

**UNIVERSITY OF PUBLIC SERVICE  
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**The food supply chain as a critical infrastructure and its  
protection**

**PHD THESIS**

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## 1. SCIENTIFIC PROBLEM STATEMENT

The phenomenology of food economics and its supply chain does not exhibit longstanding foundations and the related academic efforts are mainly focusing on applied research, furthermore having implementation at its heart. Therefore, there is a great lack of scholarly articles that are delving into to theoretical foundation of such studies that are concentrating on applications. This research, within the constraints imposed on volume and time availability, investigates the questions advancing the understanding of the topic and building on that provides a scientific perspective on resolving the related issues. Thus, the approach is two-fold, there is a focus on whether the theoretical background is confirmed by practice, and opposingly an examination of the correctness of theories developed based on empirical observations. Throughout the research the aim spanned over than a simple information collection about the topic of food economics and supply chain, having the urgency of developing connections and conclusions that are founded in logic. Therefore, in terms of classification the study is considered to be a partially foundational, partially also innovative amongst the numerous types of applied research.

The analytical evaluation of the existing literature showed that in the training of public sector and food industry employees complex knowledge-ability-skill ensemble creation, by which the affected professionals become able for recognising emergencies in advance, thus preventing special legal order, must be incorporated. It would be ideal if an effective cooperation could be realised between the aforementioned parties in recognising and managing occurring crises.

Professionals are mainly making decisions based on strict protocols, expertise and personal experience, which factors are also the major points for evaluation of those choices. Although assumed decisions are incorporating a subjective truth, their objectivity is questionable. Therefore, the scientific driver of the research is to identify a theoretical background suited for modeling such decisions, one that incorporates both the subjective and objective aspects. This phenomena is known as evidence and fact based policy in the literature. Specifically, this piece of work revolves around applying the methodology of logic risk analysis for the ascribed problem area, initially in this field of research.

Continually, the research investigates and aims to identify well-established answers for the following questions:

1. *The extent of applicability of the theory and methodology of operational logic risk analysis for investigating collapses of the food supply chain, and the required parameters of the concurrent event management database.*
2. *The extent of the awareness of Hungarian academic representatives about food supply chain security, and whether they acknowledge its gravity appropriately.*
3. *How well the current Hungarian higher education system prepares future practitioners for maintaining security throughout the food supply chain, while preventing related damages and addressing crises properly?*
4. *What training methodology is necessary in order to attain a food security system sustainable even in special legal order?*
5. *What further trainings would be required for civil servants with an academic background in agriculture or food sciences in order to equip them with the necessary skillset for handling the unusual issues of emergency situations properly?*

## 2. HYPOTHESES

An inductive approach was conducted for defining the hypotheses, which builds on practical experience for developing assumptions, except in one case, where a theorem was the starting point. In order to fulfill the relevant requirements both the type of null hypothesis and the alternative were reflected in the hypotheses.

*H<sub>1</sub>: The lack of sufficient information and preparedness is the reason why higher education participants of the field does not take particular interest in the problem area of food security.*

*H<sub>2</sub>: A significantly greater emphasis must be placed on sustainable food supply chains addressing the areas of prevention, preparation, defense and rehabilitation in the educational system of the field.*

*H<sub>3</sub>: Food security lacks a specific methodology regarding necessary protocols of restriction and policy-making in special legal order.*

*H<sub>4</sub>: Building on adequate professional statement the methodology of operational logic risk assessment is applicable for modeling correlated, harmful events affecting the food supply chain.*

### 3. RESEARCH OBJECTIVES

The work investigates and builds on the scientific revelations of the 21st century. I have defined the current food security challenges and have developed proactive solutions for those potential issues. Also, I researched and evaluated the related societal and economic aspects and suggested an alternative for managing those challenges.

I was planning on closing the research in early 2020, however due to the worldwide spread of COVID-19 and considering the effect of the first wave on the food supply chain – more specifically in food trade – it was finished eventually on the 5th of May, 2020, while extended with the period affected by the virus. Later changes are remain unaddressed by this work, although they may offer further opportunities and orientation about discussing the topic.

I aim to develop a protective security model for maintaining food security. A focus of the reserach was also identifying the devices and mechanisms for attaining a secure food supply chain. Furthermore, it is also investigated whether the affected stakeholders in the agricultural, public and food industry related sectors are sufficiently trained in terms of food security, and its extent. Does both under- and postgraduate courses contribute in preparing graduates for managing emergency situations in food security effectively? Finally, I considered the practical implications of the research results in terms of protocols for managing such situations, the related educational background and teaching methodologies.

