

Analysis and optimization regarding the activity of a Hungarian Pig Sales and Purchase Cooperation

Balogh, Péter
Ertsey, Imre
Fenyves, Veronika
Nagy, Lajos¹

Abstract

In many ways, the Hungarian pork chain faces considerable disadvantages when compared to the situation in competing countries. In countries endowed with a modern meat chain, heavy concentration is the rule, but in Hungary decentralization still prevails, although thankfully the chain is not disintegrating even further. In our research we used the operation of co-operatives as a model in terms of a generalized network problem. The model allows the quantification of the number of pigs from given farms to slaughterhouses, the maximum sales revenue, the delivery threshold prices, and an analysis of the impact co-operative members exert on sales revenues.

Keywords

pork production, integration, network, linear programming

Introduction

Vertical integration links consecutive economic activities and various functions along the product path which are constructed on one another, and these structures are usually defined by their end-products.

A supply chain is an integrated process where raw materials are acquired, converted into products, and then delivered to the consumer (Csonka and Alpár, 2007). Food supply chains are composed of organisations that are involved in the production and distribution of crop and animal-based products. Supply chains can be divided into two main types (van der Vorst, 2000). First of all, there are supply chains for fresh agricultural products where the product's intrinsic characteristics remain virtually unchanged and then there are supply chains for processed food products where agricultural products are used as raw materials to make processed products with a higher added value.

The situation of processors in agribusiness differs from those in other sectors (Szabó and Bárdos, 2006) as they are working with numerous more or less small suppliers – farmers – who all deliver the same product (Schulze et al., 2006a). For the sake of producing high quality and safe animal products (e.g. meat) the whole chain is to be investigated in terms of research and in terms of production (Talamini and Malafaia, 2006). Among international food industries, the meat sector faces the most public negativity, especially because meat consumption is associated with certain health risks (Binh et al. 2007, Krystallis et al., 2007). The meat process typically involves at least three organisations: producers (farmers), processors and retailers (Simon and Taylor, 2007).

¹ Department of Economic Analysis and Statistics, Faculty of Agricultural Economics and Rural Development, Centre of Agricultural and Technical Sciences, University of Debrecen, Hungary, 4032 Debrecen, Böszörményi street 138., balogh@agr.unideb.hu, ertsey@agr.unideb.hu, fenyves@agr.unideb.hu, nagy@agr.unideb.hu

Theuvsen (2004) claims that in the meat industry the following participants can be identified (Figure 1):

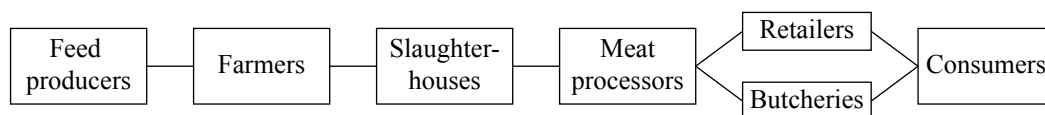


Figure 1: The food chain in the meat sector

Source: Theuvsen, 2004

In recent years, Western European countries have implemented large-scale technological changes (air conditioning, automated feeding, fodder production); therefore acquiring overwhelming advantages over new member states. To rectify this situation, a key requirement is the selection of adequate varieties and variety-specific technologies. Also needed is an improvement in the specific indicator for fodder conversion (fodder-utilization/weight growth) at growing fodder prices. Another noteworthy problem is that the majority of Hungarian pig breeders produce source materials with various genetic backgrounds so quality might radically vary from one breeder to the next. Over the past few years Hungarian genetic potential has completely failed to be renewed. Moreover, biological bases were overexploited, and breeding stock was heterogeneous. The number of breeders was low, the selection base insufficient.

High quality, safe production has to be ensured in the first segment of the animal product chain, i.e. field crop production (Goldsmith and Bender, 2004; Burer et al., 2008). Precise information is needed on soil-conservation methods, the farm's protection environment; and on whether GMO varieties are produced on the given farm (Goel et al., 2005, Beckeman and Skjoldebrand, 2007). Along the production path, the next segment is the animal feedingstuffs industry (Pérez et al., 2005). Besides the feedingstuff components of vegetable origin, industrially produced feedingstuff components and complementary feedingstuffs have to be monitored as well. Moreover, all seed mixture production steps and potential manipulations, including hydrothermic treatment, extrusion, expansion, micronisation, or other feedingstuff treatments in feed-mills have to be monitored. In this way, feedingstuffs produced are delivered to pig farms where all the significant data regarding foraging and fattening must be registered to meet the required quality standards (Kömlösi, 1999; Vigh, 2005). Animals meeting a slaughter live weight requirement are taken to slaughterhouses or to meat processing facilities. Here all the segments of processing are again monitored and these data are registered in the production's path central terminal, where data evaluation indicates irregular activities in certain segments along the production chain or non-compliance with regulations and quality requirements.

At the end of the product path, supermarkets sell goods which are manufactured using designated feedingstuffs meeting quality requirements (Davie and Veeman, 2007; Stringer and Hall, 2007) and which are safe (Backus and King, 2007). Moreover, barcodes permit consumers to test product quality before purchasing them (Babinszky, 2006). In the entire chain every initiative which improves animal performance or reduces the price of the final product (Gorton et al., 2006) is important for the meat industry (Andersen et al., 2005).

In the Hungarian pork chain, market players have to cope with the following current problems (Nyárs, 2007).

Due to geographical and economic-political reasons, Hungarian pork producers cannot compete with their counterparts in countries with developed pork sectors. Hungary's geographical location means that acquiring protein sources is more expensive because of greater transport costs and because Hungary is landlocked exporting pork to a third country is also more expensive (Bartha, 2008).

For social and political reasons, in Hungary the number of crimes against property has grown considerably, and recently established protective-preventive services further increase production costs (Horváth, 2008). The high interest (12%) on foreign capital, plus disorganization in the product cycle and in agricultural extension, also pose problems for Hungarian pig breeders. The ATEV monopoly (Company for the Production of Animal Protein) results in high costs for disposing of dead animals compared to international data. Another major competitive disadvantage is that most Hungarian pig farmers don't possess agricultural land so disposing of pig manure is difficult.

On the other hand, Danish pig farmers are legally obliged to possess land. The current Hungarian Act regarding Arable Land does not permit self-employed animal farms to obtain land so reusing organic substances is practically impossible. Another core problem for the Hungarian pig sector is that the market players are unable to make long-term decisions.

The authors of this paper contend that in today's pig sector it isn't corporations – but integrations, national or regional product paths – that compete against each other. The dynamic concept of profitability dictates that an economic environment characterised by rapid technological change has to be flexible. Is it also imperative to utilise comparative advantages (Dúl Údó, 2007). Competition in the pork sector is based on selling prices, product quality, and on producers' public image. Factors which determine long-term competitiveness are the production path structure, the infrastructure level, human resources, plus the biological and economic environment (Horváth, 2008b). In our present study we have investigated the first factor using as the concrete example of a company involved in production. Following preliminary consultations with the managers of Alföldi Sertés Értékesítő és Beszerző Szövetkezet (Alföld Pig Sales and Purchase Cooperation, APSPC), a model was needed to distribute the animals of varying quality among slaughterhouses with different requirements for the maximization of sales revenues. This model can also be used for other Sales and Purchase Cooperatives or can help in refining cooperatives' existing distribution methods.

