MATHEMATICAL MODEL FOR OPTIMIZING THE PROFIT OF THE PORK MEAT CHAIN

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Abstract: *The research of the present study answer the question whether using measures for reducing the losses on the pork meat chain enables acquiring a higher level of effectiveness. In pursuing this question, a mathematical model for optimizing the profit of the chain is elaborated and implemented in two situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The results show that in the second situation the level of profit is higher, because of reducing the losses by applying measures for their prevention: farms' re-technology, implementing an automatically system for feeding the animals, ensuring medication through feeding system, improving ventilation system, using devices for monitoring continuously the microclimate, establishing the optimal supply using scientifically methods etc. The conclusions have strong implications for chain operators who may acquire a higher level of profit by applying these measures of reducing the losses.*

Key words: *agro-food chain; effectiveness; mathematical model; performance*

Introduction

The objective of this study is to elaborate and implement a mathematical model of increasing economical efficiency of the pork meat chain. The results answer the question whether using measures for reducing the losses on the pork meat chain enables acquiring a higher level of effectiveness. In achieving this purpose, it is studied the pork meat chain in two possible situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The economical data used have been reported by an agricultural unit that has as main activities: porks' growing and slaughtering and meat and meat products' marketing.

In previous studies (La Gra, 1990), the topic of economical efficiency of agro-food products' chain is related to the losses that may result from the system. Any measure of losses' prevention enables an increasing of performance of the chain. Losses might be quantitative and qualitative and they start from the biological material and continue in each stage of the chain, until the products reach the shelves on the supermarket (Ion, 2005).

In the case of agricultural products of animal origin, the first losses occur in choosing the species and breeds. If they are not in elite category, there will result losses in yields. For instance, on the pork meat chain, in the maternity stage, the losses of pigs are 9%. Other losses result from diseases: 3% in pork growing area, 0.5% for base hers, and 1.5% for fat pork. Diseases may be prevented by vaccination and ensuring proper microclimate conditions.

Other losses occur to animal transportation. These animals loose weight because of stress. Weight loss must not overrun 7%. In practice the weight loss is situated between 5% and 7%.

For agricultural products of animal origin there are losses in slaughtering houses as well. These losses reach the level of 0.5%. In the stage of storing the meat, the humidity factor is very important. Fresh agricultural products like meat loose water. This is the reason why the humidity must be high during storage. For pork meat, there are losses of freezing and defrosting of 1.,5-1.8%, respectively 2-2.5% and technological losses of 2% for full and 2-2.5% to organs (Pîrjol, 2006).

In the last stage of the chain – marketing – there are occurring qualitative losses because of laying out the merchandise in inappropriate hygiene conditions or under direct action of sun, or psychological losses (Istudor, 2006). In the case of pork meat, the marketing losses are between 0.2-0.5%.

Model for assessing economical efficiency

Preventing the losses represents a way of increasing economical performance on the agro-food products' chain.

In this paper it is elaborated a model for increasing economical performance on the pork meat chain. This model is then implemented based on data provided by one economic agent who integrates several economical activities on the chain: porks' growing and slaughtering, meat processing and meat and meat products' marketing.

In elaborating the model of optimizing the profit of the pork meat chain, there are considered two possible situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The profit of the pork meat chain

is equal to the sum of profits of each stage of the chain (Manole, 2006). This total profit may be expressed in the two situations as follows:

Scenario 1:

$$P_1 = \left[\left(V_{fnc} - C_{fnc} \right) - \sum_{h=1}^{m} p_{fnch} \right] + \left[\left(V_{cî} - C_{cî} \right) - \sum_{i=1}^{n} p_{cîi} \right] + \left[\left(V_{ab} - C_{ab} \right) - \sum_{j=1}^{o} p_{abj} \right] +$$

$$+ \left[\left(V_{c} - C_{c} \right) - \sum_{k=1}^{p} p_{ck} \right]$$

Scenario 2:

$$P_2 = \left[\left(V_{fnc} - C_{fnc} \right) - \sum_{h=1}^{m} p'_{fnch} \right] + \left[\left(V_{cî} - C_{cî} \right) - \left(C_{mî} + \sum_{i=1}^{n} p'_{cîi} \right) \right] + \left[\left(V_{ab} - C_{ab} \right) - \left(C_{mab} + \sum_{j=1}^{o} p'_{abj} \right) \right] +$$

$$+ \left[\left(V_{c} - C_{c} \right) - \sum_{k=1}^{p} p'_{ck} \right]$$

In which:

