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PhD School of Management and Business Administration

THE SIZE ECONOMIC QUESTIONS OF VEGETABLE FORCING

Thesis of the doctoral (Ph.D.) dissertation

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INTRODUCTION

During the preparation of my doctorial dissertation, I have had the basic purpose of **creating practice-oriented vegetable-forcing models** of comprehensive and realistic characters that do not require soil and meet the requirements of the 21st century – thus applicable in size-economic research tasks.

In preparing the present scientific work I have been motivated by the fact that the special literature, dealing with the questions of vegetable forcing does not or only superficially pays any attention to this topic. The agricultural farming enterprises, which are involved in vegetable forcing technologies, and may still be considered competitive in the future, do not or only restrictively publish data on economic character and farm sizes, which encouraged me to carry out empirical and scientific research. In carrying out research I have also been helped to a great extent by the fact that I was brought up in a family in Szentes dealing with vegetable production so I have been interested in the technology and economics of vegetable forcing from the start.

The objectives of my research were the following:

1. Working out vegetable forcing models without soil that are suitable for long cultured (all year long) production and also provide continuous employment. They are also capable of creating constructions by considering the possible alternatives of heating that are easily comparable on 0.5, 1, 3, 5 and 10-hectare-sizes.

2. Knowing the farm sizes and constructions of the vegetable forcing models without soil, I was striving to produce detailed investment alternatives and plan their investment costs together with defining the exact operating costs and possible revenues of glasshouses with three types of vegetable types (green pepper for stuffing, tomato and cucumber) based on technological and economic experience.

3. Evaluating vegetable forcing models without soil with the help of the break-even point, size, capacity use and investment-related calculations (NPV, IRR) by modelling the changes in production costs and revenue with the help of sensitivity tests.

4. Defining the vegetable forcing models without soil as a construction and farm size that can be viable in the future and can be considered as farm sizes able to be developed.

5. Examining the efficiency of the heating alternatives and income generating capacity with the help of the vegetable forcing models created as a construction and depending on farm sizes.

It was not my objective during the research to analyse investments regarding liabilities from an accounting aspect and to evaluate the impact of subsidies as well as the proportion of own and external capital on the farm size.

The preliminary expectations determining the objective of the research are summarised by the following hypotheses:

H1: The models of computerised green-and glasshouses with automated climate control, irrigation, alimentary and heating systems used for vegetable forcing without soil are not viable at the farm size of 0.5 ha.

H2: Glass-and greenhouses of 5 and 10 ha size heated by thermal water reach the break-even size with a capacity use of approximately 60-70

H3: Based on the size economic examinations only the vegetable forcing models of 3, 5 and 10 ha greenhouse size can comply with the 25% revenue related income level expected in practice, which can significantly be influenced by the heating alternatives.

H4: With the decrease in the manufacturing costs due to the increase of farm sizes, economies of scale can be pointed out.

H5: The 100 Watt heating performance of the constructions heated by thermal water per m^2 exceeds that of those ones heated by fossil energy.

MATERIAL AND METHOD

During my research task I was driven by the aim of creating thorough, easily understandable and practice-oriented models to examine the question of **size economy in vegetable forcing.**

- The professional literature of the size economy in vegetable forcing does not at all or partly deal with this topic.
- The economy series data are rather incomplete in the horticultural branches especially in vegetable forcing.

These facts served me enough inspiration to start empiric and scientific examinations.

Qualitative data collection and interviews were made to collect enough information to identify problems and to base my hypotheses. My interviews consist of spontaneous interviews that ensure flexible and adaptive although a pre-planned process.

The interview as **a research method** was used in the initial phase of my empiric research to explore the problems and also in the final phase to check the validity of my results. The spontaneous interview was selected as there are no pre-planned questions there so the knowledge of the interviewer can prevail.

During the spontaneous interview the words mentioned must be interpreted in their context. Such type of interview is based on personal contact, it is like a conversation. Its advantage is improvisation and also the body language and gestures of the speakers can be seen. The latter one carries information and can influence the contact between the interviewer and the interviewee.

The **profound interview** is a face-to-face based qualitative method whose objective is getting to know the deepest motivations and unconscious (not conscious) motives of the respondent. This qualitative method has become widespread in clinical psychology and psychoanalysis. The „client-centred" school of the American psychologist, Carl Rogers, had a great impact on the development of this process.

The profound interviews, namely 32 pieces, were made in March and September, 2008.

Analysing the results of the interview is a difficult task so I think it was important to record the results of the conversation. After listening to the

recorded pieces several times, a detailed analysis in the form of a text was carried out that can also be interpreted as a content analysis.
The respondents of my interviews were such professionals who head Hungarian leading farm sin vegetable forcing. These farms are also competitive on a European level. They can provide such technological, market, economic and labour organising data that can serve as a positive example for gardeners engaged in vegetable forcing.

