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THE ECONOMIC EFFICIENCY OF APPLE PRODUCTION IN TERMS OF POST-HARVEST TECHNOLOGY

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Abstract: This study analyses how the level of postharvest technology's development influences the economic efficiency of apple production with the help of a deterministic simulation model based on primary data gathering in producer undertakings. To accomplish our objectives and to support our hypotheses three processing plant types are included in the model: firstly apple production with no postharvest and prompt sale after the harvest, secondly parallel production and storage combined with an extended selling period and thirdly production and entire postharvest infrastructure (storage, sorting-ranking, packing) with the highest level of goods production and continuous sales. Based on our results it can be stated that the parallel production (plantation) and cold storage, so the second case is proved to be totally inefficient, considering that the establishment of a cold storage carries enormously high costs with resulting a relative low plus profit compared to the first type of processing plant. The reason for this is that this type is selling bulk goods without sorting-grading or packaging; storage itself – as a means of continuously servicing the market – is not covered properly by the consumers. Absolute efficiency ranking cannot be established regarding the other two processing plants: plantation without post-harvest infrastructure resulting lower NPV, but a more favourable IRR, DPP and PI as developing a plantation and a whole post-harvest infrastructure.

Keywords: apple, economic efficiency, post-harvest, apple producing processing plant type

1. Introduction, objectives

Fruit cultivation plays a key role in the agriculture of Hungary, which is also proven by the fact that it employs significant number of workforce and resources worth billions; it provides 8–10% of cultivations gross production value (*Z. Kiss* 2003). Domestic crop lands are continuously decreasing, while there were 41 000 hectare apple plantations in 2000, it is now not more than 26 000 hectare. Due to the plantations, remarkably heterogeneous quality and worse product security the annual amount is fluctuating between 300 and 800 thousand tons and profitability is critical in the majority of the processing plants (*Fruitveb* 2013).

Recently, market prices in fruit sector have been decreasing or stagnating, selling security has become hectic and ever growing performance of producers is needed to ensure and efficient production (*Lakner* and *Apáti*, 2010). Raising the level of post-harvest processes is an option to improve economic efficiency, with which sales could be extended, such goods could be produced that fulfil the consumers' expectations and have a decent quality and appearance, moreover the average selling prices can be significantly improved (*Doluschitz* 2001; *Möhring* et. al. 2007).

Due to the formerly deducted reasons the main objective of this study is to give a scientifically grounded answer to the following questions:

- How and to what extent do the existence of post harvest technology and infrastructure influence the economic and investment efficiency of apple production?
- Which plant model, namely which combination of production and post-harvest could result the most effective production?

With reference to the abovementioned main objectives the following hypotheses were settled:

- The existence of post-harvest technology could significantly improve the economic efficiency of production.
- The best investment efficiency rate is generated by the highest degree of post-harvest supply, i.e. the simultaneous existence of plantation, storage, sorting, ranking and packing.

To accomplish the objectives above the following specific tasks are need to be accomplished first:

- Definition and specification of the most frequent types of processing plants as the combination of production and post-harvest technology.
- Determination of the investment costs as initial equity requirement in case of each plant type.

- Evaluation of operating costs and revenue as for the cost-benefit analysis of the production.
- As a result from these, characterisation and comparative assessment of each plant type should be done.
- Ranking of the main factors indicating economic efficiency of the investment based on their significance and determination of the critical value indicating the lower margin of economic efficiency.

Accomplishment these objectives make it possible to measure the impact of post-harvest technology development on economic efficiency, to choose the most efficient plant type, moreover to specify the main business advantage and disadvantage of each plant type. The importance of this subject is proved by neither foreign nor domestic literature is deficient in this topic.

