Theses of doctoral (PhD) dissertation

COMPLEX ECONOMIC ANALYSIS OF THE ECONOMIC SUSTAINABILITY AND MARKET COMPETITIVENESS OF HUNGARIAN CARP PRODUCTION

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Debrecen, 2021

1. RESEARCH BACKGROUND, OBJECTIVES AND PRESENTATION OF THE RESEARCH HYPOTHESES

The Hungarian fisheries sector is relatively small, as its gross production value accounts for about 2.5-2.6% of the gross production value of Hungarian livestock production, but the role of fish production goes far beyond this value, as it actively contributes to rural areas' potential in maintaining the rural population and providing subsistence, and it serves the recreational needs of the Hungarian population. *"In Hungary, pond and intensive farm fish production functions as one of the sectors of agriculture, despite the fact that pond fish production plays a significant role in the replacement of fish stocks in natural waters and in meeting the quantitative and qualitative demand of fishing ponds"* (MA-HAL, 2020, p. 10).

In Hungary, due to the fact that commercial fishing has been legally banned since January 2016, the supply of fish of Hungarian origin to consumers / restaurants can only be achieved from aquaculture fish production, which is why increasing competitiveness appears to be a long-term goal for fish farms. The growing prevalence of aquaculture worldwide is characterised by technological diversity, ranging from extensive fishpond production to climate-independent, intensive industrial production. This sector is also very diverse in Hungary, although conventional pond fish production is dominant at different intensity levels, but intensive closed loop fish farming is also growing dynamically, and it is important to perform its technological and production biological examination, in addition to its economic analysis (VÁRADI, 2001; PINTÉR, 2010). It can be observed that, while there is an extensive research related to various pond fish farming internationally, the amount of economic research related to Hungarian fish production is still relatively low.

The hectic nature of the Hungarian fish market, the stagnation of the consumption of fish and fishery products, the decline in competitiveness and many other phenomena suggest that it is essential to examine the efficiency of production. A common problem is the low income generation capacity of the sector compared to crop production, and an increasing number of aquaculture businesses are struggling with persistent labor problems. For almost ten years, in spite of available funds, some Hungarian fishing industry participants have been focusing solely on survival, especially those performing fish processing. However, there are also farms operating with a favorable profit ratio (SZŰCS et al., 2017). In order for the sector to remain competitive, it is necessary to identify the factors that significantly affect the cost of production and the profitability of farming. It is also a problem that there is little economic analysis that examines the various factors affecting production to help improve efficiency at different levels of intensity. It is extremely important for farmers to produce a competitive product, i.e. it is important to be aware of the main influential factors and the extent to which their changes can potentially decrease or improve the profitability of the activity.

Keeping and breeding carp as a dominant fish species in Hungary can be achieved with extensive, semi-intensive and intensive technology, or a combination of these, all of which are technically and biologically viable. By increasing the intensity of production, the duration of production is shortened, working capital is held for shorter periods, and losses caused by fish-eating animals (e.g. cormorants, otters) can be reduced to almost zero in closed or semi-closed systems, but at the same time certain specific costs increase and others decrease. As a consequence, a biologically and technically viable technological solution may not be considered economically sustainable.

Main research objectives

Based on the above facts, the primary objective of my research is to determine the global position and economic weight of fish and fishery products, including carp production, and to explore the sustainability and competitiveness factors that influence the dominant pond carp production in Hungary and induce the comparative advantage or disadvantage of carp products. Furthermore, I set the objective of exploring the cost and income conditions of carp production at the Hungarian farm level, as well as the impact of changes in the most important economic and production parameters on various economic indicators. For the farm economics analysis, I chose three different types of farms as case studies, which are the following:

1. The *classic three-year-long form* of pond farming. During the three breeding seasons, one-year-old carp are placed in juvenile rearing ponds, juvenile carp are placed in growing ponds in the second year, and three-year-old carp are placed in production ponds. The growth rate of carp is affected by population density, as well as by establishing and extending an artificial feed base (pond fertilisation) (LAJKÓ – TASNÁDI, 2001).
2. *Two-year-long, combined technology* based on off-season carp breeding: closed-loop intensive pre-rearing, post-rearing in ponds and carp production for the market, i.e. carps reach marketable carp size in two breeding seasons.
3. *Intensive closed-loop recirculation system*, i.e. the production cycle is one year long, during which carp production takes place in pools under closed, controlled operating conditions, with the use of special compound feeds.

In the course of my research, in connection with my objective, I seek to answer the following questions scientifically on the basis of primary and secondary data collection:

- What characterises the global, EU and Hungarian market for fish and fishery products and what are the main trends (production, trade and consumption) in the sector, with particular reference to carp and carp products?
- Does Hungary have a comparative advantage in the carp market?
- What production parameters (net and gross output, drop-out rate, specific feed consumption, etc.) characterise the three examined farm structures, and what are the significant differences between them?
- How could the profitability of Hungarian carp production be described in the case of the examined types of farms, what are the factors that most influence the economics/income-generating ability of production in the case of the three

examined farm structures, both from input and output aspects, and what are the critical points of each technology?

- What external and internal factors influence the efficiency of carp production for all three farm structures?
- What sustainability and competitiveness factors characterise and determine pond carp production?

After exploring the technical literature sources and formulating the research questions and objectives, I formulated the following hypotheses in close accordance with them:

H1: *In the case of different types of farms, the profitability of carp production decreases in proportion to the shortening of the production cycle.*

H2: *For the three technologies studied, only pond farming and 2-year combined carp production will be economically sustainable.*

H3: *The cost of carp production is most affected by the amount of feed used and its current market price for all three types of farms.*

H4: *Carp products produced in Hungary do not have a comparative advantage on the global market.*

The validity of the formulated hypotheses is supported by the following literature sources. WOYNÁROVICH et al. (2019) show that the profitability of carp production decreases as a result of shortening the production cycle and thus increasing production intensity, while achieving the same weight by the time of catching, as much higher feed consumption is required to produce 1 kg of carp (H1).

STÜNDL (2011); BOJTÁRNÉ LUKÁCSIK et al. (2019) and NAIK AKI (2020a) also showed that intensive production is economical only at the highest population density, however, the intensification of carp farming is subject to experiments, therefore, there is no specific and reliable data or information on when it will be worth shortening the three years of conventional pond farming (H2).

In aquaculture, the efficiency and economy of production is largely determined by feeding. In intensive systems, the cost of feeding may account for more than 50% of the total cost (FAST et al., 1997; MÜLLER, 1990; SILVA et al., 2007). There is a strong correlation between the amount of feed and compound feed and output, and they represent a significant part of material costs. SZŰCS et al. (2002); HANCZ – HORVÁTH (2007); SUSTAINAQUA (2009); KARNAI – SZŰCS (2018); MA-HAL (2018) and GYALOG et al. (2021) suggest that feed costs have the greatest effect on the cost of production. Proper feeding of fish can also significantly improve the profitability of farms (H3).

In one of their earlier papers, KARNAI – SZŰCS (2017) focused on the carp trade between Hungary and the EU-28 Member States between 2010 and 2015, concluding that Hungary does not have comparative competitive advantage even in the case of its products processed to various degrees from its most-exported fish species. For this reason, Hungary is at a disadvantage in relation to these products compared to the EU-28, especially the Czech Republic. Despite this competitive disadvantage, according to the authors, there is no significant peak in the Hungarian foreign trade balance during the examined years (H4).