Literature review

A historical description of the Hungarian meat chain

Hungarian pig breeding has existed for approximately 60 years, and it can be divided into three clearcut, but basically similar time segments. Moreover, only the segment from 1972 to 1990 can be viewed as acceptable/appropriate in terms of stock population and production level. Out-of-date breeding and foraging conditions characterised the first segment (1950-72) where a lack of intensive breeds exerted a negative influence on the level of production. The second segment was marked by the establishment of industrial farms, expansion of modern breeds, hybrids, and modern foraging technologies. During this period Hungarian pig breeding moved into the forefront of European animal breeding for a period of about 15 years.

Following the 1989 regime change, trends in the Hungarian pork chain clashed with international trends.

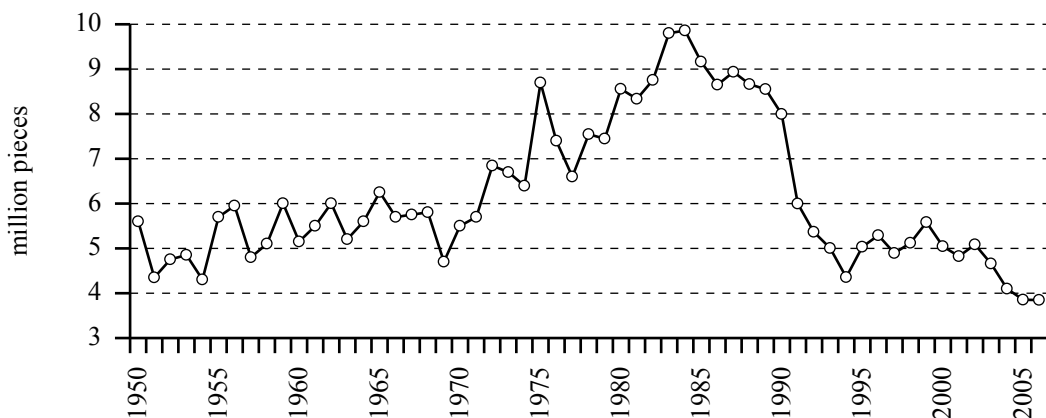


Figure 2: The development of pig stock in Hungary from 1950-2006

Source: Szabó, 2007

Unfortunately, after the 1989 regime change, the Hungarian pig sector actually fell to an even lower level than in the 1950s. This was due to a loss in export markets, technological depreciation on industrial farms, lack of proper farm sizes, and the end of integration in production. Over the past 2 decades the pig population dropped to 40%. The number of sows declined by 3%, and the production of slaughter pigs by more than 3.5%, indicating a cutback in productivity (Figure 2). Simultaneously, the number of pig breeders declined in proportion with pigs produced for slaughter leading to even less concentration.

When Hungarian data are compared with Danish data, one sees that the production of pigs for slaughter increased by 12.8% in the past 30 years and grew from the annual 7 million units in 1975 to 26.6 million, or by 385% in 2006. Meanwhile, as a result of concentration in animal stock, the number of producers plummeted to lower than 10% in the above mentioned period. The Danish pork industry is unique in terms of organization, and is unlikely to copied as it is vertically coordinated through its co-operative structure in the production chain. This characteristic coupled with higher production efficiency provides the whole system with a high level of competitiveness; the key to Danish pork's success. (Selva, 2005; Danske Slagterier, 2007). In 2006 there were 3,600 Danish finishing units, 3,100 breeding-finishing herds, and 750 piglet producers (Beynon and Best, 2007). During the same period a total of 9,500 farmers kept pigs. The majority of these farms either only kept sows with a focus on piglet production, or they only kept fattening pigs and their focus was on meat production. A small portion of the farms were mixed and both kept sows and fatteners (PVE, 2006). Keeping pigs for a given time period, widespread in Western Europe, isn't common in Hungary, but shorter production periods would lessen economic risks. In the same year in Hungary 316 thousand producers were registered, and 78 big farms provided 56% of slaughter pigs for sale. These big farms produce more than 10 thousand pigs/year and represent 0.025% of the total number of farms.

Today in Hungary the pig production path includes 4 segments (Figure 3). The first segment is the production of source materials, which we have already described above. Before Hungary's EU accession, slaughterhouses almost exclusively processed domestic source materials. In previous years, the supply of slaughter pigs continually decreased so slaughterhouses were forced to purchase pigs from abroad. In preceding years, the decline of the pig population was closely related to private farm bankruptcy. In 2006 there was a 1 million drop in the the number of pigs kept by private farms

when compared to 2000, but for economic organizations the drop was only 200 thousand. Producer organizations are weak when it comes to slaughter pig production and sales, numbering perhaps 20-25, located in the country's various regions (Nábrádi, 2007).

In most European countries, (Germany, the Netherlands, Belgium, and France) spot markets, long-term relationships and marketing contracts predominate (Traupe, 2002; Boston et al., 2004; Osinga and Hofstede, 2005; Spiller et al., 2005). In other countries such as the United States and Denmark, and partially in Brazil and Spain, production contracts, contract farming, and vertical integration have largely replaced less integrated forms of pork production (Schulze et al., 2006c; Schulze et al., 2006d). The Danish pig industry has attained a high level of competitiveness mainly thanks to its vertically integrated production chain. Besides reduced transaction costs, this unique form of coordination promotes excellent quality which adjusts quickly to consumer demand (Selva, 2005). In recent years Spanish pig production has become thoroughly professional, employing the most up-to-date technologies, and pig farming is also bolstered by high cereal productivity. Recently established Spanish farms are similar to American farms as they tend to be huge (about 100 thousand pigs) and have low production costs. In Spain vertical integrators are mills and fodder companies that also own animals, and farmers have precise contracts obliging them to feed their pigs with meal supplied by specific mills. The mill and fodder companies have also vertically integrated further along the chain; and an example of this is the slaughter of animals. What's more, they divide their business into cattle and poultry production, an idea adopted from the Tyson model. However, supplying uniform animals through contract farming is only one way of producing homogeneous products in high quantities. During the past years, new sorting technologies combined with the enormous growth in slaughterhouses allowed the same output through pre-slaughter sorting instead of vertical coordination. In Germany, a successful example of this new strategy is Toennies. Toennies, a market leader in packed pork in Germany. They created over 70 different internal classification categories into which the animals were sorted by using automatic classification technology. In the next step, the different batches are divided by automated sorting technologies to produce about 1,000 different, tailor-made products for special market destinations. A processing capacity of 20,000 pigs a day enables the company to produce sufficient quantities of uniform meat without defining homogeneous input factors (Schulze et al., 2006c). Enting and Zonderland (2006) suggest that a lack of trust between primary producers and slaughterhouses is probably the main reason why the Dutch pork industry is so unintegrated. In Germany the situation is the same (Spiller et al., 2005; Schulze et al., 2006b).