2. Material and method

During the analysis of the questions determined in the abovementioned objectives three types of processing plants are proposed, which are the most common in domestic apple industry:

- "Model A": Undertaking owns only a plantation, there is no post-harvest technology connected to the production. Fruit is sold right after it got harvested. Due to these conditions the model is characterised by mainly low initial capital investment, whereas in the years of operation – because of the unfavourable selling prices in the harvesting period – there is a lower cash income.
- "Model B": Undertaking owns a partial post-harvest infrastructure besides the plantations, it establishes a cold storage in accordance with the quantity of dessert apples, which results enormously high initial capital investment, average selling price is much higher due to the continuous sales in the season and this leads to a higher cash income in the production period.
- "Model C": Undertaking owns an entire post-harvest infrastructure (storage, sorting, ranking, package) besides plantations, similarly to "Model B" sales is continuous however in the highest level (sorted, packed). The highest initial equity investment is the main characteristics of this model; still it has the highest realized income in the years of operation.

The analysis methodology required to accomplish the objectives is provided by the means of cost-benefit analysis and investment efficiency analysis. There are two main methods of investment efficiency evaluation: static and dynamic analysis. Professionally, dynamic methods provide rather reliable and precise results, calculating with the time value of money is what makes it different from the static method (*Graham and Harvey* 2001; *Warren* 1982; *Illés* 2002). More ratios are available for dynamic investment efficiency evaluation, out of which NPV (Net Present Value), DPP (Discounted Payback Period), IRR (Internal Rate of Retrun), return on equity are assessed (*Brealey 2006*).

Leading part of data processing is a simulation model based on the mainly primer data collection – partially secondary data collection – focusing on the production's natural inputs and yields in the plants. During the investigation deterministic simulation model was compiled in the same way as *Szőllősi* (2008) and *Apáti* (2007) did in their works, where input data are on one hand technological and economic parameters on the other hand. Model is capable of complex cost-benefit, investment efficiency analysis and sensitivity-tests of apple production, where the impact of input and output prices, yields, investment costs, operating costs and the change of subsidy can be measured on income and economic efficiency.

Current prices were used during the calculations in the investment efficiency models, so inflation was included neither in the output nor in the input side. It is assumed that beside the changes of the input and output price level the income do not change considerably. Amortisation costs are not listed among expenditures and tax shield effect was not taken into consideration. Calculations disregard indirect subsidies and average costs. *Szűcs–Szőllősi* (2007) suggested the consideration of the return on government bonds and treasury bills while determining the calculative rate, they still mention that actual borrowing rate is used by the most economists in their calculations. Accordingly, the average value of the last five year's interest on government bonds was included. This way, the interest rate of 6%was used in the analyses. The average investment lifetime is determined generally as 15 years. The analyses based on the most probable realistic scenario, the uncertainty in operation and calculation was handled, based on the recommendation of *Nábrádi* and *Szőllősi* (2007), with the help of sensitivity analyses (scenario analyses, elasticity calculations, critical values calculations). At the end of the investment's lifetime, the calculation of model B and C included the residual value of the postharvest infrastructure, where the value is determined as the probable market value. The residual value is zero in case of the plantation; the value of the firewood offsets the cost of the cutting of the trees so there is no need to consider.

Our models assume an apple plantation cultivated in a high standard, having a good condition and intensive farming. Parameters of the characterized plantation type: M9 subject, slim spindle crown shape, 4.0 m row spacing and 1.0 m plant to plant distance, 2500 tree/ha cardinal number, (draining) sprinkler system, 40–50 t/ha yield rate in optimal years, out of which dessert apple is approximately 80%, the peer apple rate is about 20%. The analysed model assumes a good producing quality and a high technological discipline. Calculations focus not on the average plants in Hungary, but the good quality producers and modern plants. Data was collected in apple plants with the abovementioned characteristics. Calculations were set to a 100 ha sized plant, which assumes a nearly optimal plant size and capacity utilization. The expenditures (materials, hand and machine work) and production costs reflects the price level of 2013–2014. The price of input materials is considered without VAT and wage cost of handwork is with taxes. Production yields, quality output and selling prices are presented with the help of a long-term – between 2009–2013, 5 years – average, selling prices are also determined without VAT.