2. DATABASE AND APPLIED METHODS

In order to achieve this goal, during the secondary data collection I searched for the international and Hungarian literature closely related to the research field in connection with the topic of my dissertation, which I processed in an analytical way following the systematisation phase. During the preparation of the dissertation, I considered it important to place the fishing sector in an international dimension as well, in order to better understand the competitive advantage or disadvantage of the players in the Hungarian sector. I have collected some of the required data from sectoral materials, technical papers, as well as international and Hungarian statistical databases dating back to the last 20 years in order to explore causal relationships. This secondary research addressed the issues of production, trade and consumption at the global, European Union and national economic levels.

In order to present the processes taking place on the global market of fishery and aquaculture products and in Europe, I used the databases and reports of the FAO (*Food and Agriculture Organisation of the United Nations*), EUROSTAT (*Statistical Office of the European Communities*) and COMTRADE (*International Trade Statistics Database*). To illustrate the Hungarian situation and present its tendencies, I relied on the databases of NAIK AKI (*Institute of Agricultural Economics of the National Agricultural Research and Innovation Center*) and the CSO (*Central Statistical Office*) during the sectoral analysis, as well as related works and papers by Hungarian authors, in addition to studies presenting the yearly development of the Hungarian market. It is important to note that some databases take into account fish and fishery production, which is why I processed the publications and annual reports of MA-HAL (*Hungarian Aquaculture and Fisheries Inter-Branch Organisation*) to examine the development of carp production and trade.

The obtained data were considered for a 20-year-period and in each case I used the latest available data valid for the whole year, owing to the fact that, due to the exposure to factors affecting fish production (various diseases, damage caused by birds, etc.), no long-term conclusions can be drawn and the current changes cannot be presented. As a result of technological development, I illustrated the data related to the efficiency of production in a 5-year period, as these indicators show an identifiable trend even in the short term. As regards the European Union, the obtained data are defined for all 28 Member States.

In order to achieve the secondary objective of the dissertation, I created a model related to my analyses, shown in *Figure 1*. This model includes both the collected parameters and the range of results obtained for both production and trade.

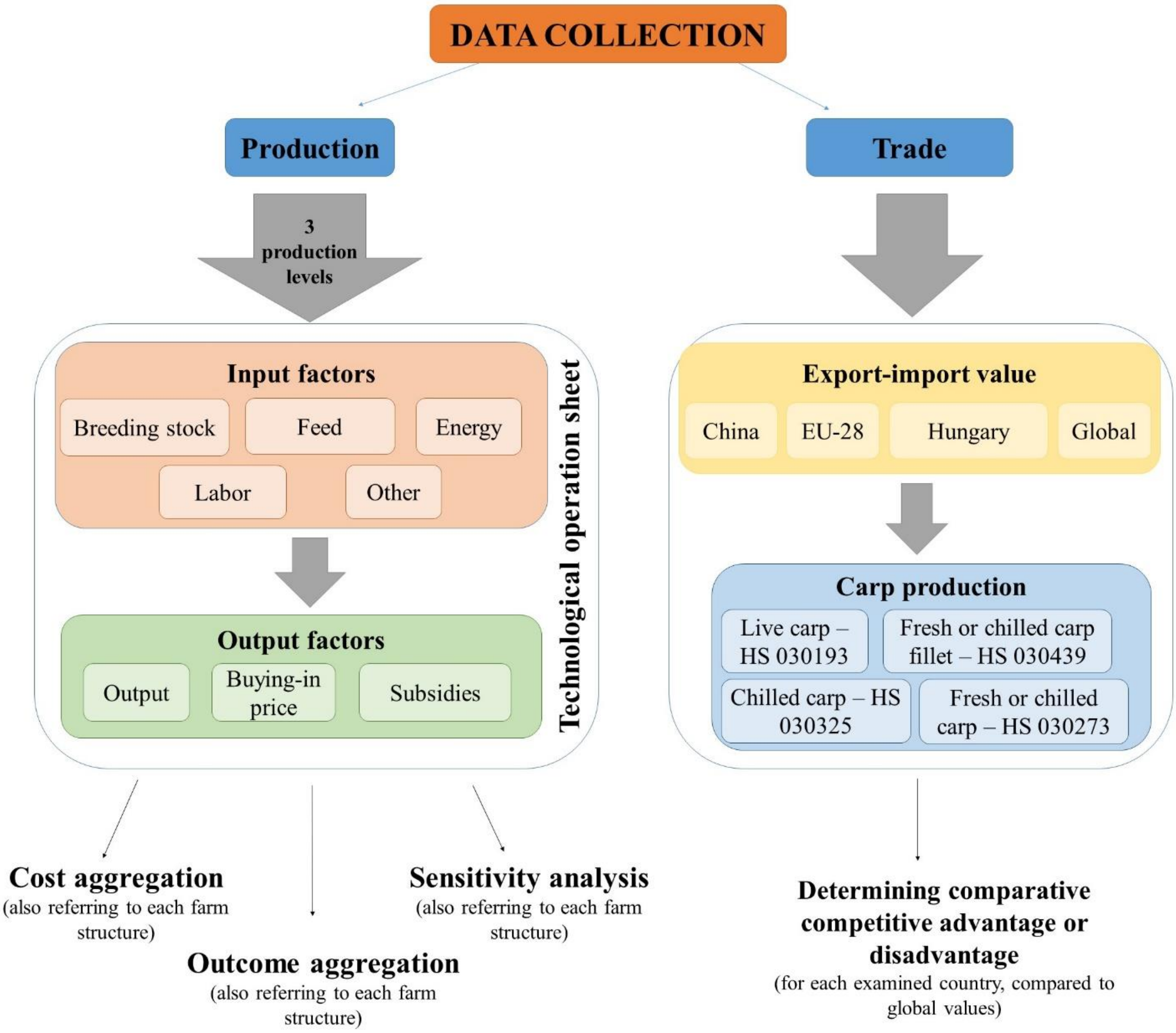

Figure 1. **Information and data collection system of the study**

Source: Own construction (2021)

I considered it important to determine the significance of carp products on the basis of the Revealed Comparative Advantage/Disadvantage Model (RCA), which measures the international specialisation of countries. In order to measure specialisation, I used the method of comparative advantages (RCA index), which is an important aspect in the theory of international trade. The index is generally used to compare regions or countries based on trade data and is usually applied to a product or group of products, which has the advantage of being able to handle international demand and supply simultaneously (BALLANCE et al., 1987; FERTŐ, 2003).

To illustrate the economic characteristics of the farm, I performed a deterministic analysis based on simulation modelling (PIEDRAHITA, 1984; PIEDRAHITA, 1988). The analysis of the cost side could not be built on the mere collection of cost data. For this reason, it was necessary to record and set up the entire production technology in the form of natural inputs. In addition to producer data, the additional data required for the study were provided by various sectoral studies and Hungarian databases. In connection with the production technology I learned during the data collection, I derived production costs using input prices obtained from other sources (e.g. AKI), because producers were not able to provide accurate information on the cost of the lots to be purchased, unlike in the case of the manual and machine work they carried out throughout the year, as well as their specific performance, the materials used and their quantity. Output data come from production plants, while sales price data come from production and trade enterprises, and from secondary sources. It is important to emphasise that all output and input prices are exclusive of VAT. Input and output prices basically reflect the 2020 price level.