My main objective is to demonstrate that an operational logic risk analysis of the collapse of the food chain can be carried out using an appropriate event management database, and to explore what further training is required for graduate and postgraduate agri-food professionals, employed by the public sector, to be able to perform their tasks in classified situations effectively.

#### 4. RESEARCH METHODS

I studied and processed both the national and international literature on the research topic, in parallel with which I analysed the results of relevant national and international research and related publications. I continually consulted my supervisor and other experts, researchers working on the topic. In addition, I participated and contributed to scientific conferences related to the topic.

In my research, I have developed a detailed operational logic risk analysis of food chain collapse, focusing on the problem of maintaining food chain security, with particular attention to the issues of mitigating the adverse consequences of deliberate breaches of security and possible prevention.

I performed an operational logic risk analysis of food chain collapse using an event management database, and found that by generating a computer-adaptable set of algorithms from the event management database, optimal food chain collapse mitigation strategies can be determined for all kind of events using the official definition of the food supply chain.

I analysed my results using a comprehensive set of rigorous and state-of-the-art mathematical-statistical tools.

The views of the target groups, academics and practitioners on threats, potential threats, risk management and risk communication in the food economy were explored through a survey.

The special methods used in my work:

- ✓ *a Boolean algebra based logical risk analysis methodology for an isolated risk system,*
- ✓ *invention of survey questions based on expert interviews,*
- ✓ *a self-administered anonymous questionnaire survey; analysis and evaluation of the responses received,*
- ✓ *as existing validated scales proved to be inapplicable for this study I developed and validated my own the scale for the tests,*

- ✓ *the selection of the core respondents was based on a contact-network, using a snowball method, with particular attention paid to the views of people working in higher education institutions of agriculture,*
- ✓ *the questionnaires were analysed by statistical methods using the SPSS software package,*
- ✓ *agent-based modelling was used to process the questionnaire survey,*
- ✓ *I used comparative study and analysis.*



## 5. STUDIES & CONCLUSIONS

### 1. LOGIC RISK ANALYSIS ON THE COLLAPSE OF THE FOOD SUPPLY CHAIN

I have carried out an operational logic risk analysis about food supply chain collapse. Operational as providing a clear, concrete answer to all specific technical questions - properly formulated.

In the paradigm of risk analysis, I interpreted the food chain as a risk system, accordingly to the official definition. Then, I processed the resulting system using the methods of logical risk theory, taking the work of Bukovics (2009) as a guide both in terms of methodology and terminology. The research assumes an event management database, which can be specified arbitrarily on a broad spectrum. The system uses the event management database to produce a sequence of algorithms that can be mechanically executed and adapted to a computer. This allows uncovering the optimal way of dealing with any food chain breakdown event suiting the formal definition.

This means that the least costly and shortest implementation time prevention or mitigation intervention or interventions to rehabilitate any given case of food chain collapse is identified algorithmically.

### 2. DIRECT SURVEY-BASED STUDIES

Survey participants were Hungarian higher education teachers questioned about their attitudes towards teaching about emergency preparation and related topics.

First, expert interviews were conducted on the factors that may play a role in the knowledge transfer about emergency management. Drawing on the interviews, I compiled a questionnaire for surveying, having questions divided into two groups. One part explored the sociodemographic characteristics of the respondents relevant to the research, while the other examined how much they agreed to the 17 statements collected during the preliminary interviews. The statements were formulated on a Likert scale up to 5 points, having these respective statements:

- 1. I do not agree at all with the statement*
- 2. I slightly agree with the statement.*
- 3. Partly agree/Partly disagree with the statement*
- 4. Strongly agree with the statement*
- 5. I agree completely with the statement.*

In my work, I followed the research principles of the Hungarian Academy of Sciences to the greatest extent possible; thus, questions violating privacy standards were abandoned. The survey was conducted using Google Forms, an online questionnaire software. The questionnaire was sent to professionals involved in agriculture related higher education with potential involvement in education on this topic. A total of 230 questionnaires were returned out of the 870 sent out. This is a respondent rate of almost 25%, which can clearly be considered positive.