3. Results and their assessment

Cost-benefit and investment efficiency analysis are calculated for all the three plant type to accomplish the previously stated objectives. Investment efficiency was the heart of the analysis; cost-benefit analysis provided primarily only the necessary partial results for the calculations. Consequently, investment costs, operating costs and incomes, and the investment efficiency analysis for 15 year-long investment life of the models are presented in the followings.

3.1. Investment costs

The lowest investment cost is present in case on 'Model A', because only the cost of plantation establishment is included, there is no post-harvest infrastructure. The previously described plantation's establishment cost is 4595 thousand HUF/ha (*Table 1*). In case of 'Model B' investment cost is 3.5 times higher, where besides the plantation; storage capacity in accordance with the quantity of the produced dessert apple is also founded with the necessary integument and transporter machines. Building cost of the cold storage approaches 9 million HUF/ha considering 31.5 tons/ha capacity, which results a 2.5 times greater investment cost in case of post-harvest technology, than the cost of the plantation itself.

The highest level of initial investment cost can be connected to 'Model C', where the entire post-harvest technology is established: sorting/ranking machine and room besides the cold storage and by this means higher added-value, sorted, packed good is offered for the sale. The establishment of sorting and packing capacity is no more than 1.0 million HUF/ha, with which 16 869 thousand HUF/ha total investment cost of 'Model C' is only exceeding the cost of 'Model B' with 6% (*Table 1*).

Table 1. Investment costs of the analysed plant types

(Thousand HUF/ha)

Cost element	'Model A'	'Model B'	'Model C'
Land and soil preparation	554	554	554
Establishment of stanchions	1 128	1 128	1 128
Grafts and planting	2 123	2 123	2 123
Acquiring of irrigation equipment	640	640	640
Other costs	150	150	150
Total cost of plant establishment	4 595	4 595	4 595
Building and equipment of cold storage	–	8 826	8 826
Integument (tanks)	–	2 311	2 311
Transporter machines, others	–	170	170
Total cost of cold storage establishment	–	11 307	11 307
Sorting/ranking machine	–	–	800
Building of sorting room	–	–	167
Total cost of sorting machine	–	–	967
Total investment cost (C_0)	4 595	15 902	16 869

Source: Own calculations

3.2. Operational incomes and costs

Parallel to the planning of the operating period's costs and incomes, it can be determined that the established intensive apple plantation becomes producing in 3–4 years, so we calculated with continuously increasing yields, incomes and operational costs. The model computes with a standard average data regarding yields and prices for the entire 11 year-long production period (5–15. year). The origin of the average data is the five year average data provided by the primary data. Investment efficiency is basically determined by the initial capital requirement (C_0) and the cash flow of the production period, therefore the focus is on the evaluation of these factors.

In the production period (year 5–15) in case of 'Model A' on average 39.4 tons/ha yield can be realized, out of which 80% is dessert apple and 20% is perry apple. Average selling price of the former is 68.83 HUF/kg, and 22.00 HUF/kg of the latter one. Both the dessert apple and perry apples are immediately sold in tanks after harvest – without storage, sorting or packing. The initial capital requirement of the model (4595 thousand HUF/ha) and the cash flow of the producing period (911 thousand HUF/ha) is relatively low, because there is no postharvest infrastructure and the product is sold on a lower price characterizing the harvesting period (*Table 2*).

'Model B' calculates with similar produced yield, with the same dessert-perry apple ratio and perry apple is considered with the same price, but the average selling price of dessert apple has increased to 88.2 HUF/kg, due to a favourable sales

Table 2. Annual yields and cash flow in 'Model A'

Years	Yield produced (tons/ha)	Yield realized (tons/ha)	Average selling price (HUF/kg)	Income (thousand HUF/ha)	Expenses (thousand HUF/ha)	Net cash flow (thousand HUF/ha)
0.	0.0	0.0	59.46	0.0	4595.0	–4595.0
1.	0.0	0.0	59.46	0.0	380.0	–380.0
2.	6.0	6.0	59.46	357.0	450.0	–93.0
3.	17.0	17.0	59.46	1011.0	655.0	356.0
4.	33.0	33.0	59.46	1962.0	1262.0	700.0
5–15.	39.4	39.4	59.46	2343.0	1432.0	911.0