P_1 = profit for scenario 1 – without measures for preventing the losses on the pork meat chain

P_2 = profit for scenario 2 – with measures for preventing the losses on the pork meat chain

V_{fnc} = revenue in the stage of obtaining the mixed feed

C_{fnc} = expenditure in the stage of obtaining the mixed feed

p_{fnch} = losses of type *h* resulted in the stage of obtaining the mixed feed, without respecting the measures of preventing the losses

p'_{fnch} = losses of type *h* resulted in the stage of obtaining the mixed feed, respecting the measures of preventing the losses

$V_{cî}$ = revenue in the stage of growing the pigs

$C_{cî}$ = expenditure in the stage of growing the pigs

$p_{cîi}$ = losses of type *i* resulted in the stage of growing the pigs, without respecting the measures of preventing the losses

$p'_{cîi}$ = losses of type *i* resulted in the stage of growing the pigs, respecting the measures of preventing the losses

V_{ab} = revenue in the stage of slaughtering

C_{ab} = expenditure in the stage of slaughtering

p_{abj} = losses of type *j* resulted in the stage of slaughtering, without respecting the measures of preventing the losses

p'_{abj} = losses of type *j* resulted in the stage of slaughtering, respecting the measures of preventing the losses

V_{c} = revenue in the stage of marketing the meat and meat products

C_{c} = expenditure in the stage of marketing the meat and meat products

p_{ck} = losses of type *k* resulted in the stage of marketing the meat and meat products, without assessing the optimal stock

p'_{ck} = losses of type *k* resulted in the stage of marketing the meat and meat products, with assessing the optimal stock

$C_{mî}$ = expenditure with measures for preventing the losses in the stage of growing the pigs

C_{mab} = expenditure with measures for preventing the losses in the stage of slaughtering

h = type of losses in the stage of obtaining the mixed feed
i = type of losses in the stage of growing the pigs
j = type of losses in the stage of slaughtering
k = type of losses in the stage of marketing the meat and the meat products
m = number of losses in the stage of obtaining the mixed feed
n = number of losses in the stage of growing the pigs
o = number of losses in the stage of slaughtering
p = number of losses in the stage of marketing the meat and the meat products.

The data needed for implementing the model of optimising the profit on the pork meat chain have been provided by an agricultural unit. It has a capacity of 92130 pigs, used 100%. Meat production accounts for 6,687,257 kilograms. Yield of slaughtering is 70%.

For assessing performance of the pork meat chain, there have been collected data about costs and revenues for each stage. They have been assessed without taking into account the quantitative and qualitative losses of production. Thus, the profit for the first stage of the chain – obtaining the mixed feed – is 5,182,661.33 lei. The profit rate, calculated as ratio between profit and total expenditure, is 14.66%, and the rate of returns, calculated as ratio between profit and revenues, is 12.79% (Table 1).

Table 1. Economical results in the stage of obtaining the mixed feed, for the whole production, 2006

- lei -

No.	Specification	Value
I	**TOTAL EXPENDITURE**, of which:	**35340869.63**
1.	Expenditures with raw materials	29475126.21
2.	Expenditures with auxiliary materials	2404486.72
3.	Expenditures with fuels	143626.96
4.	Expenditures spare parts	160160.17
5.	Expenditures with expendable materials	280205.79
6.	Expenditures with energy and water	618677.89
7.	Expenditures with merchandises	50411.18
8.	Expenditures with maintenance and repairs	36248.75
9.	Expenditures with rents	1872.37
10.	Expenditures of transportation	766057.67
11.	Other expenditures with services	97330.35
12.	Expenditures with duties and taxes	14360.83
13.	Expenditures with salaries	794319.55
14.	Expenditures with social insurance	200651.05
15.	Expenditures with unemployment	23829.35
16.	Expenditures with health insurance	55603.81
17.	Other expenditures with social protection	500
18.	Expenditures of exploitation regarding depreciation	217400.98
II	**TOTAL REVENUE,** of which:	**40523531.00**
1.	Revenues from selling the final products	2082.62
2.	Revenues from services	1384.21
3.	Revenues from rents	14465.44
4.	Revenues from selling the merchandise	52291.58
5.	Revenues from diverse activities	2630
6.	Total revenues (701-708)	72853.85