The survey was ought to explore how today's Hungarian higher education staff perceive the importance of preparation for emergency situations. I focused on maintaining security throughout the food supply chain, the tasks related to the protection against and the resolution of bio-terror attacks, and the preparation for bio-terror attacks. The survey respondents remained anonymous accordingly to the international literature on the subject. For this study, it was not possible to use existing validated scales, therefore I developed my own validated scales. The fundamental respondent group were selected using a snowball method, based on a contact network, with particular attention to the identification and exploration of the views of those working in agricultural higher education institutions on the subject. The questionnaires were analysed by the statistical toolset of the SPSS software package. Firstly, the sociodemographic characteristics of the respondents were uncovered. This was important in order to grasp an idea about the age, professional background and experience of the respondents in relation to the questions asked.

The main socio-demographic characteristics investigated are summarised in the tables below (Tables 1-2-3).

Age (years)	Distribution (%)	Cumulative distribution
< 30	13.8	13.8
30-44	42.2	56.0
45-60	21.6	77.6
61- 74	16.4	94.0
75 <	6.0	100.0

*Table 1: Age distribution of respondents*

Table 1 shows the structure of respondents in terms of age. It is apparent that the average respondent ages between 30 and 44 years, which means that the backbone of higher education is this young generation that completed the questionnaire in the largest proportion. This is of particular importance for regarding the analysis because this generation acquired their higher education after the regime change of 1989 in Hungary, which implies that they did not have

direct experience of the defence system during their a compulsory military service, nor did they learn defence studies as part of their higher education curriculum. However, an important characteristic of this age group is that the terrorist attack in New York on 11 September 2001 was a significant event in their first period of life in which they became aware of social processes. In other words, this generation is already familiar with the images of the increasing frequency of terrorist attacks in major cities around the world, broadcasted by leading news channels, consequently it is safe to assume that this generation is perhaps more accustomed, to the presence of such risks than the elderly.

Cumulative response rates show that more than three quarters of respondents were less than 60 years old. This means that members of the relatively older generation were sufficiently represented in the sample which is important as they are still the leading group in the development of the curriculum for the current system of higher education in Hungary. They set the basic direction of teaching and research activities by holding various faculty, university, academic and other leadership positions. Therefore, their inclusion in the sample is reasonable. In terms of the distribution of the respondents accordingly to their positions in higher education, it can be seen that the majority of respondents were consisting of middle generation of teachers, with an increased number of adjunct, associate, and university professors (Table 2).

Position	Distribution (%)
departmental engineer	4.3
assistant professor	11.2
research assistant	8.6
senior research fellow	4.3
adjunct professor	8.6
associate professor	16.4
university professor	12.9
professor emeritus	9.5
other	24.1

*Table 2: Distribution of respondents by their higher education classification %*

The disciplinary classification of respondents (Table 3) characterises well the current Hungarian higher education in agriculture, The vast majority of respondents work in the field of natural sciences and classified themselves in this field, but it is also clear from the survey that a substantial part of respondents have experience in economics or law. A smaller number of people from the humanities and social sciences returned completed questionnaires. This diverse disciplinary background reflects the multidisciplinary nature of agri-food training. Such different profession accurately reflect the emerging subject in higher education related to the investigated problem area.

Science area	Distribution rate
Life science/Agricultural sciences	2.6 %
Economic and legal science	15.5 %
Human and social sciences	16.4 %
Science of Nature	65.5 %

*Table 3: Classification of respondents according to their field of study*

Looking at the extent of respondents agreeableness, majority of respondents seems to be aligned with the statement that organised protection can help to prevent disasters. It is increasingly imperative to note that this statement was accurate ante-coronavirus and its related crisis starting in 2020. Given the measures put in place last year in response to the economic, social changes and restrictions that have taken place, it is very likely that a repeated survey would show greater agreement regarding the issue. The importance of organised, collective defence and disciplined cooperation would become even more important. The vast majority of respondents also agreed with the statement claiming there are not enough resources for education and training on the subject. This can be attributed to two aspects, firstly, higher education has been consistently underfunded, and secondly, there is a lack of interest by some lecturers in doing meaningful practical work alongside their teachings.

Respondents agreed that higher education institutions should communicate scientifically proven facts accepted by the relevant disciplines. This is illustrated by the fact that those working in the field seek to understand the principles that should characterise modern higher education. Also, I am convinced that it is important to emphasise drawing attention to the specificities, since there are special features of protection against bioterrorist attacks, that are, amongst others, a consequence of the unique structure of the national legal system. Results are also promising as the majority of respondents have an overall positive opinion of crisis prevention training and support the need for training in dealing with extreme situations appropriate choices of action.