The second segment includes slaughterhouses (processing I.), one third of which manufacture meat products as well as slaughter and chop. At this time, the number of purchased slaughter pigs amounted to slightly more than 50% of available slaughter capacities. Approximately 48% of produced slaughter pigs were killed in industrial meat companies, about 18% in slaughterhouses, and 34% in households (Nábrádi and Szűcs, 2004).

In the sector, not only concentration but also specialization has emerged as an important factor. 56% of pigs were primarily processed in slaughterhouses having a capacity of 200 thousand pigs/year, entailing 5% of total farms. On the other hand, in Denmark only 21,178 thousand animals were butchered in 12 slaughterhouses (Nyárs, 2007). Pig slaughter and processing are becoming increasingly separated. The third segment in the production path includes farms which exclusively manufacture meat products (processing II.), do not slaughter pigs, and purchase necessary source materials for production from slaughterhouses.

In the Netherlands there is only slight integration between the processing segment and slaughterhouses. 2003 data show that 88% of the processors do not slaughter pigs themselves, are not affiliated with a slaughterhouse, and do not belong to a business concern involved in slaughtering pigs. They purchase their carcasses from Dutch slaughterhouses or from slaughterhouses in surrounding countries like Germany, Belgium and Luxembourg. Foreign slaughterhouses' market share has reached 20%, a sign of growing internationalisation (PVE, 2004, Hoste and Bondt, 2006). In the Hungarian product path, the number of slaughterhouses exclusively producing for the domestic market is still relatively high. Nowadays, slaughtering pigs in itself is not highly lucrative, and the same holds true for boning and cutting. In fact, only finished products are lucrative (Salamon et al., 2007).

The fourth segment in the production path is domestic consumption and foreign market sales. In this segment there is a wide variety of products which require source materials of varying quality standards. Chain stores offering products customers don't require as well as competition among multinational companies (Nyárs, 2007) serve to lower quality.

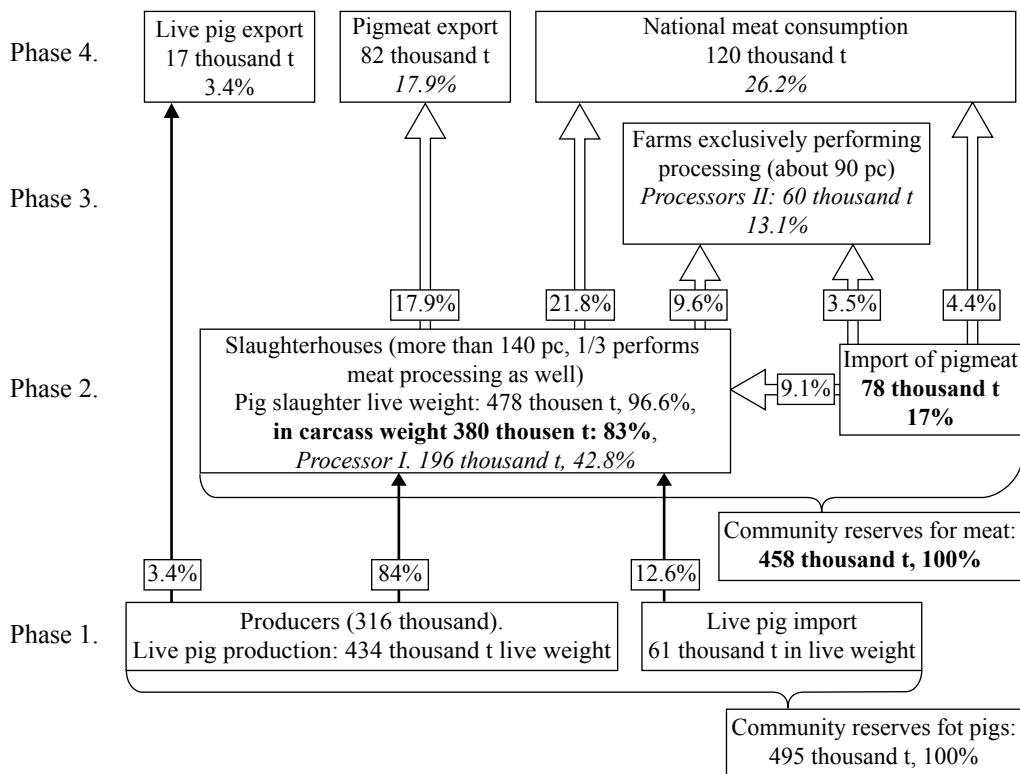


Figure 3: Segments of pork production path and distribution channels in Hungary in 2006

Source: Györe et al., 2007

Methodology

In our research we modelled a purchase and sale co-operative operating in the Northern Great Plain Region. We applied linear programming techniques within a network model. Agricultural programming models have been used in many studies such as Andersen and Stryg, 1976; Meister et al., 1978; and Pomarici and Hanf, 1996. They were also used by Jonasson and Apland, 1997; Vatn et al., 1997; and Helming, 1997. Researchers from many fields previously used the network model, among them Knoke and Kuklinski, 1982, Jonassen et al., 1993, and Iacobucci 1996. Using Winston and Albright's 1997 network model, we endeavoured to obtain an optimal solution. Our concept was very simple: to get each member to the slaughterhouse paying the highest price for the given product quality. This method benefits producers as they can derive higher sales revenue and it also benefits slaughterhouses as they receive their desired product quality

The practical realization of the concept raises two significant questions:

- How to gauge the meat quality of farm animals?
 - Grouping may be based on body weight; however, the actual meat quality parameters for certain animals will only be known after slaughterhouses provide feedback. Here it should be noted that we encountered some producers who were indifferent toward the quality of their animal which, given the current economic situation, was absolutely incomprehensible. 20 years ago English et al., (1988) reported similar cases in Great Britain.
- How to calculate return on sales for member organizations?
 - Within one organization, products having the same quality are delivered for different slaughterhouses and distribution is determined by transport distance.

The second question is the easier one and the co-operative has already found a solution. The members deliver the pigs for the co-operative and equitable distribution is ensured by applying the principle of "same weekly price for same quality". This entails joint risk-taking by the members, and ensures a safer delivery of market surplus. Trust is maintained by the continual control members exercise over management. The co-operative's Price Committee convenes weekly, oversees payment, and each member receives a weekly statement for total sales.

The first question is more difficult to answer. Through analysing previous slaughterhouse qualifications, the various meat quality distribution rates are clearly definable. Slaughterhouse quality categories can be considered uniform, but the system of deductions and bonuses is far from being uniform. Table 1 presents the primary factors influencing average prices. The basic principle is more or less the same for various slaughterhouses, but the prices and parameters that influence prices are varied.

In our network model nodes include pig farms and slaughterhouses and arcs represent the amount to be delivered (Figure 4). On the arcs we indicate the price of one pig delivered from a farm to a given slaughterhouse.