During the primary data collection, I performed separate data collection for the three technological variants (*Table 1*), the production indicators of which are described in the Results section. The peculiarity of typical fish farms in Hungary is that they perform all phases of fish production, i.e. from hatching (or mostly larval rearing) to the production of (edible) marketable sized fish. It is possible to produce edible carp that can be produced in two years, fed mainly in small-scale systems. However, from the traditional point of view, the three-year-long farming is the most common type in Hungary. In addition, intensive technology is becoming increasingly widespread, which is why it is important to consider the amount of carp produced in one year (WOYNÁROVICH et al., 2019).

Table 1. **Examined farm structures**

Farm structure	**Year 1**			**Year 2**	**Year 3**
Pond fish production	artificial propagation	fingerling rearing		growing	production of marketable fish
Combined technology	artificial propagation	fingerling rearing		production of marketable fish	-
Intensive carp production	artificial propagation	fingerling rearing	production of marketable fish	-	-

Source: Own construction (2021)

Data on the entire technology of pond fish production (3 years) were collected from several polyculture pond farms dominant in Hungary. To prepare the model calculations, I made a personal visit to industry players, where I conducted professional expert interviews and had a glimpse into their operation. The personal interview provided a good opportunity for me to become acquainted with the professionals dealing with fish farming, their everyday tasks, problems and opportunities. When selecting the interviewees, I kept in mind to visit farms that differ in size, which allowed me to learn about high, average and lower quality production.

In the case of the two-year production farm type, I collected data on the extensive and intensive technology of a combined (closed-loop pre-rearing and pond post-rearing) carp rearing experiment in Hajdú-Bihar county. The off-season propagation was carried out in the Fish Biology Laboratory of the Faculty of Agricultural and Food Sciences and Environmental Management of the University of Debrecen. As a next step, the fish population was released to the pond farm of Bocskai Fishery Ltd. in Hajdúszoboszló, Hajdú-Bihar County. As a result of the experiment, by combining recirculation and pond fish production, sectoral development has been created that allows carp farming and rearing to be carried out in a more efficient way and to shorten the production cycle.

In the case of intensive carp production, during the observed experiment, both reproduction and rearing (both phases are performed in the recirculation system) were carried out in a supervised manner by colleagues from the Faculty of Agricultural and Food Sciences and Environmental Management of the University of Debrecen, in a controlled, optimised environment, where carp rearing is performed in artificial conditions.

For all three technologies, various technological and economic data were also collected during the data collection phase, after which I formed natural efficiency indicators derived from production parameters. Primary data (technological parameters, basic economic data) and derived indicators were processed using descriptive statistical methods. Derived indicators were always defined for the given phase or for the whole year. During the pond economy model calculation, I used the average of the collected data of several pond farms, the aim of which was to illustrate the average technology in Hungary and to form a basis of the examined virtual model farm. In terms of pond size and the number of pools, as well as the amount of release, I took the collected natural data as a basis, and in the case of the pond farm I assumed that the farm performs fish production on 300 hectares and wintering takes place in the pond. In order to compare the different technologies, I developed efficiency indicators (*Table 2*).

Table 2. **Efficiency indicators of fish production**

Indicator	Method of calculation	M.u.	Description of the indicator
Gross carp output	The quotient of the quantity of carp caught and the area of the given pond	kg/ha kg/m^3	Production efficiency of pond area/pool volume per input
Net carp output	The quotient of the difference between the quantity of carp released and caught and the area of the given pond	kg/ha kg/m^3	Production efficiency of pond area/pool volume per input
Weight gain ratio	The quotient of the quantity of carp released and caught	kg/kg	Production efficiency of the breeding stock per input
Feed conversion ratio (FCR)	The ratio of the quantity of feed used and the difference between the quantity of carp caught and released (net production)	kg/kg	Production efficiency per feed input
Specific cost of carp production	Basically, the quotient of the production cost reduced by the value of the by-product and the quantity of the main product produced, however, in the case of live-weight sectors, the value of the initial stock must also be taken into account among the costs.	HUF/fish	Cost of production per unit of carp caught

Source: BOYD (2005); VERDEGEM – BOSMA (2009); VALDERRAMA et al. (2010); FAO (2016b); GYALOG et al. (2021)

In order to have an accurate interpretation and comparability of the economic analysis of the different examined models, it is important to record the parameters that result from the specifics of the analytical method and reduce the scope of interpretation. The aim was to analyse the examined technology, and not the companies providing the data. The main methodological-calculation boundary conditions according to the above principles can be summarised as follows:

- I calculated the same input material for each technology with the same input price, which reflects the price level of 2020, and the prices are exclusive of VAT.
- With regard to the specific wage costs (including public charges), I calculated a total wage cost of 1,500 HUF/hour in line with the 2020 wage level.

- The overheads charged to the sector can be considered an estimate based on my data collection (defined as 5% of direct costs), although there are different values in practice, depending on the scale, production structure and equipment of a given enterprise.
- Outputs and sales prices reflect the price level of 2020 and sales prices are exclusive of VAT.
- 100% of the marketed carp is sold. For this reason, I did not calculate winter and spring sales and I did not take into account market prices different from the catching period.
- For the cost-income analysis for an average year, I also defined a sector-level income category (contribution margin) and an enterprise-level income category (net income) interpreted together with overheads, which are considered pre-tax profit categories in all cases, i.e. I did not take profit tax liability into consideration.
- In the case of the comparative study, the difference in the scale of the carp production is a limiting factor, as much higher level of carp production took place under pond farming conditions. In contrast, in the RAS pools, there was no realistic possibility to produce the amount of a 300 ha conventional pond farming in a recirculation system. For this reason, the basis of comparison is represented by the specific values.

Supplementing the basic model, I performed sensitivity analyses for all three models, during which I examined the impact of changes in various parameters (e.g. the amount of feed and its purchase price, wage, output and sales price) on the profitability of the activity (SZŰCS et al., 2002).

Within the sensitivity analyses, I performed the elasticity analysis of the variables that have the greatest impact on the efficiency and economicalness of production, and I also carried out scenario analyses. The purpose of the elasticity of variables [1] is to determine the percentage change in the various performance indicators, usually in the output, as a result of one percentage change of a production factor "*ceteris paribus", i.e. if all other factors are unchanged. The obtained indicator expresses the sensitivity of an examined system in view of the given factor"* (SZŐLLŐSI - SZŰCS, 2015, p 111).

I also examined the effect of changes in sales price, feed price and the most important production parameters (specific feed consumption, average weight at the time of sale) on various economic indicators using cross-tabulation analysis. In the model calculation required for this purpose, I considered the sales price of carp and the average weight at the time of sale to be independent variables. I allocated fixed costs on an area basis, and I also assumed that the production value of the by-catch fish is equal to its production cost. As a next step, I examined the main economic indicators of the activity (specific income, unit cost) as dependent variables, and I used cross-tabulations to illustrate the obtained results. In the cross-tabulation, sales prices and feed prices were determined on the basis of the extremes of fluctuations experienced over the last 5 years. The average feed price was determined as the weighted arithmetic average of the feed price and quantity determined in the various phases of the activity.

It is important to emphasise that the presented calculations cannot be accepted as a single truth, they do not apply to all companies and each year, as the cost, output and price relations can show significant differences and variability between individual companies.

3. MAIN CONCLUSIONS OF THE DISSERTATION

In line with the questions raised concerning the objective of this study, I would like to present the main findings of my research as follows.