The preliminary data collection highlighted the importance of services in tight connection with production. These pieces of information that can help deepening market, technical and legal knowledge derive from professionals specialised in this area.
My models were compiled on their basis summarised on the facts listed above. The problems pointed out by the practising professionals were in connection with the fact that the old fashioned greenhouses of the present day can limit the increase in yield. The success of production depends on the climate that prevails during forcing whose prerequisite is the application of the proper production system that meets the requirements of the 21st century.

The objective was working out such a simulation model with which:
(CSÁKI, 1976)

- planning the investment and operating costs of vegetable forcing becomes possible,
- the technological plan of the forced vegetables can be compiled suiting the unique/special features of the farm,
- the production cost and the expected revenue, income of the forced vegetables can be defined,
- production costs, revenues, break-even sizes and values of using capacity properly can be measured per vegetable and construction,
- it is suitable for defining average costs or manufacturing costs and carrying out size economic analyses,
- measuring the specific costs of heating energy can be possible in relation to farm sizes and constructions,
- based on the models and the calculated indices it can be proved that size economy does exist in vegetable forcing.

Two types of production systems were considered when compiling my models: modern **plastic foil covered and glasshouses** with huge room and a height of 4.5-5 m.

Furthermore, in my models I have also defined the **farm sizes** that are most widespread in practice based on the compilation of the preliminary results so the:

- 0.5 hectare,
- 1 hectare,
- 3 hectare,
- 5 hectare,
- 10 hectare-farm sizes have become the basis of my cost-benefit analysis.

Taking the Hungarian endowments into consideration I have chosen five **methods of heating**:

- thermal water (without pumping back),
- thermal water (with pumping back),
- coal,
- wooden chips,
- natural gas.

Constructions with the combination of production systems and heating methods were created in 10 varieties. The ten varieties on 5 types of farm sizes resulted in 50 types of model variations.
The use of constructions were tested on **green pepper** for stuffing, **tomato and cucumber** among the **forced vegetables** as the listed ones represent approximately 70% of the production value in Hungary.

The **150-model varieties** were supplemented by 30 types of mixed models that are more risk-resistant based on the more diversified production system.
The mixed models were examined on the basis of the following proportions in case of the green pepper, tomato and cucumber:

- on 3 hectares 1:1:1
- on 5 hectares 2:2:1
- on 10 hectares 4:4:2.

Together with the mixed models altogether **180 vegetable forcing models** were the subject of my analyses that also represent the possible modifications in the future. While calculating investment and production costs **net prices** were considered.

During my research the following methods were used for data processing and examining the size economic questions of vegetable forcing:

1. Determining the theoretical capacity utilisation

Knowing the production costs and average prices I have examined the **break-even points per construction** and the **farm sizes** belonging to them. A **theoretical capacity-utilisation** value was determined on the basis of the sizes that belonged to the break-even points that showed how many percent of the production system must be utilised to produce the finances necessary to cover production costs. In practice such partial utilisation cannot be imagined at all as the whole surface of the greenhouse is used and surfaces above the break-even size ensure efficiency and returns.

2. Calculating break-even sizes and their sensitivity examination:

When calculating the break-even size I wished to model the changes in the economic environment by increasing and decreasing production costs and possible profits. The sensitivity examination was carried out with the help of the table-method. The examined factor, i.e. break-even size was expressed in m^2. I examined how **break-even sizes** vary **per forced vegetable, construction and farm size** when increasing or decreasing the costs and revenues by 5% and 10%.

3. Return on investment and risk sensitivity examination:

To model **the changes of the economic environment** much more perfectly, I have changed the values of revenues and operating costs due in the given periods as follows:

- **optimistic** (on the whole, both revenues and operating costs increase by 4% per annum) **(marked in green colour)**
- **realistic** (revenues increase by 3% and operating costs by an average of 4% per annum) **(marked in blue colour)**
- **pessimistic** revenues increase by only 3% and operating costs by an average of 5% per annum) **(marked in red colour)**

The so-gained cash flow values were calculated for a 20-year period and then the **optimistic, realistic and pessimistic** versions attached to them were evaluated. To calculate the **NPV values,** the NMÉ function of the Excel programme was used. In case of the built-in financial function when determining the calculative rate of interest the yield of government securities served as the basis.

By using **IRR** (Internal Rate of Return), the internal rate of return of investments was defined and this index helps examining the real efficiency of the investment. As a result, we can calculate the rate of interest at which the discounted present value of the investments equals zero, i.e. the discounted revenues and costs are equal. The sum invested will return from the profit of the investment on the level of the so-defined internal rate of return. The calculated **IRR values were grouped in categories I-IV**, whose IRR is the following:

- **Category I:** above 20%
- **Category II:** between 15-20%,
- **Category III:** between 10-15%,
- **Category IV:** below 10%.