On the basis of previous qualifications the definable data regarding farms are the following:

- SEUROP quality rates, expected average delivery weight, carcass weight from this
- By using the expected average delivery weight and earlier standard deviation values, the rate and body mass of animals having lower than the standard body weight can be estimated

- Corresponding with the previous point, calculations are also performed for potentially overweight animals
- Condemnation is estimated

Table 1

Definition of average sales price

S	Basic price (Live weight – deductions = carcase weight)
E	
U	
R	
O	
P	
Cull 1	Price reduction for animals of small weight – out of P category
Cull 2	Price reduction for animals of small weight – out of U category
Overweight animals	Average price of the all above mentioned categories – price reduction
Condemnation	

Source: Authors' own creation

Based on the above statement, and taking the contracted slaughterhouse parameters into consideration, in every aspect the average sales price is calculable and, from this, one arrives at the average sales price for one pig.

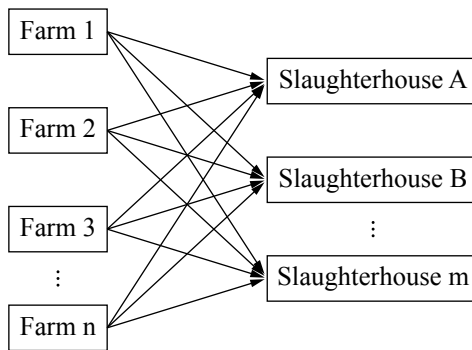


Figure 4: The schematic model of distribution

Source: Authors' own creation

The variables within the model are the network arcs, meaning, there will be as many variables as there are links which can be created between farms and slaughterhouses. Based on the above data, the model's target function can be determined:

$$\sum_{i=1}^n \sum_{j=1}^m p_{ij} x_{ij} \Rightarrow \text{MAX!} \quad (i = 1, 2, \dots, n; j = 1, 2, \dots, m) \tag{1}$$

where

p_{ij} = the average price of pigs delivered from farm i to slaughterhouse j

x_{ij} = the average number of pigs delivered from farm i to slaughterhouse j

The constraints are defined by nodes, separately for farms and separately for slaughterhouses. For farms the total output from a farm equals the volume for delivery if the whole quantity for delivery from all the farms is lower than or equal to the quantity for delivery; otherwise a lower limit is specified. For slaughterhouses, conditions will have an upper limit.

Constraints for farms:

$$-\sum x_{ij} = -T_i \text{ if } \sum T_i \leq \sum S_j \quad (2)$$

$$-\sum x_{ij} \geq -T_i \text{ if } \sum T_i > \sum S_j \quad (3)$$

where

x_{ij} = quantity flowing on arcs towards slaughterhouse j

T_i = the number of pigs to be delivered from farm i

S_j = demand of slaughterhouse j

$$\sum x_{ij} \leq S_j \quad (4)$$

where

x_{ij} = quantity flowing on arcs towards slaughterhouse j

This model is a linear programming (LP) application with 110 variables and 32 constraints. The solution requires extensive vulnerability studies. The coefficient shadow prices in the target function, and the values of permissible increases and decreases, present the threshold prices for certain delivery relations and the lower and upper limits, which can include the target functions' variations' values without modifying the optimal solution. The shadow prices related to the variables may allow evaluating the influence for the potential expansion or restriction of certain delivery relations on the sales revenues. The Co-operative members' influence on sales revenues can be analysed by "What if ..." examinations. The negative feedback from the information can inform and increase safety for the network members, which in turn facilitates production of homogenous end-products and the preservation of the farms' competitiveness.

The network model was based on a 5-week time frame, starting from the 2nd week of August in 2007. On the basis of APSPC data, 11 producers delivered their products to 5 slaughterhouses. Using producers' information the model's data can be continually updated, so it is also readily applicable for weekly optimization. Each farm and slaughterhouse represents two nodes in the network, allowing simultaneous optimization for fattening pigs and culled sows. Thus, one can receive data on the number of pigs to be delivered from certain farms to certain slaughterhouses, the total potential maximum revenue from sales, and after breaking it down, revenues for individual farms as well.

The network model's basic data include members' information on the anticipated quality and weight, and also prices and quality deductions related to various quality categories provided by slaughterhouses. When comparing the findings of the model to the actual sales data, we took the following items into consideration:

- the number of pigs calculated in specific farm/slaughterhouse relations
- for sold mass, we used the mass which was actually transported
- instead of using farm forecasts' anticipated **quality**, we considered those provided by slaughterhouses.

These modifications allowed a realistic evaluation of the model results.

Results and discussion

Introduction of the APSPC

In 2005 19 producer groups were granted official recognition. On average they had 30 members, and they produced 85,000 t i.e. HUF 22 billion, about 20% of Hungarian pig production. In 2007 there were 21 officially recognised pig producer groups in Hungary; four of which held preliminary recognition. On 20 February 2003 the APSPC was established, and at that time it had 26 members. From June 2003 the Co-operative has performed joint pig sales. Table 2 presents sales over the past 5 years.

Based on 2005 data, one observes that 40% of the production from Hungarian producer groups derive from the APSPC. Since inception the Co-operative's share of produced domestic pigs has been increasing, improving the Co-op members' position. It is important to emphasize that the Co-op members do not sell their pigs under one name, but hand them over for distribution to the Co-operative.

Table 2

APSC Pig sales in 2003-2007

Name	2003	2004	2005	2006	2007
Number of members	32	33	36	35	40
Sold animals	152,109	288,992	273,590	290,641	350,000
Sold (t)	16,948	30,443	32,244	33,482	40,250
Revenue on sales (million HUF)	4,128	8,944	9,123	10,104	11,753

Source: APSPC, 2007

Figure 5 indicates the Co-op's growing strength. The network nodes include breeder' organizations, pig farms, and slaughterhouses. 4 different levels reflect their roles in the network. Level 0. shows the replacement of foodstuffs and breeding materials, level 1. the production of own source material for breeding, and level 2. production destined for market. Level 3. again represents slaughterhouses.

The network arcs indicate the major input and output factors branching into certain nodes. For breeding purposes, producer organizations only send their gilts or sperm breeding to the Co-operative's breeding farms. The breeding farms supply gilts to farms whose production is headed for market. The Co-operative includes two types of farms producing for the market. In the first type the entire rearing process occurs in a specialized farm, which in our model was indicated as a complete farm.. Nowadays it is very rare for specialized farms to keep breeding boars, and most often the necessary sperm volume for mating is acquired from a separate boar farm. There are also special fattening farms where weaned piglets are placed and processes occur from battery and last until the end of the fattening period. As previously mentioned, the most significant breeding farm product is the production of young pigs for breeding purposes, and cull sows or animals not suitable for further breeding are directly delivered to slaughterhouses. The complete and fattening farms' major products are fattening pigs, but of course they also have technological culls, which are sold at reduced prices. Naturally, on special fattening farms the incoming input is weaned piglet. For all three types of farms, feedingstuffs from feed mills are a major factor as foraging costs basically determine the the farm's income.