1. ***What characterises the global, EU and Hungarian market for fish and fishery products and what are the main trends (production, trade and consumption) in the sector, in particular carp and carp products?***

Based on my secondary data exploration, I concluded that, thanks to aquaculture, the importance of fish and fishery production is outstanding at the global, EU and Hungarian levels, as it plays an important role in the quality protein supply of consumers. In recent years, aquaculture has become increasingly dominant and is expected to continue to grow in the future, as due to overfishing of natural waters, consumer needs can only be met by the production of fish and fishery products under artificial and controlled conditions. In my view, the trend observed so far - i.e. carp production depends on China’s aquaculture production - will continue, as there is a strong government intent in China and a significant production potential to intensify. Therefore, China's dominant role in the market is expected to be further strengthened in parallel with the stagnation of EU production and the growing share of processed products in trade will be increasingly palpable. The dominance of carp in Hungarian fish production will remain in the future, but other fish species, which can be effectively produced under intensive conditions, will also be more dominant in order to meet demand and ensure economicalness.

Hungarian carp production is based on the natural food base of fishponds, using mainly cereals as supplementary feed, i.e. this production method is practically independent of fishmeal and fish oil, which is a significant factor influencing sustainability and its importance is expected to increase in the future.

The demand for Hungarian aquaculture products, and thus indirectly the income-generating ability and competitiveness of the sector, is significantly determined by the volume of Hungarian fish consumption. The annual per capita fish consumption in Hungary (6.6 kg/year) is one of the lowest in the EU. In fact, Hungarian fish consumption is increasingly shifting towards imported products, as about 81% of the fish consumed in the country is of import origin, which can be partly explained by the growing consumer demand for processed fish products and the underdevelopment of the Hungarian fish processing industry. Reducing our import dependence requires not only increasing fish production, but also supporting competitive fish processing and product development. However, the development and implementation of community marketing programs aimed at increasing fish consumption and improving the social prestige of the sector are also needed. The younger generation is less fond of carp and foods made from carp, while the older age group that consumes carp is shrinking year by year. This tendency will be temporarily offset by growing demand in the fishing market and the ecological services provided by extensive fishponds are expected to increase in the future.

I believe that aquaculture is facing significant development, and the main elements of precision aquaculture and digitalisation solutions are becoming more widespread, which will improve the economic efficiency of production in the medium term. In addition, the ecological role of extensive pond farms is increasing. It is also a viable development direction to use so-called combined systems, which combine the favourable properties of intensive and extensive systems, as well as the development of multifunctional fish production systems, which make it possible to diversify pond farm activities and income. For this reason, continuous market research is needed to identify the factors and processes that are responsible for the current situation in the sector.

The weight of the Hungarian aquaculture sector in the national economy is relatively small. At the same time, in addition to providing the goods necessary for the country, as well as export for consumption purposes, Hungarian fish producers provide consumers with healthy and safe food produced in a sustainable way, amd they play a key role in providing the breeding stock necessary for replenishing the fish population of natural waters and in meeting the quantitative and qualitative fish needs of recreational fishing ponds. In addition, this activity is typically done in rural areas, using rural resources, thereby contributing to the ability of rural areas to sustain and retain the population. Hungarian fishpond management also contributes to the maintenance of wetlands, i.e. its importance goes beyond its narrow economic weight, all of which strengthen the sector's role in rural development and nature conservation, and make it important to preserve these functions in the future.

Further studies are needed to explore the real situation and international embeddedness of the Hungarian fish product chain in an analytical way, identifying potential opportunities, possible breakout points and specific measures for Hungary to successfully respond to Hungarian and global challenges.

2. *Does Hungary have a comparative advantage in the carp market?*

The market of live carp and other processed carp products is relatively stable and concentrated. The demand for these products has been growing steadily in recent years. China also has a leading position in carp production. In addition, the EU's carp production is also significant, with the Czech Republic, Poland and Hungary being among the highest producing countries. In international trade, sales of live carp are dominant mainly at regional level, but processed carp products, especially fresh or chilled product and fillets also play an increasingly important role. Examining their market share, it can be concluded that, due to their dynamic growth, China, as well as the Czech Republic and Poland will continue to play a dominant role in the future. Despite these factors, there is a small comparative and commercial advantage in the case of Hungarian live carp products on the international markets. Based on the obtained results, Hungary's competitive advantage lags only slightly behind that of China. In addition, the EU has a comparative competitive advantage in foreign trade with regard to carp products compared to China based on the RCA index between 2015 and 2019, but the volume of processed carp products in China is steadily increasing. It is a problem that the sector has lost or will soon lose its main export markets as Poland has recovered from the KHV (Koi herpes virus) epidemic, EFF-supported fish farms have started to produce in Romania, Croatia greatly expanded its pond fish capacities and it is difficult to compete with the Czech Republic on the German market due to its relatively low logistics costs.

As a consequence, in my opinion, increasing competitiveness can be a long-term goal, which requires a stronger presence in the market of processed products in order to improve international competition, as the demand for higher-level processed products is currently growing the most and it may lead to greater export value increase in the future. I believe it is necessary to create a production structure that specialises in higher value-added processed products in order to improve the trade balance.

The economic impact of the Covid-19 epidemic on the European fish and fishery product path has also highlighted the vulnerability of aquaculture and the supply chain of fish and fishery products, i.e. the relative vulnerability of the whole sector. For these reasons, it is important that sectoral developments take place in such a way as to help strengthen the resilience of the aquaculture and fisheries sectors to external influences. Periodic damage to supply chains has highlighted the importance of preserving and developing short supply chains (SSCs) (e.g., local direct consumer sales; use of locally produced raw materials), which significantly increases the importance of the local economic, social, and agro-ecological role of freshwater aquaculture.

Based on the analysis of competitiveness indices, I do not consider hypothesis **H4** (*Carp products produced in Hungary do not have a comparative advantage on the global market.*) to be justified. For this reason, I **reject** the hypothesis, despite the fact that there are many factors of influence that commonly used indices cannot take into account.

3. ***What production parameters (net and gross output, drop-out rate, specific feed consumption ratio, etc.) characterise the three examined farm structures, and what are the significant differences between them?***

To answer this question, it is first necessary to distinguish between the three examined technologies, as they are characterised by different growing seasons (production cycles), production indicators, and cost-income ratios. It is important to note that the data below reflect the average data of the enterprises surveyed in the case of pond production, and the data collected during the experiment for the other two technologies. For all three technologies, I distinguished three different phases.

(1) In *conventional pond fish farming*, the released larvae reach their market size by the end of year 3, with an average weight of 2,5 kg/fish due to the pond farming technology. In this case, the three phases mean the three years separately, with a total area of about 300 hectares (T1=22 ha; T2=80 ha; T3=198 ha). It is important to note that only fish of the same age are released in each phase. Moreover, with regard to the catch rate, grass carp (15%), silver carp (3%) and catfish (2%) are also included in the production structure in addition to carp. The average breeding duration of fish released in the one-year fish farming phase is 180 days (from May to October), with a specific feed consumption of 1.9 kg/kg (60% natural output) and an output of 2 thousand kg/ha at the time of catching, taking into account an average drop-out rate of 46%. Of the existing population (19.6 thousand fish/ha), 4.2 thousand individuals per hectare were reclassified to the P2 age group, while the remainder was sold (446.8 kg/ha). The next phase was the rearing of juvenile fish. The amount of caught fish was about 1.9 thousand kg/ha and 1.5 thousand kg/ha of carp farming was produced in the examined phase, with a loss of 25%. By the end of the third year, an output of 1.8 thousand kg/ha was realised, of which 1.4 thousand kg/ha is the main product, with a 6% mortality rate in general. Based on these data, a total of 216.7 thousand kg of carp were sold. The specific feed consumption for the whole period ($FCR_{fishpond}$) is 4.2 kg/kg.