Another favourable result was that many respondents stated that they regularly follow social and political events in the broader environment. However, when considering that they are higher education staff, this relatively high level of agreeing with this statement is not self-evident, as there is significant variance amongst most respondents. Interestingly, respondents did not strongly agree with the suggestion that food supply chain should be considered as a potential target of terror, i.e. that there is low level of threat perception and awareness. This is probably due to the fact that a large number of respondents - the survey was conducted in 2019

- claimed that they had no direct experience in emergency situations and their mitigation - such as a flood, epidemic or fire. Obviously, following the pandemic period that has been defining and limiting our daily lives and affecting our economic and social environment for multiple years now, this lack of personal experience is diminishing. Therefore, in a follow-up research, I plan to repeat the survey in the future and compare the two results.

A large majority of respondents agreed with the opinion that there is a lack of experience in teaching emergency management skills and related hand-on trainings. However, many felt that there was no justification for transferring additional resources for training on how to deal with extreme situations. Most of them simply agreed that specific time slots and resources should be reserved for training on topics related to the management of extreme situations. It is

Statement	Average	standard deviation
The main responsibility of university staff is education rather than research	2.88	1.112
The main aim of higher education should be the transfer of theoretical knowledge; the development of competences and practical applicability should be given less importance	2.08	1.023
Higher education institutions should, as a matter of principle, communicate universally applicable scientific truths accepted by the relevant academic community	3.89	1.102
I have direct experience of an emergency (e.g. flood, epidemic, fire)	2.66	1.610
I regularly follow wider socio-political events	3.80	1.128
I have attended some special training related to emergency response (e.g. first aid, fire safety, flood protection)	3.28	1.597
I consider it likely that a disaster situation affecting the food chain will occur in the next ten years	3.08	1.089
Organised protection can help prevent disasters from occurring	4.18	.965
High likelihood of a disaster situation with loss of life in the event of damage to the food chain	3.47	1.034
We don't have enough knowledge to teach emergency management skills, practices	3.82	.929
Not enough resources for education and training	4.10	1.050
Not enough time for education, exercises	3.60	1.179
It would be important to hold trainings either at the expense of other subjects or by extending the teaching load	3.48	1.138
In higher education, there is a need to teach about dealing with extreme situations and to transfer the appropriate behavioural conduct	3.67	1.061
I would participate in developing teaching materials and exercises in my spare time	2.83	1.274
I have sufficient knowledge of dealing with extreme situations and the rules of standard behaviour	2.41	1.165
As a parent, I would encourage my child to participate in teaching about how to deal with extreme situations and the respective rules of behaviour	3.84	1.092

*Table 4: Level of identification with each statement*

clearly promising that a significant number of respondents rejected the view that higher education should be limited to teaching only theoretical knowledge while discarding the

practical experience and a hybrid ways. Strengthening the unity of teaching and research was also considered important by respondents. Lastly, the majority did not share the view that the fundamental purpose of university education and university teaching should be exclusively teaching steering resources away from research. The degree of agreement with the other statements was below 4, as shown in Table 4.

Notably, the majority of respondents do not consider any disaster affecting the food chain will occur in the next 10 years likely. This low awareness of danger possibly explains why only a very small proportion of respondents said that they would be willing to participate in the development of educational materials or in disaster management training even if they had free time. One explanation for the relatively low level of threat perception may be that a significant proportion of respondents do not have on-the-ground experience of emergencies or of how to deal with crises that arise. It is also worth pointing out that most of them have not received specific training in emergency response. This may explain why the majority of respondents did not consider their preparedness to deal with emergency situations to be sufficient. On the positive side, however, a relatively high proportion of respondents recommend that their close relatives, e.g. their children, should be familiarised with what to do in dealing with specific situations. In conclusion, the survey provides a difficult picture of attitudes that influence patterns of behaviour in dealing with emergency situations.

In the rest of my research I looked at the relationship between the answers to the different questions. To do this, I calculated correlation coefficients for each response. As a result of this calculation, I found that the correlation coefficients between the individual responses are relatively low. The analysis of the correlation coefficients shows that the degree of agreement between the different factors is low, which indicates that all the questions asked are professionally relevant and important.