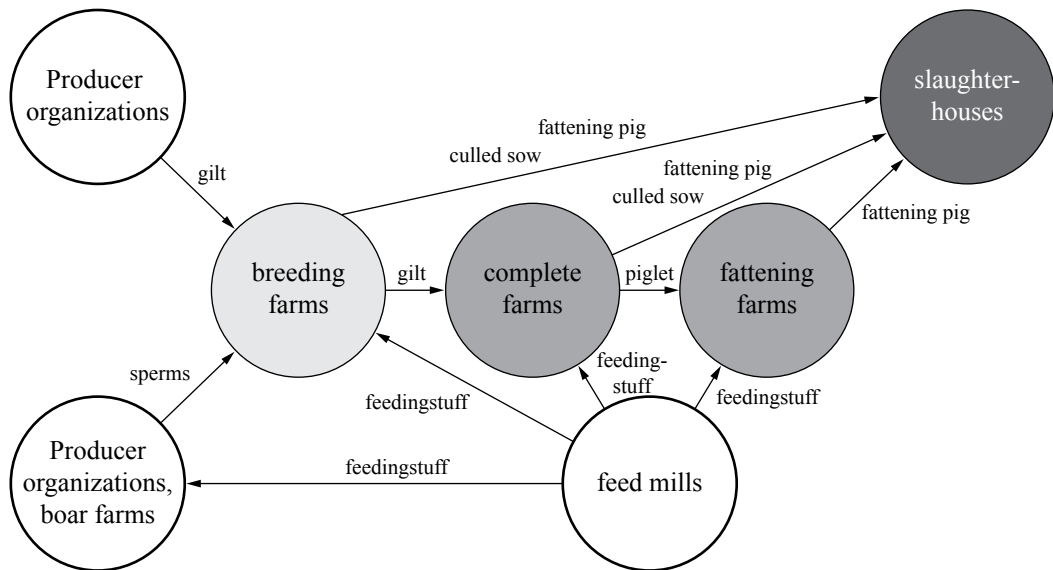


Figure 5: Schematic model of certain network nodes

Source: Authors' own creation

Figure 5 presents the network's schematic processes. In the "sample" co-operative animal stocks have varied genetic potential. As a result, the turnover between breeding animals and farms is only true for a specific breed or hybrid. Fattening farms receive their piglets from farms dealing in breeding animal production. Other than the technical reasons for breeding, this also reflects the importance of animal health and logistic considerations.

Within the current regulations, the APSPC can represent the members' interests regarding sales. The APSPC's superior bargaining position stems from the quantity of slaughter animals it produces, and can thus obtain better prices than the Hungarian average. It should be noted that slaughterhouses often offer different prices for equal quality goods at the same time. It frequently happens that slaughterhouses periodically or permanently offer more than actual market prices for animals of inferior quality or of greater body mass. The reasons for this may vary. The present study does not analyse this issue, but it includes supply and demand consumer relations, processing industry demand or existing stocks placed in cold storage. Figure 6 presents the monthly 2007 average prices of E, U and R quality categories from three (A, B, C) slaughterhouses. If one traces the price formation, one sees that in January slaughterhouse C purchased at the highest price for all three meat quality categories. In February the situation was more balanced, as slaughterhouse A offered the highest price for categories E and U, whereas slaughterhouse C offered the lowest price for category R. This price fluctuation was observable for all slaughterhouses and meat quality categories throughout the entire year. It seems natural that a given contract inherently direct goods to the slaughterhouses paying the highest price. However, it should be noted that slaughterhouses and farmers stipulate the quantities to be delivered within the framework of agreements which can only be derogated without a financial penalty when justified. However, the fundamental ethical norms of fair market behaviour must be met.

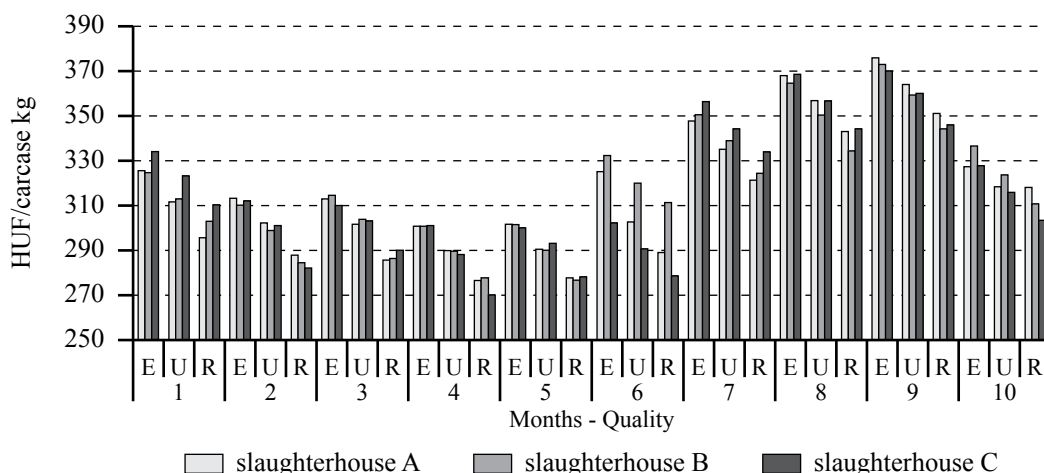


Figure 6: Formation of pig carcass prices in three slaughterhouses for E, U and R quality categories in January-November 2007

Source: Authors' own creation

How can the positive aspects of market price fluctuations serve to increase sales revenues?

For a farm the only method may be concluding exclusively short-term contracts and always selling end products to the buyer offering the highest price. In the short run this may be a useful method, but in a supply position the farm runs the risk of not finding a buyer, thus increasing risk to the point that it endangers the enterprise's existence. Long-term contracts reduce market risk; however, low volumes mean inability to capitalize on price fluctuations, which increases their vulnerability.

Table 3 indicates sales revenues during the study period, calculated on the model and the Co-operative's actual sales revenues. Sales revenue data clearly showed that for a considerable amount of sales volume applying simple network models permits the Co-op to take advantage of price fluctuations stemming from various slaughterhouse quality requirements, thus allowing surplus revenues to be gained. Moreover, further gains can be realised by more accurate meat quality forecasts, and this phenomenon explained the necessity for modifying the model data. Basically, in each case these corrections reduced the model's target function value. Unfortunately, farms lack the necessary measuring techniques and therefore mostly rely on earlier period data and their own experience.

Table 3

The development of actual sales revenue before and after optimization in the study period (million HUF)

Denomination		1. week	2. week	3. week	4. week	5. week	Total
Fattening pig	Sales revenues of optimization	93.5	78.4	114.7	90.4	123.5	500.5
	Actual sales revenues	91.2	77.0	112.6	87.9	120.2	488.9
Culled sow	Sales revenues of optimization	6.4	3.9	5.5	4.2	7.1	27.1
	Actual sales revenues	6.3	3.6	5.4	4.0	6.7	26.0
Surplus sales revenues by optimization million HUF		2.4	1.6	2.2	2.7	3.7	12.6
percent		2.4	2.0	1.8	2.9	2.8	2.4

Source: Authors' own calculation

Table 4 indicates the reduced costs of some variables and related information, which the Co-op's management emphasize, but are not included in the optimal solution. Certain relations cannot be compared in terms of calculated reduced costs because they are calculated for an individual animal. However, this comparison may be made for average carcass weight. The findings suggest that farm 10. can ship products to slaughterhouses B, C and D only when sales revenues calculated in the optimal solution decrease in the cooperative.