(2) *Combined carp production* (closed-loop pre-rearing and pond post-rearing) shortens the production cycle to two years, and the peculiarity of the technology is that in the first year, the juvenile rearing takes place in a closed-loop recirculation system, followed by intensive monoculture small pond-based rearing. As a final step, marketable fish production ends with large-pond, semi-intensive rearing. During the experiment, the juvenile fish from the larvae are reared at a population

density of 7.1 thousand fish/m^3 and 60% drop-out rate, and it takes 60 days to finish. The flexibility of this technology lies in the fact that if the external conditions (e.g. water temperature) are provided, release to ponds can be realised sooner by advancing the propagation time. During Phase 1, the individual body weight at catching is 1.2 grams at a biomass density of about 4.5 kg/m^3. The juvenile fish are released in April, after which carp can be sold following the autumn catching or even further fattened after the winter due to their reclassification. The post-rearing of the offspring takes place in small ponds, on a total area of 3,000 offsprings/0.6 hectare, with a survival rate of almost 59%. With the application of intensive feed of almost 3,000 kg/ha and the utilisation of natural fish feed, an individual body weight of nearly 800 grams was achieved, with an output of about 1.4 thousand kg at the time of catching. During Phase 3, i.e. the production of marketable sized fish, ponds have an average depth of 1.3 m and an average area of 4 hectares, and production takes place in polyculture. Carp is released at the highest ratio (80%) as the main product (which is equal to the amount of fish caught following post-rearing), followed by grass carp (15%), silver carp (3%) and catfish (2%) in the same proportion as in the conventional pond farming model. As a result, 1.4 thousand kg/ha of carp were caught. The specific feed consumption ($FCR_{combined}$) for the whole production period is 3.45 kg/kg.

(3) During intensive carp farming, the fish reaches its market size in 1 year (3 kg/individual). It is important to note that I did not take into consideration sales between phases, i.e. the quantity caught in the previous phase is the opening stock of the subsequent phase. Young larvae develop into fish of 1-gram body weight in 60 days during pre-rearing, with an average weight gain of 0.02 grams per day. The production of juvenile-sised fish from the larvae took place in a pool with a useful water volume of 350 liters, a population density of 8.9 thousand fish/m^3 and 60% drop-out rate. From the 5.9 kg/m^3 feed applied in this phase, a specific feed consumption of 1.05 kg/kg can be realised at a biomass density of 5.6 kg/m^3 at the time of catching. The total amount of larvae entered the post-rearing phase, which lasted 90 days. In this phase, carps reach an individual weight of 120 grams with

80% survival rate. Production takes place in 1 m^3 tanks with a population density of 157.9 kg/m^3, a specific feed consumption of about 17.1 kg/m^3 (FCR=1.2 kg/kg) and an increase in biomass by 14.2 kg/m^3 at the time of catching. During Phase 3, which lasts for 215 days in a closed-loop system in 12 m^3 tanks, the population density is 2.1 kg/m^3, the survival rate is 97% and intensive feeding (FCR=1.4 kg/kg) is also needed for fish to reach their marketable size. The average body weight of the fish to be sold is 3 kilograms, resulting in nearly 4.2 tons of live fish with a biomass density of 50 kg/m^3 at the end of the production cycle (one year). Regarding the whole production cycle, it can be concluded that, under controlled conditions (which helps the fish to grow at a favorable and constant water temperature), higher population can be achieved, and alternating production cycles are possible at any time during the year.

Consequently, it can be concluded that conventional pond fish production is realised with a higher loss (drop-out), over a longer period of time, with a higher FCR value and almost the same specific output as combined or intensive carp production. The primary reason for this fact is that the different rearing phases are less controlled, with a much higher risk of perpetual fish thefts and the significant damage caused by birds which is mainly due to the extraordinary growth of cormorant and little cormorant populations. It should also be mentioned here that the ecological services provided by the fishponds have only been partially reimbursed (HOP, HKP[1]), and no such compensatory aid is currently available, although the legislation would allow it. However, it is important to note that there are also obstacles to intensification, as capacity utilisation above a certain size can no longer be increased and, as a result, technological development requires a high level of expertise.

I believe that the methods used in fish production need to be constantly modernised, innovative developments in this area must be supported and further research needs to be carried out into the economic effects of various developments. In order to

[1] Fisheries Operational Program, Fisheries Environmental Management Program

increase the competitiveness and sustainability of aquaculture, it is necessary to expand the expertise and innovative practical knowledge of fish producers, which requires the development of consulting and management services. In order to increase the range of choices in pond and intensive farm fish production, it is necessary to encourage the production and market introduction of fish species with good market opportunities. At the same time, the protection of the genetic background of existing Hungarian carp species is not only an economic but also a social interest, as it is part of our agro-cultural heritage.

My findings related to answering these two questions are given in a consolidated way: ***4. What are the profitability circumstances of Hungarian carp production in the case of the examined types of farms, what are the factors that most influence the economicalness/income generating ability of the production in the case of the three examined farm structures, both from the input and output side, and what are the critical points of each technology?*** and ***5. What external and internal factors influence the efficiency of carp production for all three farm structures?***

(1) In the case of the cost structure of the traditional three-year production, the most significant cost item is material costs as in most livestock sectors. The cost item that determines the output of production the most is the cost of feeding, which represents a total of 53.7% of material costs, as one of the most important factors in the development, growth and health of fish is the regular supply of grain-based feed. In addition to these expenditures, energy costs are also significant (20.7%), including the fuel for the motorboat and tractors, the energy used for pumping and the gas required for the operation of the gas cannon. In the first phase, the share of this cost item is relatively higher, as the protection of offsprings with lower average weight requires significantly more expenditure, considering that “bird damage” is one of the most critical factors at this stage of production. Within direct costs, the cost related to special tangible assets is also significant (21.3%), as the machinery demand of a farm with a total area of 300 ha is much higher than that of a small pond system. In addition, the share of human resources expenditures is close to 10%. The

unit cost of the main product is 566 HUF/kg, which means that, based on the buying-in prices of autumn 2020, each kilogram sold provides an income of 110 HUF. However, it is important to note that, as a result of polyculture, the sale of by-catch must also be taken into account, i.e. a net income of 428.4 thousand HUF/ha can be realised at the sectoral level. I also examined that an increase in the average price of feed by 1 HUF at a given output level increases the cost by HUF 3.7, while reaching a higher output by 50 kg with the given average feed price increases the cost by 5.8 HUF. Furthermore, at a given FCR, an increase in the average price of feed by 1 HUF increases the unit cost, thereby decreasing the realisable income by 3.2 HUF per kilogram. The reduction of the specific feed consumption by 0.1 kg/kg unit results in a change of 3.8 HUF in the unit cost and specific income. Consequently, I believe that conventional pond fish production is economical, but also carries a significant risk, as a large part of the income is realised only by the end of the 3rd year, and the whole fish stock is more exposed to harmful effects (bird damage, exposure to infections) due to large pond sizes, and weather factors can have a major impact on outputs, while there is a relatively higher production risk compared to other livestock sectors. It should be mentioned here that, during the production cycle, certain information about fish can only be obtained indirectly, i.e. professional stock assessment is key.