4. Examining manufacturing costs in relation to constructions and farm sizes:

Manufacturing costs of the forced vegetables in the case of the **ten different versions** were defined and evaluated based on farm sizes. With the help of the manufacturing cost, comparing farm sizes and constructions is also possible in case of similar utility varieties.

5. The impact of heating performance on operating profit per construction and farm size:

As the comparison of the different heating methods can only be carried out on similar dimensions, I have worked out an indicator. The **indicator** presents the **formation of operating profit per m^2 on 100 Watt heating performance.**

RESULTS

1. The formation of break-even size and capacity use in the models

The capacity use values of the constructions heated by natural gas are the worst and they did not change in line with the increase of farm size. Heating the production systems by natural gas that meets the requirements of the 21st century is not competitive due to the high price of fossil energy carriers. In case of the 0.5 ha farm size, unfavourable values over 85-90% can be experienced everywhere independent of the constructions and ways of utilisation. Regarding green pepper forcing without soil in greenhouses this value reaches the 128% capacity use level.

Examining the tables, it can be seen that even values around 70% can be experienced in the case of 1 ha farm sizes except the constructions heated by natural gas but most values are still about 80-90%.
First it is the 3 ha farm sizes where we can experience that the average capacity use values decrease to 70-80%, which shows a much more unfavourable value, i.e. around 60% in the case of constructions heated by thermal water.
By increasing the sizes, the percentage values can obviously improve regarding 5 and 10 ha equipment.

The extremely high costs of greenhouses heated by thermal water without pumping back can most of all be covered by farms bigger than 3 ha, which is also reflected in their capacity use values. As in this case thermal water is pumped back to the layer where it derives from, that is why it is one of the heating methods based on renewable energy which must by all means be considered in the future.
Another renewable energy source is heating by wooden chips, which can also have potentials regarding the endowments of Hungary and it shows a value of approximately 70-75% depending on the ways of utilisation in the case of 3 ha or bigger farm sizes.

The constructions heated by coal show an acceptable 75-80% value on 3, 5 and 10 ha farm sizes. Due to the rising price of the coal and its environmental polluting impacts a decrease of this type of heating method can be envisioned in the future.

2. The sensitivity examination of vegetable forcing models based on break-even sizes

The sensitivity examination of the **plastic foil covered greenhouses** took place as follows.

Among the 0.5 ha models only the equipment with the most favourable heating method, i.e. heating by thermal water without pumping back can show values that are acceptable under optimistic circumstances from both economic and technological points of view. In case of the heating methods with a higher cost more and more unfavourable results can be experienced, which proves that this type of farm size is less viable in the long run.

Among the 1 ha models the constructions heated by thermal water show a much more favourable picture. However, the new horticultural farms with thermal wells and pumping back cannot even be termed as risk takers even here as it is only under favourable economic circumstances that they reach the revenue level of 25% or a slightly higher one. In case of the plastic foil constructions heated by wooden chips, similar data can be experienced that allows us to conclude that the 1 ha-size farms do not meet the requirements in practice.
In case of heating by coal more favourable data are gathered that can also be seen in the utility modes of green pepper, tomato and cucumber.

The advantages of size economics can first be felt in the case of the 3 ha model farms. Depending on the heating method, the highest proportion of break-even sizes reaching 25% revenue level or even exceeding it can be noticed. Regarding the constructions heated by thermal water, even in the pessimistic cases – decrease of revenues and increase of production costs- we can find favourable values.

In the case of the 5 ha-size model farms the decrease in the break-even size can be seen to a greater extent in the unfavourable economic climate but this value primarily depends on the heating method.
Concerning tomato forcing without soil and heated by wooden chips we can experience that the 5% decrease of the revenue and keeping the production costs at a certain level can result in an acceptable break-even size.

Due to the size economics advantages, the 10 ha-size farms show the best values which can refer to their higher risk-taking role in the long run.

To sum it up, concerning plastic foil covered greenhouses it is the 3, 5 and 10 ha-sized farms depending on the heating and utilising methods that are more risk-takers while meeting the requirements.

Due to the high investment costs of **glasshouses**, only the bigger 5 and 10 ha-sized farms reflect favourable break-even sizes deriving from the advantages of size economics.
In case of the 3 ha sizes, only the constructions heated by low cost thermal water can be viable in the future.

