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Efficiency of meat processing enterprises in terms of supply chain organization[2]

Abstract. Within the framework of the paper, the supply chain participants of meat products were identified and analyzed in terms of the structure. The assessment of the efficiency of meat processing enterprises, which play the role of the chain's integrator, was carried out using the SFA method (Stochastic Frontier Approach). The supply chain integration degree, showing the strength of relationships of individual enterprises with business partners, was identified. The results obtained show high correlation between the integration degree and the efficiency level.

Key words: supply chain, meat products, efficiency

Introduction

The aim of the article was, in the first step, to identify the meat supply chain links and to analyze them in terms of the structure. Secondly, the efficiency assessment of the meat processing enterprises, which play the role of the chain's integrator, was carried out using the SFA method (Stochastic Frontier Approach) and the integration degree within the chain was determined. The integration degree reflects the strength of relationship with trading partners. The supply chain with respect to food products can be defined as "cooperation in different functional areas of agricultural producers, intermediary companies (trade), processing companies, manufacturing, services and their customers, between which flow streams of agri-food products, information, and funds" [Jarzębowski and Klepacki 2013]

The assumptions about the exchange of goods, resulting from the division of labor and specialization were the basis of the analysis conducted within the framework of the paper. As these processes take place on the market (a place where demand meets supply), the analysis of the theoretical base should concern market equilibrium theory, which is a core of the classical theory of economy. During the discussion on the theory, questions regarding the adopted assumptions arose. In theory, it is assumed that consumers have full information on purchased goods, prices and technologies, which essentially precludes the existence of information asymmetry. The prevailing belief is that all actors perfectly fit good quantities, without bearing any transactional costs, the existence of which was presented by R.H. Coase and O.E. Williamson [Coase 1937, 1960; Williamson 1990].

Since the assumptions of market equilibrium theory are not satisfied in economic reality, the functional weaknesses of the market may appear, first of all, as an information asymmetry. The existence of the information asymmetry has been confirmed among others in the theory of market processes (representatives of the Austrian School pointed out the

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unequal distribution of knowledge in society), in the theory of economic development, in which the possibilities to benefit from the advantages of knowledge were highlighted, and in principal - agent theory, which focuses on the problem of entering into agreements under asymmetric information [por. Noga 2009]. Secondly, the existence of transactional costs are classified as market weaknesses, established in the theory by R.H. Coase and O.E. Williamson, who claim that transactional costs affect the evaluation and selection of organizational solutions (integration forms). Moreover, another weakness of the market is the existence of property rights, whose allocation influences the economic system, and their distribution and specification (due to external effects) are associated with increasing transactional costs. Also, the existence of increasing returns to scale is a weakness affecting the possibility of not reaching competitive equilibrium, as it results from the law of large numbers. Based on the literature review, practices that are used in order to counteract the functional weaknesses on the market include, among others: creating relationships with external partners, cooperating with subcontracting third parties, several integration forms, cooperation, collaboration and organization, long-term agreements or creating symbiotic partnerships. These various forms of cooperation occur within the supply chains.

The structure of the meat processing supply chain

In order to indicate the place of meat processing enterprises in the supply chain an analysis of the chain's structure has been carried out. The meat market is one of the largest segments of the food market. Its value (in basic prices at the manufacturer's level) is estimated at about 38 billion zlotys, which is equal to ¼ of the whole food market [Drożdż 2009]. Both red and white meat production and manufacturing is characterized by fragmentation of resource base and the processing [Drożdż 2009]. The Polish meat sector is characterized by low concentration. The following factors determined the meat industry fragmentation [Rycombel 2004]:

- low concentration of pork and beef supply being a result of fragmented agricultural structure,
- an increase in number of enterprises in the meat industry, particularly in the area of slaughter, characterizing by low technical condition and sanitary standards,
- an increasing role of companies intermediating in livestock procurement.

The structure of the meat supply chain includes farmers (suppliers of livestock), purchase and sales, the food processing industry producing meat products, wholesale traders (sale of processed meat to other companies), retail (retail networks, traditional trade) providing meat product for final customers (Figure 1).