(2) In terms of the cost structure of combined carp farming, there is a transition between the two technological variants (conventional pond farming and intensive farming), however, as in the case of the other two variants, material costs are the major cost item (51.7%). In this case, feed cost is significant (70.2%), in addition to the value of current assets that producers are faced during catching (10.5%). It is also important to mention that the production cost of carp, silver carp and catfish is around 10% due to the release of carp in the first phase and the population of the polyculture in the last phase. Personnel costs represent 35.1%, which is due to increased labor requirements during catching. The cost of special tangible assets is 6.2% on average. In the first phase, this ratio is still 26.1%, however, the special asset demand of pond fish production lags behind that of intensive fish farming,

which is the overall reason for the lower expenditure. As a consequence, at the cost price level of 665.5 HUF/kg, the sales price of 675 HUF results in a positive economic output. For this reason, as regards the main product, a net income of 9.5 HUF is realised for every kilogram caught and sold. In terms of specific cost and income relations, it can be seen that, taking into account the previously described parameters, a net income of 532.6 thousand HUF/ha (92.9 HUF/kg) can be realised in a single production cycle. It can be concluded that the increase in output per hectare reduces unit cost at a given feed price, but to an increasingly lesser extent. At the most favorable average feed price level and in the case of the highest output, the unit cost is less than 500 HUF/kg, which is about 206 HUF/kg more favorable than at the low output level. At a given sales price, the critical feed price (*cp.*) is 97.1 HUF/kg, when the net income is zero. In the same case, each HUF/kg increment in the average feed price reduces the value of net income per fish by 3.5 HUF. It is important to note that, at a feed price of 70 HUF/kg, the activity is already loss-making at a sales price below 582.2 HUF/kg. Altogether, it can be concluded that the combined (pre-rearing in closed-loop systems and post-rearing in pond farms) carp farming is economical, but it lags behind the 3-year-long farming form in terms of specific profitability. Nevertheless, due to the shortening of the production cycle by one year, multiple sources of income are realised, i.e. the liquidity of the farm can be improved and fish farming can be significantly more controlled and traced, as there is a certain kind of feedback during the reclassification between each phase. In addition to combining pond farming and intensive fish production, the goal may also be to expand the range of fish.

(3) With regard to the cost structure of *intensive carp production*, it can be concluded that material costs (54.5%), including, due to the applied technology, the cost of electricity (57.3%) and feed (35.8%), are dominant factors, given that the breeding stock is not taken into account. Depreciation of special tangible assets and the cost of repairs and maintenance are also significant (31.1%). Consequently, it can be stated that, during intensive production, the unit cost of carp is almost 1,400 HUF/kg, which, at the sales price of 675 HUF/kg, results in a loss of almost 725 HUF for

every kilogram sold. I examined the effect of the change of factors that determined cost and profitability the most, and came to the conclusion that the increase of the feed price by 10 HUF/kg reduces the cost by 14.8 HUF/kg at a given output level, and each HUF increment in sales price at a given average feed price/kg level improves the profitability of the activity by 1 HUF/kg. A change in the feed price at the given sales price level reduces specific income by 1.5 HUF/kg. Furthermore, at the given sales price level, an increase in the electricity fee by 1 HUF/KWh reduces the value of net income by 11.8 HUF/kg, whereas at a given electricity price, an increase in the sales price by 1 HUF/kg improves the specific income by the same amount. It can be stated that the activity is unprofitable, as the production cost significantly exceeds the selling price, thus, in the case of intensive technology, the further rearing of carp is advised, as in the closed-loop system, the growth rate of carp is more favorable than in pond farms and the sales price of carps over 6 kg body weight is over 2,000 HUF/kg. Under such circumstances, carps would reach an individual weight of 6 kg in 6 extra months, during which the activity would become profitable at a cost of nearly 1.8 thousand HUF/kg.

Based on all these aspects, I consider both **H1** (*In the case of different types of farms, the profitability of carp production decreases in proportion to the shortening of the production cycle.*) and **H2** (*For the three technologies studied, only pond farming and 2-year combined carp production will be economically sustainable.*) **justified**. In addition, I consider my hypothesis **H3** (*The cost of carp production is most affected by the amount of feed used and its current market price for all three types of farms.*) **only partially justified**.

6. What sustainability and competitiveness factors characterise and determine pond carp production?

I have determined that competitiveness is mainly manifested in the adaptation to consumer needs on the demand side, as well as in the reduction of unit costs and the increase of profitability on behalf of farms. Consumers are primarily looking for a high-quality, high-nutrition and reliable product that is fishbone-free and easy to prepare. However, due to the fishbone, carp as a fish product is less popular in Hungary compared to products made from salmon or other sea fish. I believe that this particular preference will not change drastically in the future, despite the fact that the slightly improving trend of pond fish production (including carp production) will continue in the next period, while processed, high value-added carp products will appear more often in the Hungarian fish supply.

The competitiveness of Hungarian produced live carp in traditional German markets compared to Czech carp is basically determined not by the significant difference in production costs, but by the relatively high specific logistics costs. The potential occurrence of KHV in Germany and Poland may temporarily put Hungarian carp exports in a favorable position. Consequently, it is important to promote carp products through stronger marketing communication, introduction and use of trademarks, which, in addition to promoting quality Hungarian fish products, also orient consumers towards Hungarian fish products and increase the consumption of high-value products. By consciously choosing products with trademark, consumers also contribute to the sustainability of fisheries and the aquaculture sector in Hungary.

Innovative developments and sectoral cooperation (e.g. the establishment of producer groups) have taken place at a relatively low level in the sector, and, despite EU support, the relatively favourable income position in many farms has led to 'growing lazy'. In my opinion, in the long run, only production in integration will be competitive, as it will lead to a greater market bargaining position on both the input (feed) and output (fish products) side of the product chain. Integrated production includes (1) production equipment manufacturing/distribution + housing technology distribution; (2) feed production + distribution of feed technology; (3) breeding activity, production of breeding stock; (4) propagation, hatching; (5) off-season propagation rearing; (6) fish farming / fattening; (7) primary and secondary processing; (8) shipping and logistics and (9) trade. However, it is important to implement the missing sectoral cooperation. According to the Hungarian circumstances, competitive market participants (small fish farms, fish processors, etc.), who have a price-accepting behavior in the market, are unwilling to cooperate in the medium and long term on their own, they would do so only due to some external circumstances (subsidy, market coercion, the drastic deterioration of the profitability of fish production, etc.).

In the near future, a specific investment aid will be needed to support sustainable and, at the same time, long-term competitive development of the sector by promoting innovation, higher value-added developments, energy and cost savings, the use of renewable energy, as well as proper feed management, quality production and protection of the natural environment. I consider the development potential of aquaculture to be mainly the improvement of human capital, the qualitative and quantitative renewal of the resources needed for production, restructuring, innovation and the production of quality products. I believe that, according to most indicators, the sector is economically sustainable in the current production conditions, but its future will be fundamentally influenced by the its ability to adapt. In order to improve the age structure of those working in the fishing industry, it is necessary to encourage the start-up of young fishermen's businesses. In order to increase the competitiveness and ensure the sustainability of aquaculture, it is necessary to expand the expertise and innovative practical knowledge of fishermen, which requires the development of consultancy, information and management services.

Altogether, it can be concluded that the economic research related to Hungarian fish production, and, more specifically, the production of any fish species, fills a gap and I suggest to carry out further research, to approach the described issues from various aspects, as changing production parameters result in significant changes in profitability. The aim of this research would be to contribute to the current situation, future challenges and opportunities of the sector and to provide a form of guidance to the players of the sector.