No.	Specification	Value
7.	Stock variation	36398324.01
III	**PROFIT**	**5182661.33**
IV	Profit rate (%)	14.66
V	Rate of returns (%)	12.79

In the second stage of the chain, growing the pigs, the profit is 7,505,717.35 lei, the profit rate is 15%, and the rate of returns is 13% (Table 2).

Table 2. Economical results in the stage of growing the pigs, for the whole production, 2006

- lei -

No.	Specification	Value
1.	Days of feeding	32152624.00
2.	Increase	12042304.00
3.	Weight	25055429.00
4.	Stock weight at 31.12.2005	4606547.00
5.	Non-suckler pigs	158780.00
6.	Suckler pigs	15159.00
I	**Current expenditure**, of which:	**50435559.60**
1.	DIRECT EXPENDITURE	46853320.35
a.	Feed	36614648.47
b.	Medication	2115356.60
c.	Materials, repairs	1956595.62
d.	Spare parts	129495.23
e.	Other expendable materials	1069714.33
f.	Sperm dosages	220595.89
g.	Maintenance and repairs	536790.17
h.	Fuels	335627.64
2.	EXPENDITURES WITH PERSONNEL	3849801.80
a.	Salaries	2833095.15
b.	Social insurance	733406.13
c.	Unemployment	84986.96
d.	Health insurance	198313.56
3.	Expenditures with livestock	0.00
4.	Depreciation	655051.13
5.	Energy and water	1326239.09
6.	INDIRECT EXPENDITURES	3582239.25
a.	Other common expenditure	1714866.42
b.	Packaging materials	1455.00
c.	Expenditures with transportation	58808.61
d.	Expenditures with displacement	27.80
e.	Expenditures with services	309750.04
f.	Expenditures with duties and taxes	56457.37
g.	Expenditures with social protection	2500.00
h.	Expenditures with exploitation	0.00
i.	Subsidies	0.00
j.	Expenditures with object in custody	38081.30
k.	Expenditures with actives given in	0.00
l.	Expenditures with merchandise	4336.00
m.	Expenditures with seeds	0.00
n.	Expenditures with auxiliary materials	1744.80
o.	Mechanical sector	1241705.50
p.	Expenditures with auxiliary sectors	1867372.83
7.	Cost per feeding day	1.57
8.	Cost kilogram/increase	4.19
9.	**Cost kilogram/weight**	**2.86**
II	**Revenues**	**57941276.95**
III	**Profit**	**7505717.35**

No.	Specification	Value
IV	Profit rate (%)	**15**
V	Rate of returns (%)	**13**

The expenditures, revenues and profit in the stage of slaughtering are presented in Table 3. Profit rate is 57.4%, and the rate of returns is 36.4%.

Table 3. Economical results in the stage of slaughtering, for the whole production, 2006

- lei -

No.	Specification	Value
I	**Total expenditure,** of which:	**44196547.67**
1.	Expenditures with raw materials	40773139.87
2.	Expenditures with auxiliary materials	16963.2
3.	Expenditures with fuels	887352.2
4.	Expenditures with packaging materials	35022.4
5.	Expenditures with spare parts	23476.12
6.	Expenditures with expendable materials	129490.23
7.	Expenditures with objects in custody	11713.62
8.	Expenditures with energy and water	319698.75
9.	Expenditures with maintenance and repairs	68651.96
10.	Expenditures with transportation	155910.47
11.	Other services	331672.7
12.	Expenditures with duties and taxes	17342.06
13.	Expenditures with salaries	975696.1
14.	Social insurance	250330.68
15.	Unemployment	29270.78
16.	Health insurance	68297.82
17.	Expenditures with depreciation	102518.71
II	**Total revenue**, of which:	**69545942.08**
1.	Revenues from selling final products	51999125.42
2.	Revenues from services	86741.29
3.	Total revenues (701-708)	52085866.71
4.	Stock variation	279170
5.	Other revenues	11617230
III	**Profit**	**25349394.4**
IV	Profit rate %	57.4
V	Rate of revenues %	36.4

The meat is stored in freezing system in order to be put on the market. The revenues and expenditures of the last stage of the chain are presented in Table 4. The marketing activity is finalised with losses, on the one hand, because high level of production losses, and, on the other hand, because of low level of selling prices.