Table 4

Development of the reduced costs of some variables in the model of week 1.

Relation of transport	Number of pieces for transport	Final value pc	Reduced cost HUF/pc	Coefficient of target function HUF/pc	Reduced cost HUF/kg	Average price HUF/kg	Upper limit HUF/kg
Farm 1 - slaughterhouse B	0	0	-190.0	36,638.8	-1.8	355.54	357.39
Farm 3 - slaughterhouse B	0	0	-117.7	32,637.6	-1.3	359.90	361.20
Farm 5 - slaughterhouse B	0	0	-158.7	39,532.7	-1.4	357.86	359.30
Farm 7 - slaughterhouse B	0	0	-102.3	34,015.1	-1.1	361.93	363.02
Farm10 - slaughterhouse B	0	0	-225.8	40,472.7	-2.0	350.67	352.62
Farm 11 - slaughterhouse B	0	0	-105.3	35,354.1	-1.1	357.37	358.44
Farm 10 - slaughterhouse C	0	0	-260.8	40,748.5	-2.3	353.06	355.32
Farm 10 - slaughterhouse D	0	0	-221.7	41,064.3	-1.9	355.79	357.71
Farm 2 - slaughterhouse E	0	0	-109.7	38,902.0	-1.0	362.99	364.01

Source: Authors' own calculation

In Table 5 shadow prices as model solutions show the amount of money by which additional transports from certain farms increase income. The sensitivity report basically calculates this amount for one pig, but as with reduced costs, it can easily be converted into a kg/HUF unit regarding average weights. In Table 3, optimized sales revenues from pigs which have been assigned a quality category is 93.548 thousand HUF in the first week, and the marketed quantity is 2,655 pigs with a carcass weight of 257,032 kg based on the model's data, yielding an average market price of 363.96 HUF/kg.

Analysing Table 5 clearly shows that extending capacity in farms 2, 6 and 9 would increase sales revenues, as shadow prices for 1 kg of weight are higher here than current average prices; however, if farm 10's transport capacities are extended, average prices can be substantially reduced. Statements regarding reduced costs already projected the conclusions for farm 10.

Table 5

Shadow prices of net flow boundaries related to quality pig sales in the model of week 1.

Cell	Name	Final value pc	Shadow price for 1 pig	Right side of condition pc	Allowable increase pc	Allowable decrease pc	Shadow price for 1 kg weight
\$L\$9	net flow of 1. farm	-320	-36,705	-320	60	255	-356.19
\$L\$10	net flow of 2. farm	-270	-39,012	-270	40	80	-364.01
\$L\$11	net flow of 3. farm	-450	-32,632	-450	60	255	-359.84
\$L\$12	net flow of 4. farm	-100	-31,804	-100	100	255	-360.54
\$L\$13	net flow of 5. farm	-200	-39,568	-200	200	255	-358.18
\$L\$14	net flow of 6. farm	-360	-30,970	-360	40	80	-364.72
\$L\$15	net flow of 7. farm	-120	-33,994	-120	40	255	-361.71
\$L\$16	net flow of 8. farm	-250	-34,700	-250	40	80	-362.86
\$L\$17	net flow of 9. farm	-320	-31,913	-320	40	80	-365.20
\$L\$18	net flow of 10. farm	-210	-40,575	-210	210	255	-351.55
\$L\$19	net flow of 11. farm	-55	-35,336	-55	55	255	-357.19

Source: Authors' own calculations

Table 6 reveals data from a sensitivity report regarding slaughterhouse boundaries. Slaughterhouse 6's demands will be fulfilled, while the other slaughterhouses will receive the required quantities. Comparing A, B, C, D slaughterhouse shadow prices clearly indicates that if a sequence is to be set up for potential excess or re-grouped quantities, the sequence of D – A – C – B slaughterhouses seems to be acceptable (the sequence of D – C – A – B seems unacceptable, as A shadow prices are lower than that of C; however, its allowable increase is higher).

Table 6

Shadow prices of slaughterhouse net flow boundaries related to quality pig sales in the model of week 1.

Cell	Name	Final value pc	Shadow price for 1 pig	Right side of condition pc	Allowable increase pc	Shadow price for 1 kg weight
\$L\$4	Slaughterhouse A	750	374	750	60	255
\$L\$5	Slaughterhouse B	250	124	250	40	80
\$L\$6	Slaughterhouse C	480	434	480	40	80
\$L\$7	Slaughterhouse D	550	711	550	40	80
\$L\$8	Slaughterhouse E	625	0	880	1E+30	255

Source: Authors' own calculation

Conclusions

Following the 1990 political transformation, the Hungarian pig population plummeted, and this tendency has continued ever since. The reasons for this decline were loss of export markets, outdated industrial farms, smaller plant sizes, and a halt in production integration. Today some of these factors are still in play, but since 2003 a majority of producers have joined producer groups having greater potential to further their own interests. Having to comply with environmental and animal protection requirements places a burden on pig farmers. Other significant factors are exceedingly high feedingstuff prices, coupled with low 2007 pork prices. Together these factors have driven the pig population to a historic low. In Hungary the pre-90s vertical integration level has disappeared. It does, however, still exist in highly developed European countries. Pig farmers have little bargaining clout when dealing with slaughterhouses and meat processors, who in turn have little clout when dealing with multinational commercial chains. Only a small proportion of the Hungarian pig population is processed within this closed chain which consists of: feedingstuff production – feedingstuff manufacture – pig keeping – slaughtering – processing – distributing meat and meat products, which is controlled by producers.

Based on previous statements in this paper, one can conclude that there simply isn't an integrated supply chain in the Hungarian pork product chain. The emergence of a supply chain implies at best only a strengthening of vertical relations or possible movement in a strategic direction. A product chain member's enhanced economic position means the member generally shapes and manages relations and, as a participant, fully comprehends the chain's mechanisms. Accepting this unilateral and informal situation as inevitable fact preserves product chain anomalies and causes low efficiency. Therefore, supply chain integration is crucial for the future competitiveness of the Hungarian pork sector.

These issues motivated us to develop a maximization of sales revenues model in order to help Hungarian pig farmers. Mathematically the model is simple and its practical application seems straightforward. However, its realization is hampered by farm record deficiency as it makes calculating anticipated quality and average prices uncertain. By providing production information feedback, the APSPC permits even farmers at the lower end of the production scale to produce better quality and more homogeneous source material for slaughter, thus allowing them to achieve higher revenues. Applying the model generates more revenue, and this gives farmers the potential to survive bad years such as 2007 and to actually improve and prosper in good years.

