Eurostat 2015

Table 2. Basic characteristics of the cyclical fluctuations of pigs stock and prices in a global scale (for real values, 1991–2012, previous year =100)

Turning points		Average length of cycle	The amplitude of annual fluc-tuations (base = 100)	Coefficient of varia-tion* (%)	Number of periods, when stock/price	
minimum (years)	maximum (years)				was decreas-ing	was growing
Stock						
1993, 97, 2001, 04, 08, 11	1992, 95, 2000, 03, 10	43 months	<99;104>	1,2	6	16
Prices						
1993, 99, 2002, 06, 09	1996, 2001, 05, 08, 12	48 months	<69;120>	14,5	7	14

* Estimated as a relation of value of the standard deviation to the average value of the time series.

Source: own study on the basis of FAO 2015 and Eurostat 2015

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As for the global price of pork trends could be summarized in two sub-periods. The first covers the period from the 90's. and is characterized by falling prices, the second, after 2000, concerns their growth. At the same time one cycle amounted from 3 to 5 years (average slightly more than 3.5 years) and had relatively high amplitude from 20 to almost 50 points (at the base of 100). Oscillations in prices were much higher than in the case of animal stock and meat production (compare figure 2) – coefficient of variation for changes in prices amounted to 14.5% against 1.2% for stock and 1.6% for production. It can therefore be concluded that reaction to the changing situation on the world pig meat market are primarily price fluctuations, rather than supply oscillations. Table 2 presents the detailed characteristics of the cyclical fluctuations of animal stock and prices in the world.

4. Volatility of production and prices in selected countries in the world

In the following part of the study the situation in the pig meat sector in selected domestic markets. was examined. We tried to verify the hypothesis that the cyclical supply of live pigs is not synchronized between countries, the characteristic is, however, a large convergence of the meat price cycle. The hypothesis was confirmed, as evidenced by the following research results. First, in each of the surveyed countries we distinguished annual fluctuations in the supply of pork. The average length of the cycle for livestock production ranged from 38 months for China to 53 months in the case of Russia, in other countries it was from 40 to 45 months. The lowest amplitude of the fluctuations was recorded for China and Italy, and the highest for the Netherlands. In turn, the coefficient of variation, specifying the level of fluctuation, was the highest in the case of Russia, and besides Netherlands and Poland, the lowest in the case of China and Italy. Other characteristics of the cyclical fluctuations of supply are presented in the table 3.

Although the cyclical nature of supply was a common feature for the economies being evaluated, construction of the hog cycle in terms of changes in the pigs stock and production (volume of fluctuations, the number and length of the cycle, the direction and dynamic of change) was individual for each country (more information: Stępień 2015). There was not a strong and statistically significant correlation for any pairs of countries. This diversity may be the result of internal factors of the state, making the specificity of the region and determining changes in the pork market. Among them one could mention changes in demand for meat, availability of production resources in farms, institutional factors (state policy towards the sector, the integration processes on the market, etc.), availability of

information or random factors, such as epidemics of animal diseases. It was also noted that feed prices have less and less importance in shaping the herd size at the level of individual countries, making it difficult to explain the contemporary hog cycle based on "traditional" reasons.

Table 3. Basic characteristics of cyclical fluctuations of pork meat production in selected countries (data for 1991-2012, previous year =100)

Country	Average cycle length (months)	The amplitude of annual fluctuations (base = 100)	Coefficient of variation (%)	Number of periods, when production:	
				was decreasing	was growing
Belgium	44	<92;115>	4,70	8	14
Brazil	40	<96;119>	5,59	2	20
China	38	<99;108>	2,33	1	21
Denmark	45	<93;110>	4,09	6	16
France	46	<88;112>	4,35	5	17
Germany	40	<86;108>	4,66	8	14
Italy	44	<95;105>	2,37	7	15
Netherlands	39	<85;125>	7,84	13	9
Poland	45	<88;117>	7,82	10	12
Russia	53	<86;114>	8,39	11	11
Spain	40	<94;114>	3,94	3	19
USA	40	<96;110>	3,19	5	17

Source: own study on the basis of FAO 2015 and Eurostat 2015

Secondly, the prices of pork in selected countries were characterized by cyclical movements. However, in contrast to the supply, there was a broad convergence of prices (in direction and dynamic) between countries. For such pairs of economies as France : Belgium, France : Denmark, France : Germany, Belgium : Denmark and Germany : Netherlands similarity in terms of annual fluctuation was the highest (Pearson correlation coefficients above 0,95). Average