Table 4. Economical results in the stage of marketing, for the whole production, 2006

- lei -

No.	Specification	Value
I	**Total expenditures**	**2213203.6**
1.	Expenditures with fuels	717129.42
2.	Expenditures with spare parts	301393.94
3.	Expenditures with expendable materials	113208.03
4.	Expenditures with objects in custody	69074.91
5.	Expenditures with merchandise	1260.24
6.	Expenditures with maintenance and repairs	217447.09
7.	Expenditures with insurance	27989.56
8.	Expenditures of transportation	15878.82
9.	Expenditures with travelling	600.6
10.	Other expenditures with services	118479.88

No.	Specification	Value
11.	Expenditures with taxes and duties	7040.82
12.	Expenditures with salaries	442509.24
13.	Social insurance	100958.22
14.	Unemployment	13273.43
15.	Health insurance	30975.3
16.	Expenditures with depreciation	35984.1
II	**Total revenues**	**1650087.64**
1.	Revenues from services	1000087.64
2.	Revenues from selling the merchandise	650000.00
4.	Stock variation	0
III	**Profit/loss**	**-563115.96**

Scenarios regarding economical efficiency on the pork meat chain

In Table 5. there are centralised data regarding expenditures, revenues, profits and losses on the pork meat chain, in two situations: scenario 1 – without measures for preventing and reducing the losses, and scenario 2 – with measures of updating the technologies for preventing and reducing the losses.

Table 5. Scenarios regarding profit assessment on the pork meat chain

No.	Specification	Value (lei)	
		Scenario 1	Scenario 2
I.	OBTAINING MIXED FEED		
1.	Production (kg)	21686411.1	22827801.17
2.	Revenues	40523531.00	40523531.00
3.	Expenditures	35340869.63	35340869.63
4.	Losses in the stage of obtaining mixed feed (10% scenario 1, respectively 5% scenario 2)	4052353.1	2026176.55
5.	Profit/loss [2-(3+4)]	1130308.23	3156484.82
6.	Rate of revenues (5/2*100), %	2.79	7.78
II.	GROWING THE PIGS		
1.	Production (kg)	29134219.77	32371355.3
2.	Revenues	57941276.95	57941276.95
3.	Expenditures	50435559.60	50435559.60
4.	Expenditures with measures of preventing the losses*	-	1200000
5.	Losses in the stage of growing (14% scenario 1, respectively 10% scenario 2)	8111778.77	5794127.70
6.	Profit/loss [2-(3+4+5)]	-606061.42	511589.66
7.	Rate of revenues (6/2*100), %	-	0.88
III.	SLAUGHTERING		
1.	Production (kg)	7268757.6	7732721
2.	Revenues	69545942.08	69545942.08
3.	Expenditures	44196547.67	44196547.67
4.	Expenditures with measures of preventing the losses**	-	1300000
5.	Losses during slaughtering (8% scenario 1, respectively 4% scenario 2)	5563675.37	2781837.68
6.	Profit/loss [2-(3+4+5)]	19785719.04	21267556.73
7.	Rate of revenues (6/2*100), %	28.44	30.58
IV.	MARKETING		
1.	Production (kg)	7268757.6	7732721
2.	Revenues	1650087.64	1650087.64
3.	Expenditures	2213203.60	2213203.60
4.	Losses during marketing (0.5% scenario 1, respectively 0.25% scenario 2)	8250.4	4125.2
5.	Profit/loss [2-(3+4)]	-571366.4	-567241.16
V.	Total profit (I.6.+II.6.+III.6.+IV.5)	19738599.5	24368390.05

* - expenditures with measures of preventing the losses in the stage of growing the pigs refer to updating the technology with an automatic feeding system, realising medication throughout feeding etc. The new technology suffers depreciation in time. While the model is not implemented in dynamic, it is considered that, for one year, the expenditures with investment depreciation are 1200000 lei.