Thus, the long-term prospects for Hungarian farming could become smoother and more balanced, improving production and profit security for members all along the chain. However, it is essential that political decision-makers create regulations ensuring that, throughout the chain, members are cognisant of quality requirements.

Acknowledgements

I would like to thank Sándor Mészáros, Gábor Szabó and Levente Nyárs for their comments on earlier drafts of this paper. The research was supported by OTKA No. F 62949.

References

1. **Andersen, F. and Stryg, P. E.** (1976): "Inter-regional recursive LP model used in forecasting Danish agricultural development up to 1985." *European Review of Agricultural Economics* 1. 3:7-21.
2. **Andersen, H. J.; Oksbjerg, N. and Therkildsen, M.** (2005): Potential quality control tools in the production of fresh pork, beef and lamb demanded by the European society *Livestock Production Science* 94. pp. 105–124.
3. **APSPC**, (2007): Personal communication
4. **Babinszky, L.** (2006): Compound feed as a factor influencing food quality and safety. *Acta Agraria Kaposváriensis*, 10(2): 43-54.
5. **Backus, G. B. C. and King, R. P.** (2007): An Incentive System for Salmonella Control in the Pork Supply Chain AAEA Annual Meeting, Portland, OR, July 29- August 1, 2007 pp. 1-28.
6. **Bartha, A.** (2008): Árképzés a sertéságazatban, (Pricing in the pig sector), 11th International Scientific Days Economics of Enterprises II. Presentations of Scientific Days Károly Róbert College Gyöngyös, Hungary March 27-28, pp. 215-223.
7. **Beckeman, M. and Skjoldebrand, C.** (2007): Clusters/networks regarding food innovation. *Journal of Food Engineers*, No. 79. pp. 1418–1425.
8. **Beynon N. and Best, P.** (2007): A data check on the Danes, *Pig International*, 11, pp. 14-15.
9. **Binh, V. T.; Thai, B. T.; Quang, H. V. and Moustier, P.** (2007): The role of farmer organisations and research support in the inclusion of smallholders in quality pork supply chains in Vietnam, EAAE seminar 106, pp. 1-21.
10. **Burer, S.; Jones, P. C. and Lowe, T. J.** (2008): Coordinating the supply chain in the agricultural seed industry. *O.R. Applications European Journal of Operational Research* 185, pp. 354–377.
11. **Csonka, A. and Alpár, Gy.** (2007): Integrált ellátási lánc-menedzsment rendszerek kialakításának lehetőségei a sertés termékpályán, (Potential for forming integrated supply chain management systems in the pork product-chain). *International Conference on Agricultural Economics, Rural Development and Informatics AVA3 Debrecen, Hungary CD issue*
12. **Danske Slagterier**, (2007): Co-operation from farm to table. http://www.danskeslagterier.dk/smcms/Danske_Slagterier_UK/The_Danish_Pork/Co-operation_from/Index.htm?ID=3394
13. **Davie, C. and Veeman, M.** (2007): China: export market prospects and Alberta's agricultural sector, *Western Centre for Economic Research Information Bulletin* No. 102 pp. 1-48.
14. **Dúl Údó, E.** (2007): A szakmaközi szervezetek szerepe a sertésvertikum versenyképességének javításában, (Trade organisations' role in improving pork chain competitiveness, In: Bittner, B. és Kovács, K. (eds.), *A sertéságazat helyzete, kilátásai és fejlesztési lehetőségei Szaktanácsadási füzetek* 11, Debrecen pp.117-127.
15. **English, P. R.; Fowler, V. R.; Baxter, S. and Smith, B.** (1988): *The growing and Finishing Pig: Improving Efficiency.* Farming Press Books, United Kingdom, pp. 469-474.
16. **Enting, J. and Zonderland, J. J.** (2006): Actions to enhance vertical coordination in the Dutch pig chain. Paper presented at 16th annual IAMA Forum and Symposium, June 10-13, Buenos Aires, Argentina. Paper No. 1048.

17. **Goel**, A.; **Zobel**, C. W. and **Jones**, E. C. (2005): A multi-agent system for supporting the electronic contracting of food grains, *Computers and Electronics in Agriculture*, No. 48. pp. 123–137.
18. **Goldsmith**, P. and **Bender**, K. (2004): Ten conversations about identity preservation *Journal on Chain and Network Science*, No. 4. pp. 111-123.
19. **Gorton** M.; **Dumitrashko**, M. and **White**, J. (2006): Overcoming supply chain failure in the agri-food sector: A case study from Moldova *Food Policy* No. 31. pp. 90–103.
20. **Györe**, D.; **Hodina**, P.; **Horváth**, Zs.; **Kemény**, G.; **Mizik**, T.; **Németh**, N.; **Stummr**, I.; **Thury**, E.; **Tunyoginé Nechay**, V.; **Varga**, T. and **Vágó**, Sz. (2007): A mezőgazdasági árképzés elméleti alapjai és hazai gyakorlata. (The theoretical bases for agricultural pricing and how it is practised domestically), *Agrárgazdasági Tanulmányok 2007/2*, Budapest: AKI
21. **Helming**, J. F. M. (1997): “Agriculture and Environment after CAP reform in the Netherlands; an application of an agri-environmental sector model.” *Tijdschrift voor Sociaal wetenschappelijk Onderzoek van de Landbouw* No. 4. pp. 334-356.
22. **Horváth**, J. (2008a): A sertéságazat fejlesztési lehetőségei. (Opportunities for Development in the Pork Sector), *AgrárUnió* 9(3): 52-54.
23. **Horváth**, J. (2008b): Integrated Supply Chain Management in Pork Production. *Review of Agricultural and Rural Development*. 3(1): in press
24. **Hoste**, R. and **Bondt**, N. (2006): Productiekosten varkensvlees Den Haag, LEI, pp. 1-42.
25. **Iacobucci**, D.; **Henderson**, G.; **Marcati**, A. and **Chang**, J. (1996): Network Analysis of Brand Switching Behaviour. *International Journal of Research in Marketing*, No. 13, pp. 415-429.
26. **Jonassen**, D. H.; **Beissner**, K., and **Yacci**, M. (1993): *Structural Knowledge*, Hillsdale, New Jersey, 267 p.
27. **Jonasson**, L. and **Apland**, J. (1997): “Frontier technology and inefficiencies in programming sector models: An application to Swedish agriculture.” *European Review of Agricultural Economics* No. 24. pp. 109-131.
28. **Knoke**, D. and **Kuklinski**, J. H. (1982): *Network Analysis*. SAGE Publications, Newbury Park, London, New Delhi, Series/Number 07-028.
29. **Komlósi**, I. (1999): A tenyésztérbécselés európai gyakorlata. (European practices regarding the estimation of breeding value) *A Sertés*. 4(1): 4-9.
30. **Krystallis**, A.; **Chrysochoidis**, G. and **Scholderer**, J. (2007): Consumer-perceived quality in ‘traditional’ food chains: The case of the Greek meat supply chain, *Appetite* No. 48. pp. 54–68.
31. **Meister**, A. D.; **Chen**, C. C. and **Heady**, E. O. (1978): *Quadratic Programming Models Applied to Agricultural Policies*. First edition ed. Ames: The Iowa State University Press.
32. **Nábrádi**, A. (2007): A minőség szerepe és ára a sertésvertikumban (The role of quality and price in the pork sector) In: *Bittner, B. and Kovács, K. (eds.), A sertéságazat helyzete, kilátásai és fejlesztési lehetőségei, Szaktanácsadási füzetek 11*. Debrecen, pp. 94-116.
33. **Nábrádi**, A. and **Szűcs**, I. (2004): Gazdasági tartalékok a sertéságazatban, (Economic reserves in the pork sector) *A Hús, Országos Húsipari Kutatóintézet Kht*. Budapest, 14(1): 47-53.