In case of the multi-heating methods (coal or wooden chips) it is only the 10 ha-sized ones that are able to reach the appropriate level of revenue meeting the requirements of practice.
To sum it up, concerning glasshouses heated by thermal water it is the 3, 5 and 10 ha-sized farms and only the 5 ha sized or bigger ones and those of 10 ha when heated by coal or wooden chips that are viable in the long run while retaining their competitiveness.

3. The investment-efficiency and risk sensitivity examinations of vegetable forcing models

When evaluating the investment changes of the vegetable forcing models the 0.5 ha sized ones were not examined as based on the break-even sizes they did not meet the requirements of the practice. Among the models the 1, 3, 5 and 10 ha-sized farms were assessed.

In case of the 1 ha-sized ones we can see that most NPV values are negative. In this size the investments into modern plastic foil and glass-covered greenhouses meeting the needs of the 21st century have not returned in the period. Positive NPV values can only be noticed in the case of greenhouses heated by thermal water without pumping back where the investment costs were 364 million Ft per ha in the plastic foil covered greenhouses and 464 million Ft in glasshouses.
Based on my examinations in case of the 1 ha-sized model farms only the constructions with the lowest investment and heating cost could produce 20-200 million Ft net present values in 20 years when presuming optimistic circumstances.

In case of the 3 ha-sized models where investments costs reached 741 million-1.1 billion Ft in plastic foil covered greenhouses, most of the investment and utility varieties showed a positive NPV value. Negative data could only be noticed in pessimistic versions. The most favourable values were shown by greenhouses heated by thermal water (with or without pumping back) in an optimistic point of view with a net present value of 250-1000 million Ft.

In case of the 3 ha-areas the investment costs of greenhouses (1-1.4 million Ft) were 250-300 million Ft higher than those of the plastic foil covered ones. Its consequence is the unfavourable formation of NPV values, which resulted in negative NPV values both in the optimistic and pessimistic view of the constructions with high heating costs (by coal or wooden chips). Most 3 ha-greenhouse investments a more than zero NPV can only be found in the optimistic versions.

Regarding the investment versions of the 5 ha-farms it can be stated that plastic foil covered greenhouses everywhere produced a positive NPV value regardless of the heating method. Only in a pessimistic view and in case of green pepper forcing heated by coal or wooden chips can negative values be experienced. Evaluating the investment of the plastic foil covered greenhouses the positive NPV values could reach 1-1.5 billion NPV in the most favourable case, which can be especially viable in the long run considering the 1-1.7 billion Ft investments depending on the constructions. The weakest NPV values of the 5 ha plastic foil covered greenhouses derived from the constructions heated by coal.
Examining the net present values of the greenhouse investments it can be seen that mostly constructions heated by thermal water show positive values. The greenhouses heated by coal and wooden chips can only result in a positive NPV under positive circumstances.

In case of the investments of the plastic foil covered greenhouses of 10 ha-size only positive NPV values can be seen everywhere except the pessimistic investment version of green pepper forcing greenhouses heated by coal resulted in a negative value. The 2.1-3.3 billion Ft investments produced 1-3 billion Ft net present value under the period depending on the view and utilisation.
The 10 ha-sized greenhouse models heated by thermal water with a 3.1-4.3 billion Ft investment could gain 0.5-1.5 billion Ft NPV in a pessimistic, 1-2 billion NPV in a realistic and 1.5-3 billion NPV in an optimistic view by the end of the 20-year period.

Most greenhouse models heated by coal had mainly negative while those heated by wooden chips had positive NPV value in the optimistic version.
Based on my examinations in case of the 10 ha farm sizes as well as in 3 and 5 ha sizes in most utility modes it is the glasshouse constructions heated by thermal water that show such NPV value with which they are able to retain their viability even under hard economic circumstances.

When examining the internal rate of return of the investment models I have analysed the real efficiency of investments. The calculated IRR values were grouped into 4 categories, which are the following:

Category I: IRR above 20%, Category II: IRR between 15 and 20%, Category III: IRR between 10 and 15%, Category V: IRR below 10%.

When calculating IRR, the investments were assessed according to optimistic, realistic and pessimistic points of view likewise in the case of NPV. During the examination of the investments, ways of utilisation were also considered and in the case of plastic foil covered greenhouses and glasshouses it was green pepper, tomato and cucumber. Regarding all three plants and employing all three aspects altogether 9 IRR values were received per construction (equipment/heating method).

On the basis of my examinations in case of the 1 ha-sized plastic foil covered greenhouses, only the constructions heated by thermal water without pumping back had favourable results. In these cases the IRR value of approximately 10-15% was the most common while other constructions reached a result of below 10%.

Concerning 3 ha-size farms both constructions either heated by thermal water with pumping back or by wooden chips performed well and it was only in one single case when both of them had worse results. The greenhouses covered by plastic foil and heated by coal had an IRR value of below 10% three times at this farm size category.
Assessing the investment results of glasshouses we can notice that in case of the 3 ha size only the data of the constructions heated by thermal water without pumping back ranked well and IRR values of below 10% were primarily typical of the other ways of heating.