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length of one cycle was similar and ranged between 41 and 43 months (compare table 4). With high probability we could confirm the statement that functioning within homogeneous market and/or strengthening trade relations leads to synchronization in hog cycle in terms of pork price fluctuations, but not in terms of supply, because they are conditioned first of all by factors of an internal, national nature (more information: Stępień 2015). This was confirmed by correlation coefficients for the EU and Poland before and after accession, the EU and Russia and the United States and Brazil. Only in the case of China interdependence with other countries is very weak (and not statistically significant). This means that the annual changes in prices in this region are shaped mainly as a result of internal factors, which include, among others, changes in the structure of pig production (concentration and consolidation of farming), developed system of state intervention, susceptibility to crises related to animal diseases, and especially rare in other parts of the world increase in domestic demand for pork.

**Table 4. Basic characteristics of cyclical fluctuations
of pork meat prices in selected countries (data for 1991-2012, previous year =100**

Country	Aver-age cycle length (months)	The amplitude of annual fluctua-tions (base = 100)	Coefficient of variation (%)	Number of periods, when production:	
				was de-creasing	was grow-ing
Belgium	42	<69;123>	15,7	8	13
Brazil	42	<71;133>	18,0	12	9
China	41	<62;224>	31,4	7	14
Denmark	41	<69;123>	14,5	7	14
France	41	<69;119>	14,7	8	13
Germany	42	<67;130>	16,3	7	13
Italy	43	<68;164>	19,4	10	11
Netherlands	41	<64;138>	17,3	8	13
Poland	43	<77;140>	16,2	9	12
Russia	51	<72;156>	20,1	6	15

Spain	42	<70;121>	16,1	9	12
USA	41	<64;137>	18,6	9	12

Source: own study on the basis of FAO 2015 and Eurostat 2015
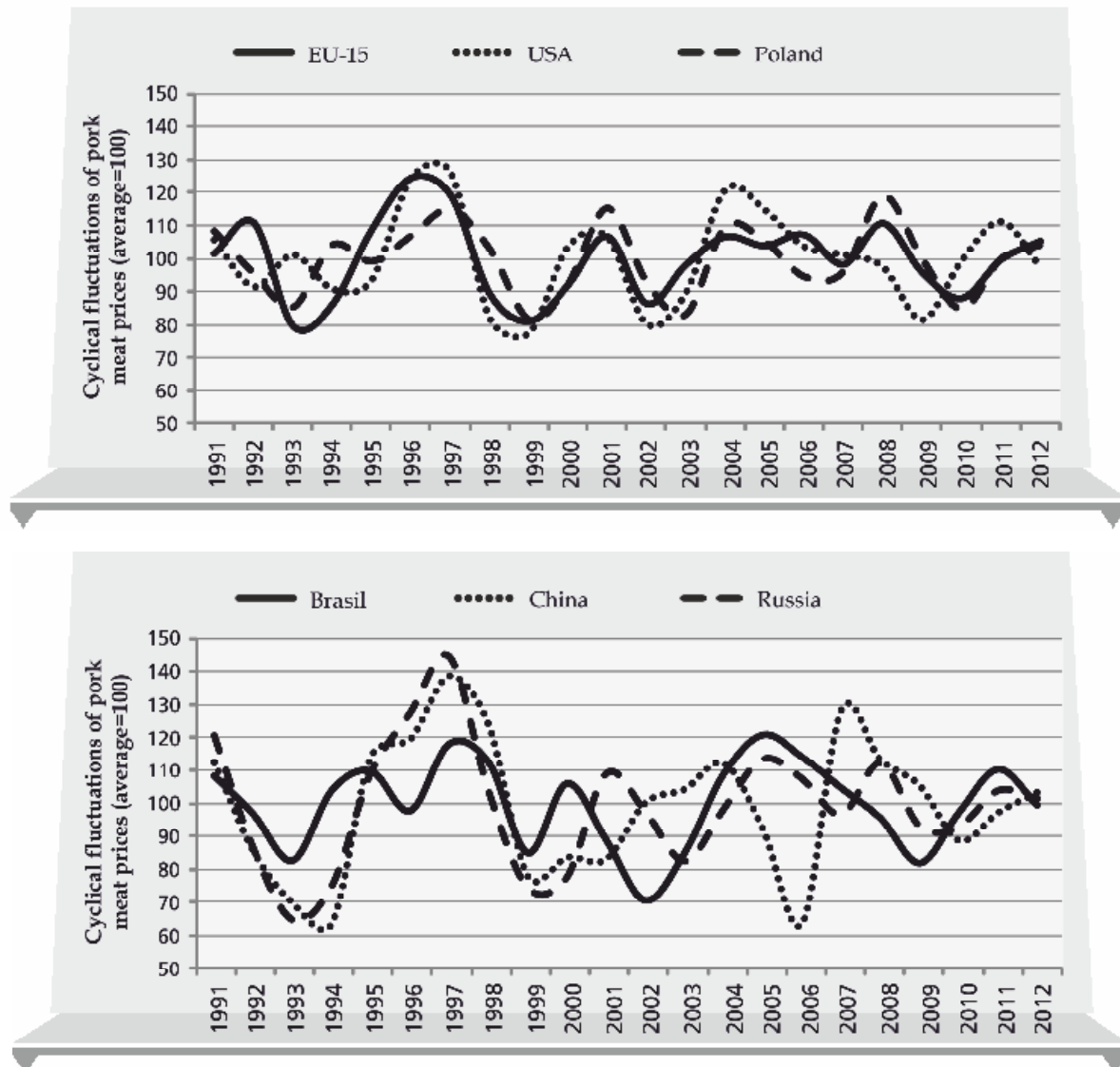
Figure 3. Model of cyclical fluctuations of pork meat prices in selected countries in 1991-2012