Source: Own data collection and calculations

Table 3. Annual yields and cash flow in 'Model B'

Years	Yield produced (tons/ha)	Yield realized (tons/ha)	Average selling price (HUF/kg)	Income (thousand HUF/ha)	Expenses (thousand HUF/ha)	Net cash flow (thousand HUF/ha)
0.	0.0	0.00	74.29	0.0	15 902.0	–15 902.0
1.	0.0	0.00	74.29	0.0	380.0	–380.0
2.	6.0	5.71	74.29	424.0	505.0	–81.0
3.	17.0	16.18	74.29	1202.0	811.0	391.0
4.	33.0	31.42	74.29	2334.0	1 566.0	768.0
5–15.	39.4	37.51	74.29	2787.0	1 794.0	992.0

Source: Own data collection and calculations

Table 4. Annual yields and cash flow in 'Model B'

Years	Yield produced (tons/ha)	Yield realized (tons/ha)	Average selling price (HUF/kg)	Income (thousand HUF/ha)	Expenses (thousand HUF/ha)	Net cash flow (thousand HUF/ha)
0.	0.0	0.00	134.96	0.0	16 869.0	–16 869.0
1.	0.0	0.00	134.96	0.0	380.0	–380.0
2.	6.0	5.71	134.96	771.0	626.0	145.0
3.	17.0	16.18	134.96	2184.0	1 153.0	1 031.0
4.	33.0	31.42	134.96	4240.0	2 229.0	2 011.0
5–15.	39.4	37.51	134.96	5062.0	2 637.0	2 425.0

Source: Own data collection and calculations

position from January to April. The product enters the market without sorting and packing, in tanks. Sold quantity is less than the produced quantity by 6% due to storing losses. Comparing 'Model B' to 'Model A' the main difference is the 3.5 times higher initial capital requirement because of the establishment of storage capacity, moreover the cost of the operating period is higher with 25% as for the operating cost of cold storage. Annual income increases by 19% parallel to higher selling prices. As a result – comparing to 'Model A' besides 3.5 times higher initial capital require-ment only 9% increase is observed in annual cash flow in the producing period (*Table 3*).

The main difference in 'Model C' (*Table 4*) compared to 'Model B' is that the average selling price is higher with 80%, because dessert apple stored, sorted by size and colour, in paperboard package of 13 kg has the average selling price of 165.0 HUF/kg. Yield and quantity parameters are the same in both models. According to this, annual income nearly doubled in the producing period, still the sorting and packing represents a 842 thousand HUF/ha extra operating cost. Consequently, with only 6% higher initial $C_{0,}$ in comparison to 'Model B', 244% higher cash flow can be reached in the producing period.

1.3. Investment efficiency

With the help of the presented data the economic efficiency of production and each plant type can be determined. The results of the analysis are summarized in *Figure 1* and *Table 5.*

In case of 'Model A' low initial capital requirement is the starting point of NPV and – after 3–4 years of transition period – due to the relative low cash flow in production period the graph does not show a steeply rose (*Figure 1*). At the same time, the investment pays back (DPP) in 12th year, at the end of the investment period (15th year) 1507 thousand HUF/ha NPV, besides 9.37% if internal rate of return (IRR) and 1.33 profitability index (PI). Based on the indicators, the investment is economically efficient, still NPV is considered to be too high, IRR barely exceeds r and PI is not much higher than 1 (*Table 5*). As for *Apáti* (2012) – in which he summarized the main results of his research – the economic efficiency of an apple plantation considered to be good if IRR reaches 15% and DPP is not more than 7–9 years due to the high initial capital requirement and the first few years of unproductive period. Taking these into consideration, the economic efficiency of 'Model A' is acceptable but not good.