In the plastic foil covered greenhouses of 5 ha size favourable rankings are noticeable in case of all heating methods and most IRR values of greenhouses heated by thermal water or wooden chips belong to classes of 15-20% or even above 20%. Among the constructions heated by coal and covered by plastic foil only 2 data showed a value of below 10%.
Concerning the results of greenhouses it is still the constructions of low cost and heated by thermal water that show suitable figures.

In my examinations among the 10 ha vegetable forcing models all plastic foil covered ones produced a favourable IRR value without exceptions and it holds true in the optimistic, realistic and pessimistic points of view alike without exceptions. The most common values were between 15-20% so belonged to IRR Class II.
In my glasshouse investment models it was only the constructions heated by thermal water which produced such values that can ensure their efficiency in the long run.

4. The examination of manufacturing costs in line with the constructions and farm sizes

Reducing manufacturing cost and increasing farm sizes can be seen in all constructions and ways of utilisation. However, there can be differences in the pace of decrease.

Size economics becomes more emphasised in case of the technologies of higher investment cost. This strong decrease in manufacturing cost is especially marked between 0.5 ha and 1 ha as well as from 1 ha to 1 ha-sized farms. It can be also noted that the value of manufacturing costs decrease to a smaller extent in case of the farm sizes above 3 ha (5 and 10 ha).

The manufacturing costs of forcing green pepper without soil in the construction heated by natural gas with the highest expenses decrease from 550 Ft/kg to 400 Ft/kg in the plastic foil covered greenhouses.
Size economics may be best marked in the construction heated by new thermal water. The 550 Ft/kg manufacturing cost on 0.5 ha farms reaches 300 Ft/kg on 3 ha due to the cost reduction of 150 Ft per kg. Furthermore, this value seems not to change in this pace in case of 5 and 10 ha farm sizes.

In case of green pepper forcing in a greenhouse without soil the tendencies are similar although manufacturing costs are 15-20 Ft higher per kg.

Regarding the manufacturing costs of tomato forcing without soil we can see that the versions heated by thermal water are the most favourable while those heated by natural gas are the least favourable ones. The values experienced in case of the smallest 0.5 ha farm size in plastic foil covered greenhouses decrease from 220 – 280 Ft/kg to 160 – 240 Ft/kg on 3 ha so between the most and the least favourable versions of the heating methods regarding tomato there is approximately 80Ft difference.

In case of tomato forced in a greenhouse the manufacturing costs decrease below 200Ft on a 3 ha-sized farm while it is 160-170Ft on 5 and 10 ha heated by thermal water and 180-190Ft/kg heated by wooden chips.

In case of the manufacturing costs of cucumber forcing without soil it can be well discerned that the manufacturing costs significantly decrease with the growth of farm sizes. Reduction again takes place in the case of the smallest 0.5 ha size up to 3 ha, which can primarily be explained by the specific decrease in value of investment. The values of 180-250 Ft/kg experienced in plastic foil covered greenhouses reach the unit price of 140-200 Ft/kg at 3 ha. This decrease starts from 190-260 Ft/kg on 0.5 ha and reaches 150-210 Ft/kg on 3 ha in cucumber forcing in a greenhouse.

5. The impact of different heating methods on operation costs in the vegetable forcing models without soil

One of the highest expenses of vegetable forcing is energy, especially heating. Our dependence on import regarding fossil energy resources puts the farms dealing with vegetable forcing without soil at a disadvantageous situation. By utilising domestic green and thermal energy resources this dependency could significantly be reduced and from this aspect Hungary has excellent endowments. That is why I regarded it important to examine the efficiency and income generating capacity of the single heating methods per construction in line with farm sizes and with the help of the created vegetable forcing models.

As comparing different heating methods is only possible alongside similar dimensions, an indicator was worked out. The indicator shows the formation of pre-tax profit per m^2 on 100 Watt heating performance (Figures 1-3).

The value of the indicator is influenced by several factors as the operating profit depends on amortisation per m^2, wages, materials used and costs of services within production costs and a lot of other factors such as available revenue. In my vegetable forcing model farms I experienced that the costs of the single heating methods showed significant differences, which is also influenced by farm sizes besides the cost of the heating material as costs incurred by investment into heating equipment decrease in line with the increase in farm sizes.

In case of heating by natural gas the value of the indicator is negative in most cases and was positive only in bigger farm sizes. Within the heating methods the constructions heated by thermal water had the highest values but on 0.5 ha not even this type of heating method meets the requirements in practice (25% or bigger income-related revenue).