Source: own study on the basis of FAO 2015, OECD 2015 and Eurostat 2015

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5. Conclusions

The analysis of time series of pork production and prices indicates the cyclical fluctuations of these two values, both globally and at the level of individual countries. Oscillations of prices were significantly higher than in the case of livestock and pork meat production which suggests that the reaction to the changing situation on the pigs market are primarily price fluctuations, to a lesser extent they relate to the supply. At the same time it is noted that in the case of supply fluctuating there is no relationship between the states. This suggests that the size of production is determined to a greater extent by the internal conditions of the region. There was observed, however, synchronization of cyclical changes in prices for selected groups of countries. Synchronization is the stronger, the stronger the economic relationships of companies surveyed.

Summary

The phenomenon of cyclical fluctuations on the pork market - global perspective

The aim of publication was to recognize the characteristics and morphology of today's hog cycle. The hypothesis was that known in the economy since the second half of the nineteenth century hog cycle is also a typical phenomenon in the contemporary economy. It is also claimed that cyclical supply changes of pig meat are not synchronized between countries. Fluctuations in production are country-specific and are influenced by local conditions. While in the case of pork prices there is a characteristic broad convergence of cycle between countries. Development of world trade exchange and economic integration of groups of countries lead to uniformity of cyclical changes in prices. The study included the world economy and eight selected countries with the largest share in the global production and/or foreign trade. The time range of empirical analysis (analyzing fluctuations in supply and prices) concerned the period 1991-2012.

Key words: *pork meat market, cyclical fluctuations, supply, prices, global perspective.*

Streszczenie

Fenomen wahań cyklicznych na rynku żywca wieprzowego – perspektywa globalna

Celem publikacji jest wskazanie cech i morfologii współczesnego

cyklu świńskiego. Postawiono hipotezę, że znany w ekonomii od II połowy XIX wieku cykl świński jest cechą typową także dla współczesnej gospodarki. Jednocześnie twierdzi się, że wahania cykliczne podaży mięsa wieprzowego nie podlegają synchronizacji pomiędzy państwami. Fluktuacje produkcji są specyficzne dla danego kraju i kształtują się pod wpływem lokalnych uwarunkowań. Natomiast w przypadku cen żywca wieprzowego charakterystyczna jest duża zbieżność cyklu między poszczególnymi krajami. Zwiększenie wymiany handlowej i integracji gospodarczej krajów prowadzi do ujednolicenia cyklicznych zmian cen. Badaniem objęto gospodarkę światową oraz 8 wybranych krajów o największym udziale w globalnej produkcji i/lub handlu zagranicznym mięsem wieprzowym. Zakres czasowy analizy empirycznej (analiza wahań podaży i cen) dotyczy okresu 1991–2012.

Słowa kluczowe:	*rynek żywca wieprzowego, wahania cykliczne, , ceny, podaż, skala globalna.*

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