** - expenditures with measures of preventing the losses in the stage of slaughtering refer to expenditures for improving the system of ventilation, updating the technology of monitoring the temperature etc. The investment with the new technology suffers depreciation in time. While the model is not implemented in dynamic, it is considered that, for one year, the expenditures with investment depreciation are 1300000 lei.

In the first stage of the chain – obtaining the mixed feed – the losses decrease from 10% to 5% as a result of implementing agro-technical and plant protection measures more efficient. The cost per kilogram decreases from 1.63 lei to 1.55 lei. The profit grows from 1130308.23 lei to 3156484.82 lei.

In the stage of growing the pigs, there are registered high levels of losses – 14% in scenario 1, of which: 9% in maternity shelter, 3% in youth shelter, 1.5% in fat pigs shelter, and 0.5% for base herd. Thus, the activity of growing the pigs has not finalised with profit (as seen in Table no.2, the profit resulting from the activity of growing the pigs is 7505717.35 lei; but this level is achieved when the losses are not taken into consideration), but with a loss of 606061.42 lei.

A solution for reducing the losses is upgrading the technology of growing the pigs, by implementing an automatic system for feeding the livestock, ensuring medication through feeding etc. The losses are not all put out, but they might be reduced from 14% to 10%.

Reducing the losses means increasing efficiency for the activity of growing the pigs, even there are registered additional costs with depreciation of the investment realised for up grading the technology (1200000 lei per year). Thus, the activity of growing the pigs finalised with a profit of 511589.66 lei, the rate of returns being 0.88%.

In the stage of slaughtering the animals it results losses of 8% (scenario 1), of which: 2% technological losses because of freezing the meat and another 2% because of freezing the organs, 0.5% for meat hunk, 1.5% losses of deep-freezing, and 2% losses of un deep-freezing. As a result, this activity finalised with a lower level of profit: 19785719.04 lei (as seen in Table 3, the profit for slaughtering activity is 25349394.4 lei, but it was not taken into account the losses of production). The rate of returns is 28.44%.

A solution for reducing the losses could be upgrading the slaughterhouse by improving the system of ventilation, providing devices for monitoring the climate conditions, ventilation, temperature from slaughterhouse and storehouse, and for measuring the meat temperature etc. The losses are not all put out, but they might be reduced from 8% to 4% (with 50%).

Reducing the losses means increasing efficiency for the activity of slaughtering the pigs, even there are registered additional costs with depreciation of the investment realised for upgrading the technology (1300000 lei per year). Thus, the activity of slaughtering the pigs finalised with a profit of 21267556.73 lei, the rate of returns being 30.58%.

In the stage of selling the meat and the meat products, there are losses of 0.5%. This activity is finalised with losses of 571366.4 lei (as seen in Table no.4, the activity of selling the products finalises with a loss of 563115.96 lei, without taking into consideration the losses of production).

In scenario 2, a solution for reducing the losses might be the assessment of optimal stock using scientifically methods. Thus, by assessing the optimal stock, the economic agent will determine the exact quantity of merchandise needed for selling, so there were no breakings in stocks or over stocks (Istudor, 2005). It is underlined the importance of assessing the optimal stock especially in the case of meat, which is a very perishable

product. The losses are not all put out, but they might be reduced from 0.05% to 0.025%. Hereby, the losses are reduced from 571366.4 lei to 567241.16 lei.

Conclusions

Losses' cutting down on the pork meat chain is a way of increasing economical performance of chains' activities, because, by implementing the model of augmentation the economical efficiency, the total profit in scenario 2, in which there are applied measures for preventing the losses, is 16% higher than in scenario 1, in which there are not applied any measures of preventing the losses. The profit has increased in absolute values from 19738599.5 lei to 24368390.05 lei.

Increasing performance on the pork meat chain by reducing quantitative and qualitative losses as a result of implementing measures for their prevention represents the main objective for each economic agent. This approach is even more important in the context of Romanian agro-food sector integration into European Union. In this context, the competition on European single market will increase and the fight for customers will be gained by those economic agents that provide high quality products for the lowest costs.

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