It is also discernible that within the single constructions (equipment/heating method) among the 3, 5 and 10 ha farm sizes the value of the indicator only slightly differed. The advantages of size economics deriving from the increase in farm sizes primarily exist in case of a 3 ha vegetable forcing model but in line with the growth in farm sizes the value of the indicator slightly increases in 5 and 10 ha model farms.

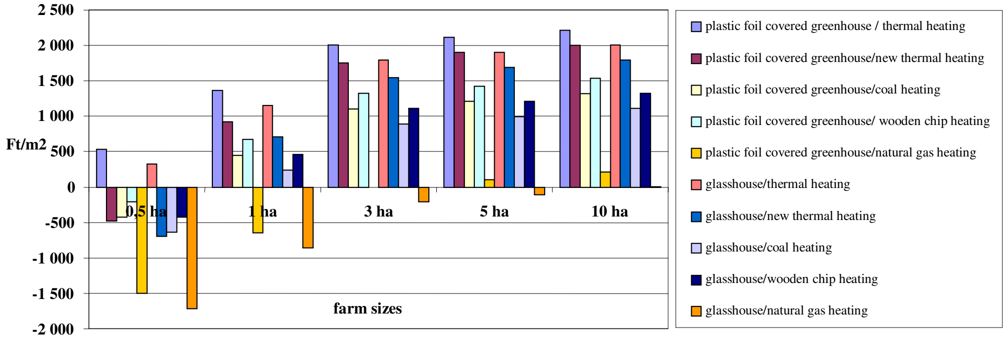

Figure 1: The formation of the operating profit per m^2 on 100 Watt heating performance in case of green pepper forcing without soil on different farm sizes

Source: own compilation

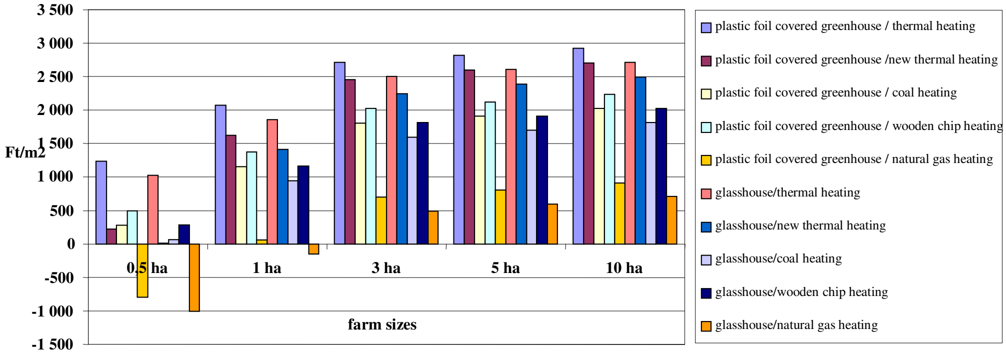

Figure 2: The formation of the operating profit per m^2 on 100 Watt heating performance in case of tomato forcing without soil on different farm sizes

Source: own compilation

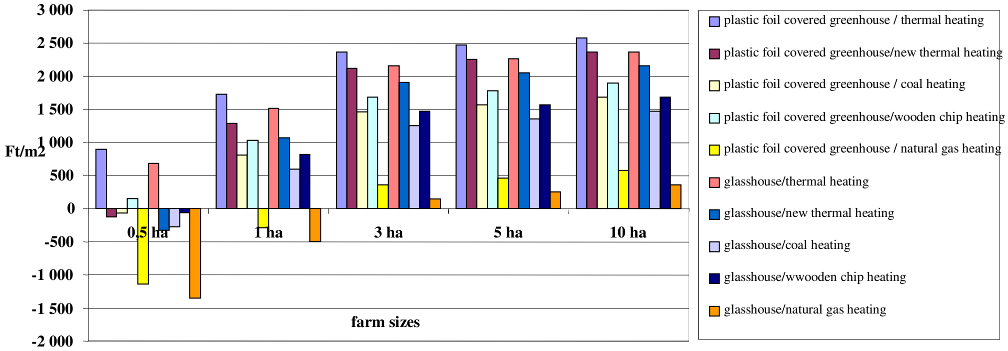

Figure 3: The formation of the operating profit per m^2 on 100 Watt heating performance in case of cucumber forcing without soil on different farm sizes

Source: own compilation

NEW AND NOVEL SCIENTIFIC RESULTS

1. I have worked out such **vegetable-forcing models** without soil that meet the technical and technological requirements of the 21st century and suitable for long cultured (all year long) production involving the continuous employment of the workforce – thus they can be applied in size-economic researches.
2. I have proved that the vegetable forcing models of the most modern greenhouses – made of glass or plastic –and equipped with the latest computerized climatic control, irrigation, alimentary-, and heating systems cannot be regarded viable in the long run on a 0.5 ha farm size.