4. NEW AND NOVEL RESULTS OF THE DISSERTATION

During the implementation of the objectives of the dissertation, I identified the following new and novel results:

1. By adapting the definitions of sustainability and competitiveness in the technical literature, **I have developed** the following concepts in relation to aquaculture: "*sustainable freshwater fish production is a system of socio-economic conditions and activities that maintains/preserves the natural values associated with fish production (e.g. wetlands) in a way that it does not exhaust them, that is, in addition to satisfying the needs of the present generation, it also preserves them in the appropriate quantity and quality for future generations. In accordance with the concept of circular economy, the natural resources necessary for fish production (e.g. water, animal resources) are used sparingly and expediently, without polluting the environment, and by ensuring the improvement of the quality of life and the preservation of diversity in the long term, while reducing or moderating the ecological footprint"*. According to the available definitions studied, *"I consider a product to be a* ***competitive fish product*** *that has the expected quality and adequate value for use for consumers and a reasonable price of processed products for a wide range of consumers, while providing continuous market sales and profits for the given business throughout the entire year. Furthermore, an aquaculture enterprise that produces competitive fish products on the market, realises long-lasting profits, produces at a lower cost than its competitors and reacts quickly to environmental changes is considered competitive. It is also an important factor that, through its various products and resources, a competitive aquaculture enterprise is able to maintain its market position in the future, preserve its natural environment, maintain its market condition and further develop its ability to respond to change*".

2. I **demonstrated** the significance and possible comparative competitive advantage of Hungary in the world market of carp products (live carp and processed carp products) according to foreign trade-based indicators and

competitiveness indices based on secondary databases for live carp compared to China and the European Union. The competitive advantage of Hungary is mainly due to the relatively lower production costs, which are determined by the Hungarian production conditions (*e.g. climatic conditions, the length of growing season/production cycle, water supply, production technology*).

3. I **developed** a deterministic business model for traditional pond fish production, off-season (2-year-long) combined fish farming and intensive (1-year-long) carp production, during which I considered the existing and identifiable differences in the production cost structure and the typical production and economic indicators to be important. The model is suitable for the dynamic simulation of changes in the farm economic conditions of different technologies, assuming the effect of changes in the given input and output factors as independent variables. This model reflects possible changes in the economic and social environment (macro, meso and micro levels).

4. Based on the obtained research results, I **demonstrated** that, with the shortening of the production cycle and the presented technological solutions, the unit cost of marketable carp (P3) increases, which can be observed due to the higher feed cost and energy demand resulting from the intensification of technology at the relatively high extent of fixed capital typical of pond fish production. I found that the 1-year-long intensive carp production (RAS) is uneconomical in the current economic conditions due to its ability to produce relatively small quantities of carp in an experimental/semi-commercial system and, therefore, it has a comparative disadvantage compared to the other two forms of production and technologies studied.

5. PRACTICAL APPLICABILITY OF RESULTS

My results serve as a guideline for the identification of the development directions of the sector and for the preparation of the sectoral operational development plans for the decision-makers and the professional organisation, as no comprehensive profitability analysis was carried out for the three different technologies examined during carp production and even each technological variant is available only to a limited extent. The obtained results contribute to the knowledge of the current situation, future challenges and opportunities of the sector, and provide a form of guidance to the players of the sector with regard to further research directions and possible developments.

For carp production companies, the results of the research could be thought-provoking and interesting, as their long-term goal is continuous and controlled economical fish production, which requires certain improvements. Comparing these development directions and determining their efficiency and profitability will help fish farmers answer the relevant questions.

In the field of education, the results of the dissertation contribute to the expansion of the knowledge conveyed in connection with the business economics analysis of agricultural sectors based on the traditions of the Debrecen School of Business Administration. In addition, these findings can be incorporated into the subjects of Sectoral Economics and Farm Economics both in agricultural and agroeconomy courses.

In addition, I consider it necessary to carry out further studies to determine the extent to which the applied technologies affect the income-generating ability of carp production, and to reveal the factors which can improve the cost of production by acquiring and refining the applied technological solutions.

REFERENCES

1. Ballance, R. H. – Forstner, H. – Murray, T. (1987): Consistency tests of alternative measures of comparative advantage. Review of Economics and Statistics. 69 (2) pp. 157–161.
2. Bojtárné Lukácsik M. – Berzi-Nagy L. – Tóth F. – Gyalog G. (2019): Tógazdasági termelési mutatók régiók és üzemméret szerinti megoszlása. XLII. Halászati Tudományos Tanácskozás, Szarvas, 2019. 05. 29-30. pp. 66-70
3. Boyd, C. E. (2005): Water use in aquaculture. World Aquaculture. 36 (3) pp. 12-15
4. FAO (2016b): Aquaculture Big Numbers, by Michael Phillips, Rohana P. Subasinghe, Nhuong Tran, Laila Kassam and Chin Yee Chan. FAO Fisheries and Aquaculture Technical Paper No. 601. Rome, Italy.
5. Fast, A. W. – Quin, T. – Szyper, J. P. (1997): A new method for assessing fish feeding rhythms using demand feeders and automated data acquisition. Aquacultural Engineering. 16 (4) pp. 213-220. DOI: 10.1016/S0144-8609(97)00003-4
6. Fertő I. (2003): A komparatív előnyök mérése. Statisztikai Szemle. 81 (4) pp. 309-327.
7. Gyalog G. – Berzi-Nagy L. – Tóth F. – Békefi E. – Bojtárné Lukácsik M. (2021): A hazai pontyhozamokat meghatározó tényezők és a termelést korlátozó erőforrások elemzése termelési függvény alapján. Gazdálkodás, befogadott kézirat.
8. Hancz Cs. – Horváth L. (2007): A tógazdasági haltenyésztés gyakorlata (szerk.: Hancz Cs.) in: Haltenyésztés. Kaposvár. 262 p.
9. Karnai L. – Szűcs I. (2017): Pontytermelés és kereskedelem az EU28-ban. ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA / ANIMAL WELFARE ETHOLOGY AND HOUSING SYSTEMS 13 (2) pp. 60-67.
10. Karnai L. – Szűcs I. (2018): Outlooks and perspectives of the Common Carp production. Annals of The Polish Association of Agricultural and Agribusiness Economists. 20 (1) pp. 64-72.
11. Lajkó I. – Tasnádi R. (2001): A tógazdasági haltenyésztés alapjai. Budapest. Agroinform Kiadó.
12. MAHAL (2018): Jelentés a Szövetség működésének 2017. évi eredményeiről. Budapest URL: http://new.magyarhal.hu/UserFiles/files/jelentesek/2017__evi_jelentes.pdf, (letöltés dátuma: 2020. október 02.)
13. MAHAL (2020): Jelentés a Szövetség működésének 2019. évi eredményeiről. Budapest URL: http://new.magyarhal.hu/UserFiles/files/jelentesek/MAHAL%20%C3%89ves%20Jelent%C3%A9s_2019.pdf (letöltés dátuma: 2020. december 15.)