'Model B' is proved to be perfectly economical efficient (*Table 5*). As deducted in *Table 3*, it produces slightly higher cash flow than 'Model A', so the production can be continued in case of cash income. This annual result is not enough at all to compensate the financial yield of the alternative investment calculated with r=6%, because of the considerable high initial capital requirement. The reason why 'Model B' is economically inefficient is demonstrated by the result of the cost-benefit analysis: using stored apple 19.37 HUF/kg annual price increase could be reached, which is resulted in 444 thousand HUF/ha extra revenue, on the contrary the annual operating cost of the storage is 362 thousand HUF/ha. However the 82 thousand HUF/ha more cash flow do not cover even the 754 thousand HUF/ha amortisation cost, so this operation is obviously showing deficit. The low sales price surplus can be explained by the price increase in the beginning of season

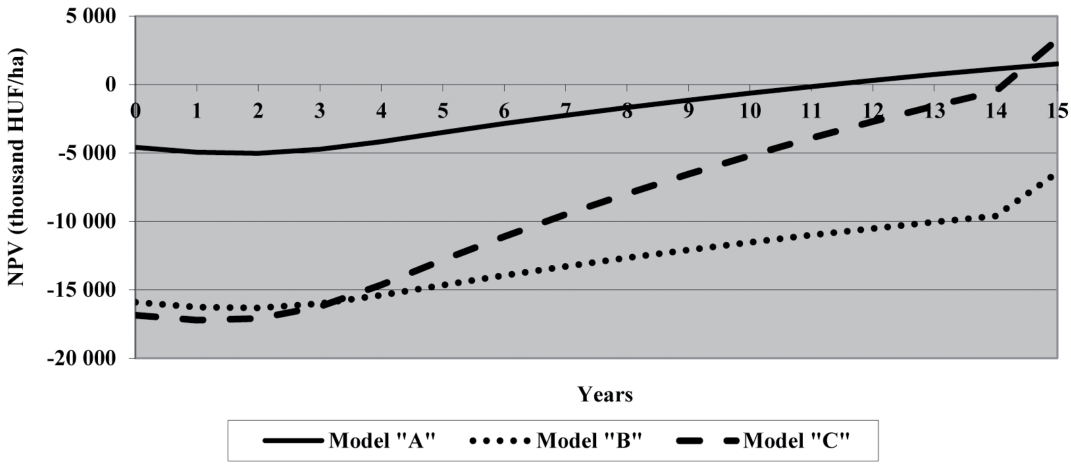

Figure 1. NPV values in the lifetime of the investment regarding realistic case without subsidy (t=5 years, r=6%)

Source: Own calculations

Table 5. Investment efficiency ratios of the models regarding realistic case without subsidy (t=15 years; r=6%)

Indicator	Unit	'Model A'	'Model B'	'Model C'
Net present value (NPV)	thousand HUF/ha	1507.0	–6436.0	3274.0
Internal rate of return (IRR)	%	9.37	1,19	8.01
Discounted Payback Period (DPP)	year	12.	>15.	15.
Profitability index (PI)	-	1.33	0.60	1.19

Source: Own calculations

(autumn) and average price decrease in the end of the season (spring) in the last 4–5 years, with which the relative extra price by means of storage diminished. 'Model B' is not economic efficient even with the cold storage's amortization calculated at the end of the 15th year.

'Model C' reaches the minimal level of economic efficiency besides 3274 thousand HUF/ha NPV, 15 year long DPP of and 8.01% IRR. Figure 1 also illustrates that the residual value of the cold storage calculated in the last year make the efficiency ratios rise. However, it would also payback/return in year 15 without the residual value, but it would barely exceed the alternative investment calculated with r=6%.

Meaningful relation could be gained in the comparison of each model only in case of 'Model A' and 'Model C', because 'Model B' is not economic efficient. 'Model C' represents 3.67 times higher initial capital requirement, 2.17 times higher NPV, but 15% lower IRR, 11% lower PI and resulting 25% longer payback period. So 'Model A' shows more preferable results considering capital adequacy ratios, while 'Model C' considering absolute income-generating capability (profit/hectare).

