Analysis of the operation of a large Pig Sales and Purchase Cooperative in Hungary

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Abstract

In our research the operation of the co-operative was modelled as a generalized network problem. The cooperative provides more than 10% of Hungarian unprocessed pork. Live pigs are sold for 5 Hungarian slaughter houses. The model allows the quantification of the number of pigs from given farms to slaughterhouses, the maximum revenue from sales, the threshold prices of deliveries and the analysis on the impacts that the members of co-operatives exert on sales revenues.The negative feedback of this information guarantees safety for the members of the network and provides knowledge that enables the production of homogenous end-product for maintaining competitiveness.

Keywords: pork production, integration, network, linear programming

1. Introduction

Vertical integration links consequent activities and functions on the product path which are built on one another, and these structures are usually named by their end-products (Osinga and Hofstede, 2005; Szabó and Bárdos, 2006). A supply chain is an integrated process where raw materials are acquired, converted into products and then delivered to the consumer (Pakurár et al., 2005; Csonka and Alpár, 2007). Food supply chains are made up of organisations that are involved in the production and distribution of farm and animal-based products (Ertsey and Mainsant, 1992; Enting and Zonderland, 2006). Today in the pig sector not corporations, but integrations, national or regional product paths compete with each other (Nábrádi and Szűcs, 2004; Nyárs, 2007). The dynamic conception of profitability means that an economic environment that is able to adapt to accelerated technological development, to renew flexibly and to facilitate the development of comparative advantages, is of key priority (Schulze et al., 2006a; Salamon et al., 2007). Competition in the case of pork meat is based on selling prices, on the quality of products (Krystallis et al., 2007; Bartha, 2008) and on the public image of producers. The structure of the production path, the level of infrastructure, human resources, biological and economic environment are the factors which determine the competitiveness of the production path in the long term (Komlósi, 1999; Horváth, 2008). In our present study we have investigated the first factor through the example of a concrete producer enterprise. In the wake of preliminary consulations 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 varied quality among slaughterhouses with different requirements for the maximization of sales revenues (APSPC, 2008). This model can also be used for other Sales and Purchase Cooperatives or it can help with refining the existing distribution methods of the cooperatives.

2. **Methods, techniques**

In our research we modelled the operation of a purchase and sale co-operative in the East-Hungarian Region. We sought the optimal solution by the help of a network model. Our conception was very simple: to deliver from each member to the slaughterhouse that pays the highest price for the produced quality. This method is advantageous for producers and slaughterhouses as well. It is advantageous for producers, because they can have higher revenue from sales; and for slaughterhouses, because they receive the product quality that they really need.

On the basis of the above mentioned, taking the contracted slaughterhouse parameters into consideration, the average sales price can be calculated in every aspect and based on this, the average sales price of one pig as well.

The variables of the model are the arcs of the network, i.e. there will be as many variables as many links can be created between farms and slaughterhouses. On the basis of the above data the target function of the model can be determined:

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

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 in nodes, separately for farms and separately for slaughterhouses. In the event of farms the total output from a farm equals with the volume for delivery if the whole quantity for delivery from all the farms is lower than or equal with the quantity for delivery, otherwise a lower limit is given. In the case of slaughterhouses, conditions will have an upper limit.

Constraints for farms:

$$\sum x_{ij} = T_i \text{ if } \sum T_i \leq \sum S_j \tag{2}$$

$$\sum x_{ij} \geq T_i \text{ if } \sum T_i > \sum S_j \tag{3}$$

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}

Constraints for slaughterhouses :

$$\sum x_{ij} \leq S_j \tag{4}$$

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 widespread vulnerability studies. The shadow prices of the coefficients in the target function, the values of permissible increases and decreases present the threshold prices of certain delivery relations and those lower and upper limits, which can include the variations of the values of the target function without modifying the optimal solution. The shadow prices related to the variables may allow the evaluation of the influences of the potential expansion or restriction of certain delivery relations on the sales revenues. The influence of the members of the Co-operative on sales revenues can be analysed by "What if…" examinations. The negative feedback of the information can provide knowledge and safety for the network members, which facilitate the production of homogenous end-products and the preservation of the competitiveness of farms.

The network model was run from the 2nd week of August for 5 weeks in 2007. On the basis of data from the APSPC, 11 producers delivered their products to 5 slaughterhouses. By information from producers the data of the model can be continuously refreshed, so it can be easily applied for even weekly optimization as well. Each farm and slaughterhouse represents two nodes in the network, allowing the simultaneous optimization of fattening pigs and culled sows. As a result, we 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 basic data of the network model include members' information on the expected quality and weight, and also prices and quality deductions related to various quality categories given 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 given farm-slaughterhouse relations
- in the case of sold mass, actually transported mass
- for quality, instead of forecasts by farms, actual qualifications by slaughterhouses.

These modifications allowed the realistic evaluation of the model results.

3. Results and discussion

In 2005 19 producer groups were granted official recognition, the number of their average members was 30, their production was 85.000 t i.e. 22 billion HUF, about 20% of Hungarian pig production. In 2007 there were 21 officially recognised pig producer groups in Hungary; four ones with preliminary recognition. The APSPC was established on 20 February 2003 with 26 members. The APSPC, considering the current regulations, can represent the interests of its members in terms of sales. As a result of the quantity of its produced slaughter animals, it can achieve higher prices than Hungarian average ones, due exclusively to its bargaining position.