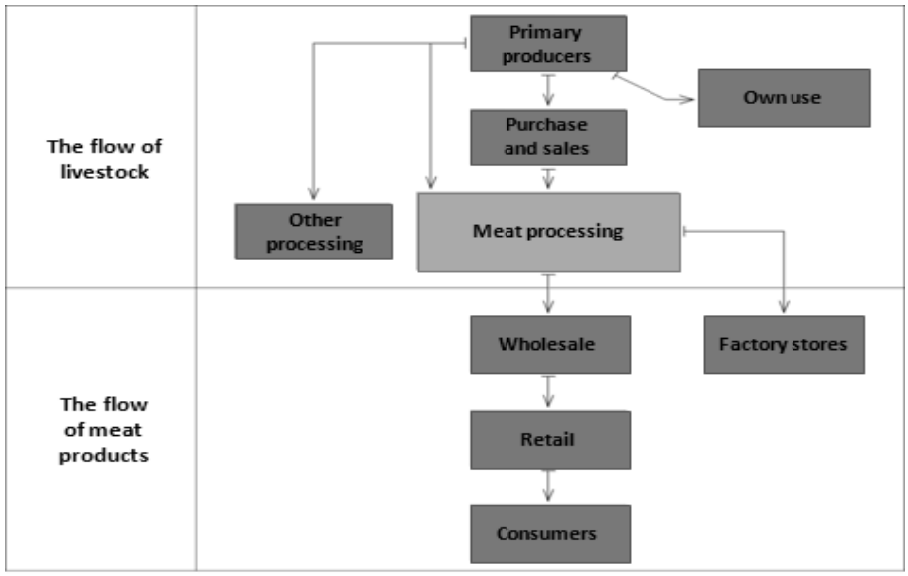

Fig. 1. The structure of the supply chain of meat products

Source: own work.

In the next part of the paper, the individual stages of the supply chain (production, processing, distribution) were presented for pork and beef.

Primary production

In 2010 the largest share in purchase value (45,4%) was observed for pigs – 7732 mln zlotys. Poultry and cattle took the next positions with values of 6246 mln zlotys (36,7%) and 2797 mln zlotys (16,4%). Purchase of calves, horses and sheep (together 1,4%) had marginal significance [GUS 2012].

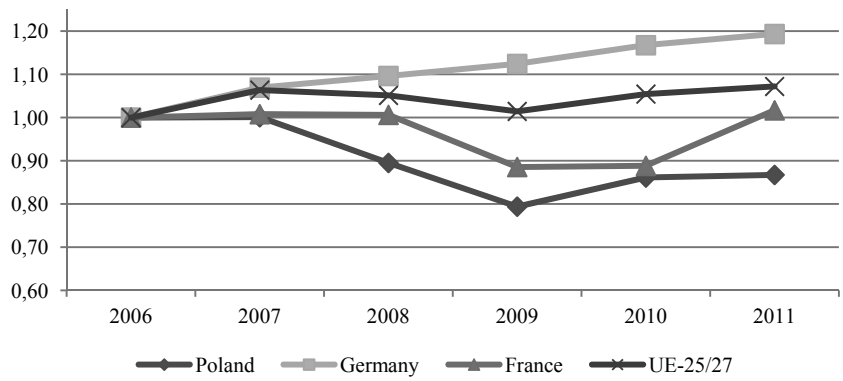

Fig. 2. Dynamics of pork production in thousands tonnes of carcass weight (year 2006 = 100)

Source: own work based on [Małkowski et al. 2012] and [Małkowski et al. 2010].

The dynamics of production of pork and beef in EU-27, including Poland, Germany[3] and France[4] was presented in Figures 2 and 3. The decrease in production was caused by a decline in stock in recent years [Małkowski et al. 2012]. High grain and feed prices were the reason for the decrease in pig population.

In Poland, there has been a stagnation in both population and beef production since a few years. This situation was caused by low domestic demand conditioned by a low-income population, and consequently, poor quality of the offer. The stagnation in beef production was a result of the fact that it is basically a by-product of milk production (which is a leading production) [Małkowski et al. 2012].