3. Based on my vegetable forcing models without soil I have worked out an indicator which presents the formation of operating profit per m^2 on 100 Watt heating performance depending on the utilisation and farm sizes. This index is suitable for indicating the profitability of the constructions (equipment/heating method) per farm size.

4. With the help of size economic examinations I have defined the vegetable forcing models without soil that are risk taking ones in the future and can be regarded as farm sizes capable of being improved. My recommendations for practice are the following:

   - in case of plastic foil covered greenhouses constructions of 3 ha or bigger size heated by thermal water, wooden chips or coal,
   - in case of glasshouses constructions of 5 ha or bigger size heated by thermal water, wooden chips or coal.

5. I have carried out such sensitivity examinations with the changes in the production costs and revenues of vegetable forcing without soil that are capable of showing the risk-taking ability of vegetable forcing models by indicating the impact on break-even size. Based on the results of the examinations the following vegetable forcing models have suitable risk-taking abilities:

   - in case of plastic foil covered greenhouses the 1 ha one heated by thermal water without pumping back or the 3 ha or bigger ones heated by thermal water with pumping back, coal or wooden chips,
   - in case of glasshouses the 3 ha ones heated by thermal water without pumping back or the 5 ha or bigger ones heated by thermal water with pumping back, coal or wooden chips.

CONCLUSIONS AND RECOMMENDATIONS

My conclusions and recommendations can be summarised as follows:

The most favourable results were gained in the case of plastic foil covered greenhouses heated by thermal water without pumping back, which met the requirements of practice at 1 ha farm size. The variations of the plastic foil covered greenhouses heated by thermal water with pumping back, coal or wooden chips were regarded as suitable concerning risk taking when the size reached or exceeded 3 ha. The versions of glasshouses heated by thermal water resulted in acceptable profits on 3 ha while their vegetable forcing models heated by coal or wooden chips on 5 ha or more.

With the help of the sensitivity examinations of investment efficiency indicators (NPV, IRR) the investment alternatives were compared regarding different farm sizes and constructions and the following experience was gathered.

Among the **1-hectare** farms favourable NPV and IRR results were gained only in case of the plastic foil covered constructions heated by thermal water without pumping back.

Considering the **3-hectare** farm sizes, the constructions in the case of the plastic foil covered constructions heated by thermal water with pumping back or wooden chips also performed well on the basis of investment efficiency indices while among the glasshouses only the construction heated by thermal water without pumping back.

Among the **5-hectare** farm sizes the plastic foil covered ones heated by coal and the glasshouses heated by thermal water accompanied the models previously regarded as favourable based on their NPV and IRR indicators.

In case of the **10-hectare** farm size all constructions and utilisations ranked favourably except natural gas regarding investment efficiency indicators.

Finally, as in most methodological examinations, one of the most decisive costs is heating costs; my vegetable forcing models were evaluated by means of an **indicator** created by me regarding constructions and farm sizes. The indicators show **the formation of the operating profit per m^2 on 100 Watt heating performance**.
On the basis of this, the value of the indicator in case of heating by natural gas was negative in most cases and turned positive only in the case of a bigger farm size. Among the heating methods the constructions heated by thermal water had the highest values but in case of the 0.5 ha farm size not

even this type of heating method met the requirements of practice (25% or greater revenue-related returns).

Among the single constructions (equipment/heating method) in case of the 3, 5 and 10 ha farm sizes slight deviations were experiences regarding the value of the indicator. The advantages of size economics deriving from increasing farm sizes could first be pointed out in the case of the 3 ha- vegetable forcing models but on the 5 and 10 ha-model farms the value of the indicator rose only slightly when increasing the farm size.

To sum it up, in Hungary the vegetable forcing based on thermal energy and renewable energy resources (wooden chips) has a future. Besides them, systems heated by energy from waste can also be significant. Regarding the points of view of size economics in vegetable forcing firstly it is the 3 and 5-ha size farms heated by geothermal energy and biomass that can reach such operating profit that can ensure the development of the branch with a great degree of certainty. To achieve this, the marketing and sales conditions of vegetable forcing should be changed so that competitive advantage for the Hungarian branded products could be ensured.

Investing into 10-15 farms of 3-5 ha size with 30-70 ha new surfaces for vegetable forcing can provide employment opportunities for 300-700 people. For this, 17-32 billion Ft capital is necessary, which can alleviate the problems of areas stricken by unemployment and reduce the dependency of vegetables on import when operating efficiently.

However, on export markets 250-300 ha increase of vegetable forcing areas is necessary to ensure a strong market position. This can only be achieved alongside clear strategic objectives by using significant amount of capital as investment.