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These modifications allowed the realistic evaluation of the model results. Table 1. presents the sales revenues of the study period calculated by the model and the actual sales revenues of the cooperation. Sales revenue data showed clearly that for considerable amounts of sale volumes, the application of simple network models can exploit price fluctuations as a result of various quality requirements by slaughterhouses and thus surplus revenues can be gained.

Table 1.

The development of actual sales revenue before and after optimization in the study period.

Measurement unit: million HUF

		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
	%	2.4	2.0	1.8	2.9	2.8	2.4

However, further gaines can be made by more precise meat quality forecasts, as this explained the necessity for the modification of the model data. These corrections reduced the value of the model target function more or less in each case. Unfortunately, farms mostly rely on the data of earlier periods and their own experience, as they lack the required measurement devices. The model is an LP application; therefore the solution requires widespread vulnerability studies. The shadow prices of the coefficients in the target function, the values of permissible increases and decreases present the threshold prices of certain delivery relations and those lower and upper limits, which can include the variations of the values of the target function without modifying the optimal solution. The shadow prices related to the variables may allow the evaluation of the influences of the potential expansion or restriction of certain delivery relations on the sales revenues. The influence of the members of the co-operative on sales revenues can be analysed by "What if…" examinations. The negative feedback of the information can provide knowledge and safety for the network members, which facilitate the production of homogenous end-products and the preservation of the competitiveness of farms.

Table 2. presents the reduced costs of some variables and related information, which are highlighted by the the management of the Co-operative, but are not included in the optimal solution. Certain relations cannot be actually compared in terms of calculated reduced costs,

as they are calculated for one animal. However, this comparison may be carried out by average carcass weight. The findings suggest that farm 10. can transport to slaughterhouses B, C and D only when sales revenues calculated in the optimal solution decrease in the cooperative.

Table 2.

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	36638.8	-1.8	355.54	357.39
Farm 3.- slaughterhouse B	0	0	-117.7	32637.6	-1.3	359.90	361.20
Farm 5.- slaughterhouse B	0	0	-158.7	39532.7	-1.4	357.86	359.30
Farm 7.- slaughterhouse B	0	0	-102.3	34015.1	-1.1	361.93	363.02
Farm10.- slaughterhouse B	0	0	-225.8	40472.7	-2.0	350.67	352.62
Farm 11.- slaughterhouse B	0	0	-105.3	35354.1	-1.1	357.37	358.44
Farm 10.- slaughterhouse C	0	0	-260.8	40748.5	-2.3	353.06	355.32
Farm 10.- slaughterhouse D	0	0	-221.7	41064.3	-1.9	355.79	357.71
Farm 2.- slaughterhouse E	0	0	-109.7	38902.0	-1.0	362.99	364.01

Source: Authors' own calculation

On Table 3 shadow prices as model solutions show the amount of money by which further transports from certain farms increase income. The sensitivity report calculates this amount for one pig basically, but similarly to reduced costs, it can be converted into kg/HUF unit easily in the light of average weights.

Table 3.

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

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
net flow of 1. farm	-320	-36705	-320	60	255	-356.19
net flow of 2. farm	-270	-39012	-270	40	80	-364.01
net flow of 3. farm	-450	-32632	-450	60	255	-359.84
net flow of 4. farm	-100	-31804	-100	100	255	-360.54
net flow of 5. farm	-200	-39568	-200	200	255	-358.18
net flow of 6. farm	-360	-30970	-360	40	80	-364.72
net flow of 7. farm	-120	-33994	-120	40	255	-361.71
net flow of 8. farm	-250	-34700	-250	40	80	-362.86
net flow of 9. farm	-320	-31913	-320	40	80	-365.20
net flow of 10. farm	-210	-40575	-210	210	255	-351.55
net flow of 11. farm	-55	-35336	-55	55	255	-357.19

Source: Authors' own calculation

On Table 1, optimized sales revenues from qualified pigs is 93.5 million HUF on the first week, marketed quantity is 2655 pigs with the carcass weight of 257032 kg based on the model's data, so the average market price is 363.96 HUF/kg. The analysis of Table 3. clearly shows that the extension of capacities 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 transport capacities of farm 10. are extended, average prices can be reduced substantially. Statements on reduced costs already projected the conclusions on farm 10.

Table 4. demonstrates sensitivity report data related to slaughterhouse boundaries. The demands of slaughterhouse 6. shall not be fully met, while the other slaughterhouses will receive the required quantities. The comparison of 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 4.

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

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

Source: Authors' own calculation

4. Conclusions

We developed a model for the maximization of sales revenues from the viewpoint of pig farmers. By the feedback of production information, the APSPC makes farmers on lower production levels as well produce better quality and more homogeneous source material for slaughter, thus they can achieve higher revenues. The extra income generated by the application of the model provides potentials for survival in years similar to 2007 and for improvement in normal or more favourable years.

Thus our long-term farming can be more balanced, which affects the production safety of the other members of the chain; therefore, profitability risk can be reduced in the whole chain. However, it should become clear for political decision-makers that regulations should enhance the quality awareness of each member in the chain.

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