3.4. Sensitivity analyses

Uncertainty present in economic efficiency calculations is handled by sensitivity analyses. Scenario analysis was carried out to determine, how each plant types' economic efficiency of each plant type is affected by the generally available 40% subsidy in Hungary. Elasticity calculation was used for the selection and classification of the most influential factors of economic efficiency. Furthermore, critical value tests quantified the values of factors, with which the investment pays back till the end of the investment period.

Based on the data shown on *Figure 2* and in *Table 6*, all the three plant models' economic efficiency index increased significantly thanks to the 40% investment aid, which also has impact on the initial capital requirement (C_0) by reducing it with 60%. This way 'Model B' reaches the margin of economic efficiency; it almost returns in year 15 and its NPV is almost zero. NPV of 'Model A' increased more than twice, its IRR and PI almost doubled and its DPP shorten from 12 to 8 years. 'Model C' shows similar extent and direction of change, but in this case NPV increase more than three times and DPP is more closer to the payback period of 'Model A', than the period without any aid. Comparing 'Model A and C', it can be stated that the difference is more preferable from 'Model C's point of view: NPV is three times the amount of 'Model A' and there are relatively smaller differences in case of the other indicators too.

Elasticity tests highlighted (*Table 7*) that the price of dessert apple, as the main product in all plant models, influences the economic efficiency the most. Subsequently, in every model the yield and quality of production – so the income part – are the most determinant factors, while operating costs and investment costs have the lowest influence on economic efficiency.

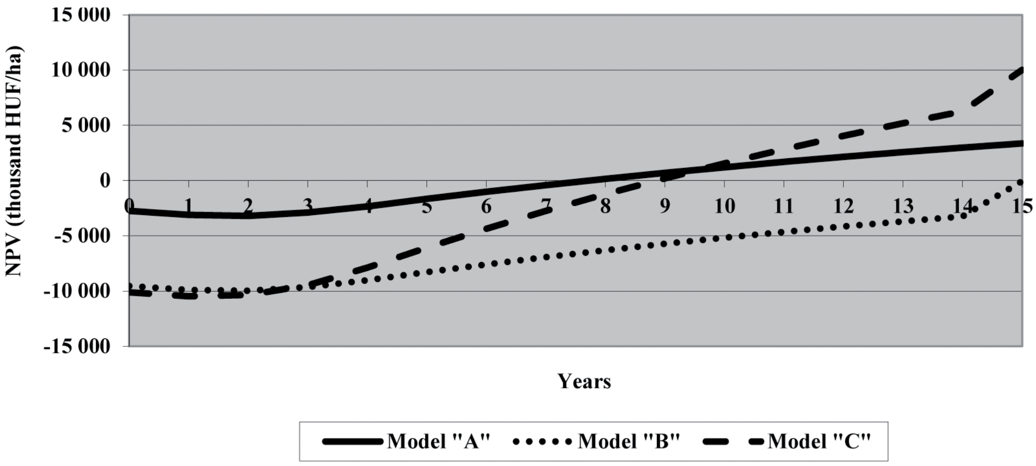

Figure 2. NPV values in the duration of the investment regarding realistic case with subsidy (t=5 years, r=6%, aid intensity=40%)

Source: Own calculations

Table 6. Investment efficiency ratios of the analysed three model regarding realistic case with subsidy (t=5 years, r=6%, aid intensity=40%)

Indicator	Unit	'Model A'	'Model B'	'Model C'
Net present value (NPV)	thousand HUF/ha	3345.0	–75.0	10 021.0
Internal rate of return (IRR)	%	15.95	5.92	14.39
Discounted Payback Period (DPP)	year	8.	>15.	9.
Profitability index (PI)	–	2.21	0.99	1.99

Source: Own calculations

Table 7. The results of elasticity analysis and their influence on the main economic efficiency determinant factors (the impact of drivers' 1% positive change on NPV)

Factors	Unit	'Model A'	'Model B'	'Model C'
Selling price of dessert apple	%	10.68	3.01	11.05
Production yield	%	9.68	2.34	9.56
Ratio of dessert apple quality	%	7.29	2.22	8.67
Operating cost of producing age	%	5.97	1.80	4.91
Investment cost	%	3.05	2.47	5.16

Source: own calculations

Nevertheless, a few differences can be observed between the model's sensitivity. In case of 'Model C' high initial capital requirement makes it more sensible to the change of investment costs, than in 'Model A', this is why the result of investment costs is better as the impact of the investment aid (See in *Table 5* and *6*). In 'Model B' the factors of yield, price and quality – compared to cost part factors – have a lower significance, than on the other two models. The reason is that plant types determined by high investment costs are much more sensitive of the change in the cost side, especially the change of the investment cost. There is roughly the same sensitivity present than in case of yield and selling price (*Table 7*).