LIST OF PUBLICATIONS

Scientific publications (books, part of books, research reports)

In a foreign language:

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In Hungarian:

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3. **Tégla Zs.**: A szántóföldi zöldpaprika-termesztés szervezése és ökonómiája fejezet. Mezőgazdasági üzemtan II. (Szerk.: Pfau E. - Széles Gy.) Mezőgazdasági Szaktudás Kiadó. Budapest. 2001. 239-243 p. ISBN: 963 356 325 9
4. **Tégla Zs.:** A zöldséghajtatás szervezése és ökonómiája fejezet. Kertészeti ágazatok szervezése és ökonómiája. (Szerk.: Magda S.) Szaktudás Kiadó, Budapest 2003. 59-70 p. ISBN: 963 9422 88 6
5. **Tégla Zs.**: A régió agrárfejlesztésének lehetőségei. Észak-Magyarország agrárfejlesztésének lehetőségei. 95-108 p. (Szerk.: Szűcs I.) Agroinform Kiadó, Budapest, 2003 ISBN 963 502 807 5
6. **Tégla Zs.** - Marselek S.: A dinnyetermesztés szervezése és ökonómiája. A zöldségtermesztés, tárolás, értékesítés szervezése és ökonómiája. Szerk.: Z-Kiss L – Rédai J.: Mezőgazdasági kiadó Budapest, 2005. 140-148 p. ISBN 963 286 255 4
7. **Tégla Zs.** - Marselek S. – Salamon L.: Intenzív és extenzív technológiai rendszerek hatékonysági különbözőségei In: „A hatékonyság javításának feltételei a mezőgazdaság erőforrásainak hasznosításában: optimumok és gyakorlati alkalmazások” című program keretében A részjelentések összefoglalása (szerk. Marselek S.) Károly Róbert Főiskola Gyöngyös, 2007. 40–49. p.

8. **Tégla Zs. –** Deme P. – Kovács E. – Marselek S. – Miller Gy.: Alkalmazkodó technológiai rendszerek In: Hatékonyság a mezőgazdaságban (szerk. Szűcs I.) Agroinform Kiadó, Budapest, 2008. 147-196 p. ISBN 978-963-502-889-4

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4. **Füstös Zs.:** Az uborkatermesztés ökonómiája. In.: A zöldségtermesztés, tárolás, értékesítés szervezése és ökonómiája. Szerk.: Z-Kiss L – Rédai J.: Mezőgazdasági kiadó Budapest, 2005. 140-148 p. ISBN 963 286 255 4
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10. **Kerek Z. Deme P. Szabó F.:** A farmerek adaptációs képességének elemzése In: „A hatékonyság javításának feltételei a mezőgazdaság erőforrásainak hasznosításában: optimumok és gyakorlati alkalmazások" című program keretében (NKFP–2004/4–014) A részjelentések összefoglalása (szerk. Marselek S.) Károly Róbert Főiskola Gyöngyös. 2007. 80–96. p.

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14. **Marselek S. – Hágen I. Zs.:** Biomassza mint energiaforrás hasznosítása Magyarországon. Nemzetközi Konferencia Mezőtúr. 2008. CD lemezen

RESUME

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Professional experience:

2007- membership in the senate Károly Róbert College

2005- membership in the European Association of Agricultural Economists (EAAE)

2005 taking part in CEEPUS teacher mobility programme, Nitra, Slovakia

2004- engagement in the OM (Ministry of Education) research programme entitled The conditions of improving competitiveness in using agricultural resources- Optimums and practical applications (NKFP-2004/4-014-04)

2004- senior assistant professor at Károly Róbert College taking part in the educational, research and project application activities of the institution as well as organises professional programmes, writes course books, develops e-learning educational aids and TCU – Texas Learning Systems (developing IT study materials)

2003- PhD student at Szent István University, PhD School of Management and Business Administration

2003- membership in the council of the Faculty of Economics at college

2002 Niveau Award by the publisher given for working on Agricultural economics II.

2001- engagement in the OM (Ministry of Education) research programme entitled The conditions of improving competitiveness in using agricultural resources (NKFP-2001-4-032/OM-00158/2001)

2001- membership in the Agrieconomic Working Committee of the Agricultural Professional Committee of the Miskolc Academic Committee

1998- 2003 teaching assistant then assistant professor at Szent István University, College faculty of Economics and Agriculture

1997 internship in Naaldwijk, the Netherlands in ornamental plant-and vegetable gardening

1993-1998 student at the University of Horticulture and Food Science, Faculty of Horticulture, Budapest, degree in Horticultural Engineering

Subjects taught:
Strategic business planning
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Language skills:

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