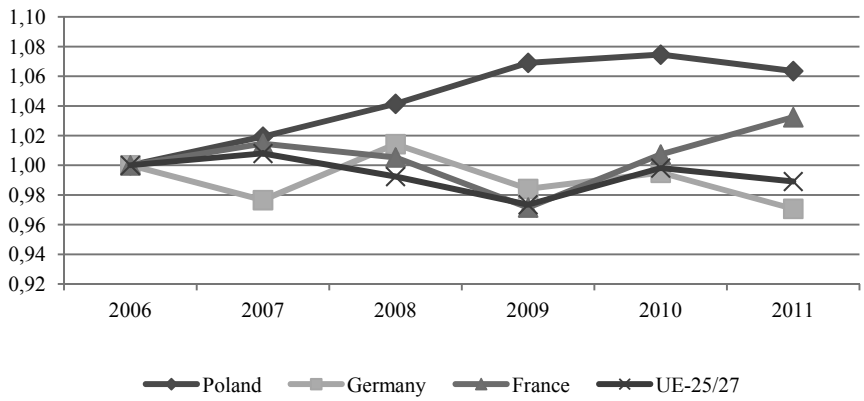

Fig. 3. Dynamics of beef production in thousands tonnes of carcass weight (year 2006 = 100)
Source: own work based on [Małkowski et al. 2012] and [Małkowski et al. 2010].

The purchase of both pork and beef livestock by the processing enterprises is equal to about 80% of production, self-supply in case of pork and beef amounts to respectively 14,5% and 5,5% [GUS 2012].

Processing

In 2009 there were around 3,6 thousand companies (including micro companies) operating in the meat industry (including poultry industry). About 1,1 thousand companies are authorized to trade within the EU market, while others operate only on local and regional markets [Drożdż 2009].

Despite the decrease in farm production levels, there was an increase in the turnover of companies of the meat industry. In 2011 the total revenues of companies reporting financial statements and employing over 9 persons amounted to 32986 mln zlotys and were 5% higher (in current prices) than in the previous year (Figure 4). The source of the increased turnover was not only an increase in sales prices but also an increased processing of imported pork (12,5%) and fast growing trade in foreign goods [Małkowski et al. 2012]. The improvement of results and financial situation of the meat companies allowed them to in-

[3] European leader in pork production.
[4] European leader in beef production.

crease their investment activity. Nevertheless, the technological level of the meat industry is diverse. The production capacity of the industry is used, on average, 50-70% [Rycombel 2004].

The Polish meat industry is highly diverse. The companies range from small local enterprises to large companies, which are part of national or international groups. With strong market fragmentation there is also a lack of sufficient specialization and capacity of some plants. Competition is accompanied by low margins and low profitability, in comparison with the entire food sector [Górnicka 2005]. However, the economic and financial state of the sector generally does not pose a threat for the existence of most meat processing companies.

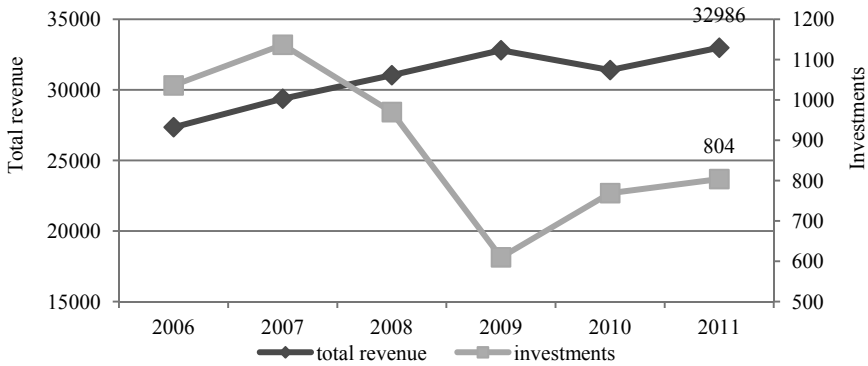

Fig. 4. Total revenues and expenditures in the meat industry (million zł)

Source: own work based on [Małkowski et al. 2012] and [Małkowski et al. 2010].