14. Müller F. (1990): Economical analysis of some superintensive technologies for fish production in Szarvas. Aquacultural Hungarica. 6 pp. 235-246.
15. NAIK AKI (2020): Tógazdasági jövedelemfelmérés eredményei 2018-as számviteli év. Készítette: MAHOP DCF munkacsoport INfók
16. Piedrahita, R. H. (1984): Development of a computer model of the aquaculture pond ecosystem. Ph.D. Thesis. University of California, Davis, CA.
17. Piedrahita, R.H. (1988): Introduction to computer modelling of aquaculture pond ecosystems. Aquaculture Research, 19 (1) pp. 1-12. DOI: 10.1111/j.1365-2109.1988.tb00328.x
18. Pintér K. (2010): Magyarország halászata 2009-ben. Halászat 103 (2), pp. 43-48.
19. Silva, C. R. – Gomes, L. C. – Brandao, F. R. (2007): Effect of feeding rate and frequency on tambaqui (Colossoma macropomum) growth, production and feeding costs during the first growth phase in cages. Aquaculture. 264 (1) pp. 135-139. DOI: 10.1016/j.aquaculture.2006.12.007
20. Stündl L. (2011): Az intenzívüzemi haltermelés egyes új és újszerű technológiai megoldásai és fejlesztési lehetőségei. „Konferencia a hazai akvakultúra ágazat megújulásáért" Szeged, 2011. szeptember 2. előadás diaanyag, URL: http://www.masz.org/files/05_Stundl_Laszlo.pdf (letöltés dátuma: 2017. szeptember 12.)
21. SUSTAINAQUA (2009): A fenntartható akvakultúra kézikönyve. 119 p. URL:https://haki.naik.hu/sites/default/files/uploads/201809/sustainaqua_handbook_hu.pdf (letöltés dátuma: 2020. szeptember 30.)
22. Szőllősi L. – Szűcs I. (2015): Az üzleti tervezés alapjai. Debreceni Egyetem. ISBN 978-615-80290-7-0, 116 p.
23. Szűcs I. – Stündl L. – Karnai L. – Szőllősi L. (2017): Az akvakultúra helyzete és lehetőségei, a magyar halgazdálkodási operatív program (MAHOP) hatása az ágazat fejlődésére (szerk.: Szűcs I.), OTP Bank Nyrt Agrár Kollégiuma, 110 p.
24. Szűcs I. – Stündl L. – Nábrádi A. (2002): A halászati ágazat gazdasági szervezési és piaci kérdései. (szerk.: Szűcs I.) Mezőgazdasági Szaktudás Kiadó, Budapest, 2002. 1-221 p.
25. Valderrama, D. – Hishamunda, N. – Zhou X. (2010): Estimating employment in world aquaculture. FAO Aquaculture Newsletter. 45 pp. 24–25.
26. Váradi L. (2001): Erőforrás kímélő haltermelő rendszerek fejlesztése, különös tekintettel az integrációra. Doktori PhD értekezés Debrecen, 132 p.
27. Verdegem, M. – Bosma, R. (2009): Water withdrawal for brackish and inland aquaculture, and options to produce more fish in ponds with present water use. Water Policy. 11 (S1) pp. 52-68. DOI: 10.2166/wp.2009.003
28. Woynárovich A. – Kovács É. – Péteri A. (2019): A takarmányozás gyakorlati szempontjai a tógazdasági haltermelésben. Duna-Mix Kft., Budapest. ISBN: 978-615-5673-57-3, 86 p.

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Doctoral School: Károly Ihrig Doctoral School of Management and Business
MTMT ID: 10057050

List of publications related to the dissertation

Articles, studies (7)

1. **Karnai, L.**, Szűcs, I.: Profitability analysis of fish production in an extensive pond fish system: a Hungarian case study.
   Annals of the Polish Association of Agricultural and Agribusiness Economists. 22 (2), 60-69, 2020. ISSN: 2657-781X.
   DOI: http://dx.doi.org/10.5604/01.3001.0014.1387
2. Fenyves, V., Bács, Z., **Karnai, L.**, Nagy, A. S., Tarnóczi, T.: Financial Performance Measurement of Hungarian Retail Food Companies.
   Contemporary Economics. 12 (4), 459-472, 2018. ISSN: 2084-0845.
3. **Karnai, L.**, Szűcs, I.: Outlooks and perspectives of the common carp production.
   Annals of the Polish Association of Agricultural and Agribusiness Economists. 20 (1), 64-72, 2018. ISSN: 2657-781X.
   DOI: http://dx.doi.org/10.5604/01.3001.0011.7230
4. **Karnai, L.**: Production and trade of trout in the EU28.
   Journal of Central European Agriculture. 19 (3), 615-628, 2018. EISSN: 1332-9049.
   DOI: http://dx.doi.org/10.5513/JCEA01/19.3.2086
5. Szőllősi, L., Molnár, S., Ladányi, K., **Karnai, L.**, Szűcs, I.: Cost analysis of pig slaughtering: a hungarian case study.
   Apstract. 11 (3-4), 121-130, 2017. ISSN: 1789-221X.
   DOI: http://dx.doi.org/10.19041/APSTRACT/2017/3-4/17
6. **Karnai, L.**, Szűcs, I.: Pontytermelés és kereskedelem az EU28-ban.
   Animal welfare, ethology and housing systems. 13 (2), 60-67, 2017. ISSN: 1786-8440.
   DOI: http://dx.doi.org/10.17205/SZIE.AWETH.2017.2.060
7. Szűcs, I., Tikász, I. E., **Karnai, L.**, Stündl, L.: Füstölt barramundi filé termékek hazai fogyasztói megítélésének vizsgálata.
   Táplálkozásmarketing. 3 (1), 21-36, 2016. EISSN: 2064-8839.
   DOI: http://dx.doi.org/10.20494/TM/3/1/2

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List of other publications

Articles, studies (5)

8. **Karnai, L.**, Szőllősi, L., Bauerné Gáthy, A., Szűcs, I.: Attitudes of Debrecen University students towards healthy life based on their dietary habits.
   International Journal For Quality Research. 15 (1), 125-138, 2021. ISSN: 1800-6450.
   DOI: http://dx.doi.org/10.24874/IJQR15.01-07

9. Szűcs, I., Bauerné Gáthy, A., Soltész, A., **Karnai, L.**: Examination of the perceived and real environmental and health consciousness of students attending the University of Debrecen.
   International Review of Applied Sciences and Engineering. Epub, 1-9, 2020. ISSN: 2062-0810.
   DOI: http://dx.doi.org/10.1556/1848.2020.00185

10. **Karnai, L.**, Szűcs, I.: Táplálkozási szokások vizsgálata a debreceni egyetemisták körében.
    Táplálkozásmarketing. 6 (2), 39-50, 2019. ISSN: 2064-8839.
    DOI: http://dx.doi.org/10.20494/TM/6/2/4

11. **Karnai, L.**: A hazai kézműves bonbongyártás technológiája és költség viszonya.
    Acta Carolus RobertusS. 6 (1), 83-91, 2016. ISSN: 2062-8269.
    DOI: http://dx.doi.org/10.22004/ag.econ.233825

12. **Karnai, L.**, Szűcs, I.: Kézműves csokoládéfogyasztás főbb jellemzői Hajdú-Bihar megyében.
    Táplálkozásmarketing. 2 (2), 59-66, 2015. EISSN: 2064-8839.

Conference presentations (1)

13. **Karnai, L.**: A család megélhetési modell vizsgálata egy kézműves bonbongyártó vállalkozás példáján keresztül.
    In: interTALENT UNIDEB. Szerk.: Mándy Zsuzsanna, Debreceni Egyetem, Debrecen, 109-110, 2016. ISBN: 9789634732457

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

04 March, 2021

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