Table 8 illustrates a similar situation to the recently detailed one, where critical value of main economic efficiency determinant factors and their ratio regarding its initial values are given. The latter demonstrates that to what extent and to which direction deviation is allowed regarding realistic values to ensure that the investment's economic efficiency. The lower margin of economic efficiency is NPV=0. In case of currently economic efficient 'Models A and C' a small decline (9–13%) of yields and selling price is enough to turn the model inefficient. Quality output of the plants are also similarly sensitive, the highest possible decrease 14–17%. This amount of yield, price and quality deterioration is feasible in horticultural terms. Regarding operating and investment cost further 16–32% growth is acceptable to reach economic efficiency.

In case of 'Model B' 33.2% increase in the dessert apple's selling price and 42,6% increase of yield would be required to become economic efficient, which is practically not possible. At the planned level of 39.4 t/ha yields even 100% output would not be able to fulfil economic efficiency requirements. Operating and investment cost should be half as much,

Table 8. The critical value of main economic efficiency determinant factors and their ratio compared to realistic scenario's initial values

Factors	Unit	'Model A'		'Model B'		'Model C'	
		Value	Ratio	Value	Ratio	Value	Ratio
Price of dessert apple	HUF/kg	62.38	90.6%	117.51	133.2%	150.10	91.0%
Yield*	t/ha	34.40	87.3%	56.20	142.6%	35.00	88.8%
Prandial yield*	%	66.90	83.6%	>100	–	69.00	86.3%
Operating costs*	thousand HUF/ha	1673.00	116.8%	764.00	42.6%	3161.00	119.9%
Investment costs	thousand HUF/ha	6102.00	132.8%	9466.00	59.5%	20143.00	119.4%

*Comment: per production year

Source: Own calculations

which is also inconceivable scenario. Based on the mentioned results, it is obvious that 'Model B' is impossibly far from economic efficiency.

4. Conclusions and recommendations

Summarizing the results of the analyses, answering the formulated objectives it can be stated that the post-harvest processes significantly influence the economic efficiency of the production, which is present mainly in the followings:

- Post-harvest investments increase the plantation establishment of 4000–5000 thousand HUF/ha capital requirement with an extra 11 000–13 000 thousand HUF/ha, i.e. enhance the initial capital requirement, which surplus is 90% due to the establishment of cold storage. Investment cost of sorting and packing do not represent a significant weight.
- Plantation establishment itself without post-harvest ('Model A') can operate economic efficiently. Generally, the investment payback with 1507 thousand HUF/ha NPV and 9.37% IRR in the 12th year.
- It is also economical efficient to establish post-harvest technology (storage, sorting and packing) besides plantations ('Model C'), which results 3207 thousand HUF/ha NPV and 8.01% IRR and payback in the 15th year.
- 'Model B' as an intermediate version (plantation and the cold storage) is proved to be totally not economic efficient.
- Investment aids of 40% intensity significantly improve efficiency in all cases: including the aid 'Model B' reaches the margin of efficiency, the indicators of 'Model A and C' are increased by 1.5–3 times.
- Yield in 'Model A and C' mainly yield, ratio and the price of dessert apple determine efficiency, while the factors of operating and investment costs have a much more moderate impact. In case of 'Model B' the mentioned factors counts with the almost the same weight.
- In case of both 'Model A and C' there is a huge risk that an unfavourable change of economic and natural environment could turn the production not efficient, because input variables mainly determining efficiency are only 9–17% away from the critical value.