On the other hand, the expected further decline in the supply of pig livestock and increasing commodity prices may temporarily worsen the financial results of companies [Małkowski et al. 2012].

Distribution

Wholesale trade is a link in the supply chain impending food producers to retailers and consumers. Table 1 shows the characteristics of wholesale companies of food products (including meat products) due to the scale of activity.

Table 1. Changes in the structure of revolutions in wholesale trade enterprises by. employment size

Number of Employees	2002	2005	2007
1	5,7	5,6	5,2
2 - 9	28,1	23,9	21,7
10 - 19	9,2	11,5	7,6
20 - 49	19,7	15,9	14,7
50 - 249	25,4	27,3	31,2
250 and more	11,9	15,7	19,6

Source: Own work based on Annual detailed enterprise statistics on trade, Eurostat.

The presented information shows that there was an increase in importance of the turnover of large and medium enterprises (employing more than 50 persons). In 2007, their share in turnover approached 50%. However, the fact is that wholesale trade in Poland is fragmented.

Retail trade is the last link in the food chain, which is responsible for supplying the final consumer. Analyzing the institutional forms of retailing, it should be highlighted: department stores, trading houses, supermarkets and hypermarkets. Table 2 shows changes in the structure of retail trade in Poland.

Table 2. Changes in the structure of retail trade in Poland by organizational forms

The structure of retail trade – Number of stores					
Specification	2000	2005	2006	2007	2008
Total	431991	385990	395458	371364	385663
Department stores	135	95	91	76	63
Trading houses	500	462	431	372	312
Supermarkets	1602	2716	3003	3506	3629
Hypermarkets	99	374	410	396	463
Petrol stations	7744	10086	10159	9831	10073

Source: Own work based on Rynek wewnętrzny w 2008 r., Informacje i Opracowania Statystyczne, GUS, Warszawa 2008 .

Analysis of the structure and understanding of the competitive behavior of retail requires attention to the development of supermarkets (sales area from 400 to 2500 m^2) and hypermarkets (sales area is over 2500 m^2). Their number is increasing significantly in the last years.

Evaluation of efficiency of the meat processing companies

The study included companies engaged in meat processing. The analyzed period covered 2006-2011. The sample included 195 to 210 companies, depending on the analyzed years. In order to evaluate the efficiency of the companies, the SFA method (Stochastic Frontier Approach) was applied, the variables used to construct the model include on the side of inputs: fixed assets (x_1) and operational costs (x_2), and on the side of outputs: sales revenues (y) expressed in zlotys.

The model specification – SFA

Using the SFA method, the *a priori* identification of a functional form determining the relationship between input(s) and output, is required [Coelli et al. 2005]. In the literature on the efficiency determined based on production function it may be observed that the Cobb-Douglas function is one of the most widely used functional forms in empirical research. As it is shown by J. Piesse and C. Thirtle, the adequacy of the Cobb-Douglas model is tested with respect to a less restrictive form – the translog form [Piesse and Thirtle 2000, pp. 474]. To evaluate efficiency in the meat processing industry within the period 2006-2011, the SFA method was applied based on functions well-established in theory and practice: Cobb-

Douglas and translog. The Cobb-Douglas function was presented in equation (1), and the translog function in equation (2) [Coelli et al. 2005]:

$$\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ij} + v_i - u_i \tag{1}$$

and

$$\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ij} + \frac{1}{2} \sum_{j=1}^{k} \sum_{l=1}^{k} \beta_{jl} \ln x_{ij} \ln x_{il} + v_i - u_i \tag{2}$$

where:
i – index indicating the next object $i=1,...,I$, where I is the number of objects in the sample,
j – index indicating the next input $j=1,...,l$,
k – number of inputs,
y_i – effect of an object i,
x_{ij} – input j in an object i,
β – parameters to be estimated,
v_i – random variable representing the random component,
u_i – positive random component associated with inefficiency (*TE*).