34. **Nyárs, L.** (2007): A hazai és a dán sertéshús-előállítás üzemgazdasági helyzete, különös tekintettel az üzemméretre (The Situation of domestic and Danish pork production, in terms of company size) In: Bittner, B. and Kovács, K. (eds), A sertéságazat helyzete, kilátásai és fejlesztési lehetőségei, Szaktanácsadási füzetek 11. Debrecen pp. 71-89.
35. **Osinga, S. A. and Hofstede, G. J.** (2005): Transparency in the Pork Supply Chain: Comparing China and The Netherlands EAAE 99th Seminar 'Trust and Risk in Business Networks', Bonn, Germany, pp. 93-102.
36. **Pérez, C.; De Castro, R. and Simons, D.** (2005): Pork Supply Chain: a Review. Proceedings of the 10th International Symposium on Logistics 3–5 July 2005, Lisbon
37. **Pomarici, E. and Hanf, C. H.** (1996): Outline of a Dynamic Mathematical Programming Model for Regional Analysis of Agricultural Development. 1.
38. **PVE**, (2004): De structuur van de Nederlandse vleesveredelaars in 2003. Report nr 0413, December, PVE, Afdeling Markt en Communicatie.
39. **PVE**, (2006): Vee, Vlees en Eieren in Nederland 2006. Het jaarboekje Vee Vlees en Eieren, April, PVE, Afdeling Markt en Communicatie.
40. **Salamon, L.; Kettinger, A. and Káldi, J.** (2007): A termékpályák hazai jellemzői az állattenyésztésben, Domestic product chain regarding animal husbandry) International Conference on Agricultural Economics, Rural Development and Informatics AVA3 Debrecen, Hungary CD issue
41. **Schulze, B.; Spiller, A. and Theuvsen, L.** (2006c): Is more vertical integration the future of food supply chains? In: Bijman, J.; Omta, S. W. F.; Trienekens, J. H.; Wijnands, J. H. M. and Wubben, E. F. M. (eds.), International agri-food chains and networks: Management and organization. Wageningen : Wageningen Academic Publishers, pp. 49-63.
42. **Schulze, B.; Spiller, A. and Theuvsen, L.** (2006d): More Trust instead of More Vertical Integration in the German Pork Production? Empirical Evidence and Theoretical Considerations EAAE 99th Seminar 'Trust and Risk in Business Networks', Bonn, Germany, pp. 373-381.
43. **Schulze, B.; Spiller, A. and Wocken, C.** (2006a): Supplier Relationship Quality in the German Pork and Dairy Sector: Theoretical Considerations and Empirical Evidence Paper presented at the 16th Annual World Forum and Symposium "Agribusiness, Food, Health, and Nutrition", IAMA Conference, June 10 – 13, in Buenos Aires, Argentina
44. **Schulze, B.; Spiller, A. and Wocken, C.** (2006b): Relationship quality in agri-food chains: Supplier management in the German pork and dairy sector, Journal on Chain and Network Science, No. 6, pp. 55-68.
45. **Selva, G.** (2005): Analysis of the competitiveness of the pork industry in Denmark, 99th seminar of the EAAE "The Future of Rural Europe in the Global Agri-Food System", Copenhagen, Denmark, August 24-27.
46. **Simon, D. and Taylor, D.** (2007): Lean thinking in the UK red meat industry: A systems and contingency approach. International Journal of Production Economics No. 106. pp. 70-81.
47. **Spiller, A.; Theuvsen, L.; Recke, G. and Schulze, B.** (2005): Sicherstellung der Wertschöpfung in der Schweineerzeugung: Perspektiven des Nordwestdeutschen Modells, Muenster.
48. **Stringer, M. F. and Hall, M. N.** (2007): A generic model of the integrated food supply chain to aid the investigation of food safety breakdowns, Food Control No. 18. pp. 755–765

49. **Szabó, G. G. and Bárdos, K.** (2006): Contracts in agribusiness: A survey in the Hungarian dairy sector. In: Bijman, J.; Omta, S. W. F.; Trienekens, J. H.; Wijnands, J. H. M. and Wubben, E. F. M. (eds.), *International agri-food chains and networks: Management and organization*. Wageningen: Wageningen Academic Publishers, pp. 65-80.
50. **Szabó, P.** (2007): A hazai kistermelői sertéstartás dilemmái (Dilemmas facing small domestic pork producers who keep their own pigs) In: **Bittner, B. and Kovács, K.** (eds.), *A sertéságazat helyzete, kilátásai és fejlesztési lehetőségei*, Szaktanácsadási füzetek 11. Debrecen pp. 156-165.
51. **Talamini, E. and Malafaia, G. C.** (2006): Traceability, transparency and assurance (TTA) systems implementation for the Brazilian exporter pork meat chain, Paper presented at 16th annual IAMA Forum and Symposium, June 10-13, Buenos Aires, Argentina.
52. **Theuvsen, L.** (2004): Transparency in netchains as an organizational phenomenon: exploring the role of interdependencies, *Journal on Chain and Network Science*, No. 4. pp. 125-138.
53. **Tóth, P.** (2007): Sertéspiaci helyzetkép (Pork market general survey) 2006, *A Sertés* 12(3): 8-17.
54. **van der Vorst, J. G. A. J.** (2000): *Effective food supply chains. Generating, modelling and evaluating supply chain scenarios*. Wageningen: Wageningen University.
55. **Vatn, A.; Bakken, L. R.; Botterweg, P.; Lundeby, H.; Romstad, E.; Rørstad, P. Kr. and Vold, A.** (1997) "Regulating nonpoint-source pollution from agriculture: An integrated modelling analysis." *European Review of Agricultural Economics* 2. 24. pp. 207-230.
56. **Vígh, Zs.; Nagy, I.; Farkas, J. and Csató, L.** (2005): A BLUP alapú tenyésztékek és tenészetek kapcsolatának vizsgálata hazai sertésfajtákban (BLUP basic breeding values and an examination on how the presence of pedigree breeding affects domestic pork varieties) *Acta Agraria Kaposváriensis* 9(2): 13-22.
57. **Winston, W. and Albright, C.** (1997): *Practical Management Science*, ITP Thomson Learning