Based on the abovementioned, out hypothesis has been partially proved, because post-harvest could only improve significantly the economic efficiency of the investment if the whole post-harvest technology is established. The establishment of the cold storage itself –without preparing a product – makes the investment considerably inefficient. The second hypothesis is also partially true, because 'Model A and C' could not be unambiguously ranked as the latter performed better regarding income-generating capability, while the former has more favourable values regarding capital adequacy (IRR, PI) ratios.

The results reflects the scientifically confirmed conclusions of Apáti (2012) that in fructiculture generally capital intensive methods are capable to produce higher profit per unit of area, while the more extensive methods often perform better regarding capital adequacy ratios and in terms of payback period (DPP) there is not unconditionally significant difference between the two farming method.

References

Apáti F (2009): *The comparative economic analysis of Hungarian and German apple production of good standard.* In.: „International Journal of Horticultural Science" Vol. 15., Number 4, 2009., 79–85. pp. HU ISSN 1585 0404

Apáti F (2012): *Gyümölcsültetvények fagy- és jégvédelmének technológiai lehetőségei és gazdasági megfontolásai.* Debreceni Egyetem AGTC Kertészettudomány Intézet. Debrecen, 2012. 227 p. ISBN 978-615-5183-28-7

Brealey RA, Myers SC & Allen F (2006): Corporate Finance. Eight Edition, McGraw-Hill, 84–143. p., 244–272. p.

Doluschitz R (2001): Kooperation in der Landwirtschaft. In.: Berichte über die Landwirtschaft – Zeitschrift für Agrarpolitik und Landwirtschaft, 79, (3): 375–398

Fruitveb (2013): Apple. In.: Fruit and vegetable report. FruitVeB Hungarian Interprofessional Organisation for Fruit and Vegetables. Budapest, 2013. pp. 16–17.

Graham & Harvey (2001): "The Theory and Practice of Finance: Evidence from the Field". Journal of Financial Economics 61, 187–243. p.

Illés M (2002): A beruházások gazdaságossága. In: Vezetői gazdaságtan. Szerk.: Illés M. Kossuth Kiadó 2002. 115–162. p.

Lakner Z & Apáti F (2010): *Economics of apple-storage I.: Comparative time series analysis of apple producer prices in Germany and Hungary.* In.: „International Journal of Horticultural Science" Vol. 16., Number 4, 2010., pp. 75–79. HU ISSN 1585 0404

Möhring A, Lauber S & Anken T (2007): Relevanz der überbetrieblichen Zusammenarbeit in der Landwirtschaft. Kostensenkung – wie hoch ist das Potential wirklich?. 30: Informationstagung Agrarökonomie, 13.09.2007, Tänikon, Ettenhausen.

Nábrádi A & Szőllősi L (2007): „Key aspects of investment analysis" In: Applied Studies in Agribusiness and Commerce (APSTRACT) 1: (1) 2007. pp. 53–56. Agroinform Publishing House, HU-ISSN 1789-221X

Szőllősi L (2008): „A vágócsirke termékpálya 2007. évi költség és jövedelem viszonyai" In.: Baromfi Ágazat 8: (4) 2008/4. december, Budapest, pp. 4–12.

Szűcs I & Szőllősi L (2008): „A beruházások ökonómiai megítélése" In.: Üzemtan I. (Szerk.: Nábrádi A.–Pupos T.–Takácsné György K.) Szaktudás Kiadó Ház, Budapest, 2008. 3.2.3.3. fejezet, pp. 46–59. ISBN 978-963-9736-91-7; ISBN 978-963-9736-90-0-ö

Warren MF (1982): Financial Management for Farmers, the Basic Techniques of 'Money Farming'. Third Edition, Stanly Thornes Ltd, 240–246., 259–260. p.

Z Kiss L (2003): A gyümölcstermesztés feltételrendszere. In.: A gyümölcstermesztés, -tárolás, -értékesítés szervezése és ökonómiája. (Szerk.: Z. Kiss). Mezőgazda Kiadó. Budapest, 2003. 13. p.