The comparison of the functional form was made based on the likelihood ratio statistics test (LR), which takes the following form

$$LR = -2[\ln L(\hat{\theta}_R) - \ln L(\hat{\theta}_N)] \tag{3}$$

where:
$\ln L(\hat{\theta}_R)$ – logarithm of the maximum likelihood value of the model with restrictions,
$\ln L(\hat{\theta}_N)$ – logarithm of the maximum likelihood value of the model without restrictions.

Based on the results of hypothesis verification concerning the choice of the functional form, it was stated that the proper form describing relations between the adopted inputs and outputs is the Cobb-Douglas model in each of the sectors in all the analyzed periods (at the significance level of less than 0,1). The efficiency was assessed on the basis of the quotient of the observed output (y; equation 1) and the maximum output to be achieved characterized by $exp(v_i)$, denoted by y^* (this value assumes no inefficiency - $u_i=0$), thus the efficiency ratio may be written as [Coelli et al. 2005]:

$$TE_i = \frac{y_i}{y_i^*} = \frac{\exp(\beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ij} + v_i - u_i)}{\exp(\beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ij} + v_i)} = \exp(-u_i) \tag{4}$$

Table 3. Hypothesis verification for the selection of model's functional form

	year	$\ln L(\hat{\theta}_R)$	$\ln L(\hat{\theta}_N)$	LR	result[(1)]	model
Meatt processing	2006	-324,69	-322,25	4,88**	No reason for rejecting H_0	Cobb-Douglas
	2007	-346,47	-344,33	4,28**	No reason for rejecting H0	Cobb-Douglas
	2008	-329,28	-326,27	6,00**	No reason for rejecting H0	Cobb-Douglas
	2009	-346,17	-341,15	10,04*	No reason for rejecting H0	Cobb-Douglas
	2010	-348,03	-342,38	11,30*	No reason for rejecting H0	Cobb-Douglas
	2011	-327,77	-322,37	10,80*	No reason for rejecting H0	Cobb-Douglas

(1) The value of $\chi 2$ distribution for 3[5] degrees of freedom and at the significance level of 0,05 (**) was equal to 7,82; at the significance level of 0,1 (*) was equal to 11,34. If LR*< $\chi 2(3)$, there is no reason for rejecting H_0.

Source: Own calculation, see also [Jarzębowski 2013a].

The efficiency frontier was determined on the basis of the estimation (using the maximum likelihood method[6]) of parameters of production function adopted in the SFA method, i.e. the Cobb-Douglas function.

Efficiency of enterprises and integration within the supply chain

The integration with environment (external organizations) of the system is highlighted (a company is understood as the system). Cooperation is here the main element of the organizational integration of a company with environment [Steffen & Born 1987, pp. 210]. The need for integration between an enterprise and its environment increases with the degree of intensification of global competition. In this context, the concept of integration, considered as a key factor in achieving better results by an enterprise, is one of the most important topics in the scientific literature. N. Fabbe-Costes and M. Jahre, in their literature review, argue that authors generally agree that stronger relationships and higher degrees of integration lead to better business performance [Fabbe-Costes and Jahre 2008]. The efficiency ratios obtained by using the SFA method are presented for empirical illustration for all size groups (Table 4).

On the basis of the results presented in Table 4 one can state that in the analyzed sector in each year the average efficiency ratio increases together with an increase of a company's size[7]. The micro enterprises achieved the efficiency ratio ranging from 0,24 to 0,33; the average ratio for small enterprises ranged from 0,34 to 0,42; the efficiency ratio for medium

[5] The number of the degrees of freedom is equal to the difference in the number of parameters in the model without restrictions (here the translog model) and in the model with restrictions (here the Cobb-Douglas model).

[6] The least squares method and its derivates are the other methods for estimation of the parameters of the production function while determining the efficiency frontier [Coelli et al. 2005].

[7] Due to the fact that the relative efficiency is determined using the SFA method, there is no possibility of comparing the results achieved in the different models. Within the framework of the SFA method, one of the approaches to assess efficiency between years is the creation of a dynamic model for balanced panel data, see. Bezat A. (2011) Estimation of technical efficiency by application of the SFA method for panel data, Scientific Journal Warsaw University of Life Sciences – SGGW, Problems of World Agriculture 2011, Vol. 11, No. 3, pp. 5-13.

enterprises took values from the range 0,40-0,5; in the case of the large enterprises the lowest ratio was equal to 0,48 and the highest – 0,59.

Table 4. Average efficiency ratio calculated by using the SFA method in size groups of enterprises in period 2006-2011

Year/company's size	2006	2007	2008	2009	2010	2011
micro	0,239	0,326	0,266	0,271	0,300	0,307
small	0,378	0,423	0,344	0,362	0,378	0,397
medium	0,493	0,483	0,404	0,494	0,499	0,488
large	0,507	0,483	0,480	0,559	0,564	0,592

Source: Own work.

In the literature, there are studies in which the statement that integration in both directions (upstream and downstream) is more preferable than the integration only with customers or only with suppliers is highlighted. [Frohlich & Westbrook 2001; Rosenzweig et al. 2003]. In order to determine the integration degree in the supply chain reflecting the strength of relations between trading partners, the SCIDM ratio of integration level was applied (Supply Chain Integration's Degree Measure) that includes integration with both suppliers and customers[8].

Table 5. Integration's degree ratio SCIDM in size groups of enterprises within period 2006-2011

Year/company's size	2006	2007	2008	2009	2010	2011
micro	53,2	60,2	59,0	66,3	64,1	63,5
small	82,4	86,0	80,6	85,7	82,0	84,5
medium	105,8	88,9	92,0	110,5	97,8	90,0
large	115,3	101,0	88,1	95,7	104,4	110,8

Source: Own calculation.

Based on the ratio it may be noticed that the average SCIDM ratio increases together with the increase of the company size in each of the analyzed years, i.e. 2006-2011. The Pearson correlation coefficients were determined between the integration degree and the efficiency level. The coefficients ranged from 0,73 in 2008 to 0,79 in 2009. High correlation between two analyzed variables shows that integration (through creation of various form of cooperation) with its environment - so other participant (stages) of meat supply chain, presented in this paper, can lead to better efficiency of meat processing companies.

[8] Due to the size limitations of the paper, the synthetic results were presented. The detailed description of the SCIDM ratio may be find in Jarzębowski S. (2013): Integracja łańcucha dostaw jako element kształtowania efektywności sektora przetwórstwa rolno-spożywczego, Wydawnictwo SGGW, Warsaw.

Summary and conclusions

The basis of the undertaken analyses were the assumptions about the exchange of goods resulting from the division of labor and specialization. Since these processes take place on the market (a place where demand meets supply), the analysis of the theoretical base should concern the market equilibrium theory, which is a core of the classical theory of economy. Since the assumptions of the market equilibrium theory are not satisfied in economic reality, the functional weaknesses of the market may appear, e.g. information asymmetry, transactional costs, the existence of property rights and increasing returns to scale. Practices that are used in order to counteract the functional weaknesses on the market include among others: creating relationships with external partners, cooperating with subcontracting third parties, different integration forms, cooperation, collaboration, organization, long-term agreements or creating symbiotic partnerships. These various forms of cooperation occur within the supply chains. In the paper, the links of the supply chain were identified and analyzed in terms of the structure to indicate the place of analyzed companies in the chain.

In the analytical part of the article, the efficiency of the companies has been assessed by using the SFA method (Stochastic Frontier Approach) and the integration degree in the supply chain has been determined, showing the strength of relations between trading partners. On the basis of the conducted analysis, it was stated that the largest enterprises are characterized by the highest integration degree, these enterprises are also the most efficient ones. This means that mainly large enterprises of the meat processing industry undertake actions aimed at creating relations with external partners, in order to counteract the functional markets weaknesses and to achieve the highest level of efficiency.

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