The context is important because the need to mobilise more resources for practical training has been identified as a demand, since the aim of higher education is not only to transfer theoretical but also practical knowledge. The relationship between the different factors and the principal component was examined using principal component analysis. In doing so, I found that a relatively large number of principal components describe the phenomena that belong to each of the sets of factors under study.

As individual factors were not separated appropriately, further investigation proved to be necessary. I continued my work by rotating the individual factors. The new factor structure is shown in Table 14 of the doctoral thesis (pages 188-191) and is much more sensible.

In the first factor, three factors had a high factor weighting, all of them containing some kind of reasoning, e.g. why the respondent does not see the possibility of training in emergency management. In the second factor, statements related to whether the respondent had already participated in training on emergency management and, remarkably, the role of personal experience was the highest. The third factor related to awareness of threats, having factor weight of the statements. The ambivalence exhibited by respondents is illustrated as at the fourth factor, the two statements that emphasised the role of higher education in dealing with emergency situations had been weight the most, distinct from the others. In the fifth factor, the ideal type of higher education that emphasises the transfer of theoretical knowledge and in the sixth factor the ideal type of higher education that offers the transfer of scientific knowledge that is universally appropriate appeared. In the next part of my work, I carried out a cluster analysis of the responses and used this to identify the main respondent groups.

The first cluster mainly consists of trainers focusing on education, including the theoretical basics. Relatively little attention is paid to emergency preparedness in their thinking. In the second cluster, the importance of practical training is strongly emphasised. The third cluster, on the other hand, consists mainly of trainers who focus on theoretical contexts.

### 3. AGENT-BASED MODELING AND RESULTS

Agent based modelling is a relatively new field of research. Its origins date back to the second half of the 1960s. Its diffusion has been greatly accelerated by the widespread of powerful computers. Today, its results are applied in a wide range of disciplines. This interdisciplinary discipline also offers a good opportunity for organisational science, because it allows fast and efficient models to be built.

Agent-based modelling is capable of describing and graphically representing a large number of agents of different types, following different behavioural rules. Once the behavioural rules of the agents and the initial state had been determined, the simulation is performed, based on fixed, predefined behavioural norms (rules).

A typical agent-based model is composed of three main elements: (1) the set of agents with their properties and behavioural patterns, (2) the relationships between the agents and the way they interact, (3) the environment of the agents. The main characteristic of agents is sovereignty. This means that they are able to make autonomous "decisions" without external guidance based on their own set of rules. Agents are clearly distinguishable from each other and from their environment. Behavioural - decision - rules describe the choices an agent makes based on the its perceived information. These behavioural rules can be very diverse, ranging

from simple decision rules to complex, rather abstract decision models (e.g. neural networks, artificial intelligence, etc.).

Each agent can be characterized by a continuously changing state having an affect on its behaviour. The state of an agent determines the state of the whole system. Agents are social, i.e. they have a dynamic relationship with other agents, which also influences their behaviour. The way they communicate with each other is usually predetermined in different models. The behaviour of agents can be adaptive, i.e. modifying behaviour based on previous experience and environment. This adaptiveness at the individual level also makes the whole system adaptive. Agents that are better adapted to their environment may proliferate in the population. Agents can be goal-driven (not necessarily optimizers), which allows the agent to compare its performance against its goals and modify its behaviour accordingly.

I used the Insight Maker software for conducting my tests. I chose this software because it allows modeling agent-based systems in a relatively simple way. In this respective part of my work, I used agent-based modeling to simulate a possible bio-terror attack. In my model, I compared three scenarios. They were chosen carefully to show that it is relatively straightforward to quantify the risks of bioterror attacks and calculate the expected spread. This has been used to demonstrate that agent-based modeling is a useful tool for predicting the impact of bioterror attacks and provides decision-makers with the opportunity to manage the work of intervention staff with optimal efficiency. For example, if a terrorist attack threatens livestock, it is possible to identify geo-informatically optimal quarantine systems.



## 6. NEW SCIENTIFIC RESULTS

After examining the hypotheses I have formulated two major new scientific discoveries of outstanding importance:

### 1. SCIENTIFIC KEY RESULT 1:

Using the event management database, I have produced a series of algorithms that can be mechanically executed and adapted to a computer. This allows to determine the optimal way to deal with any food supply chain breakdown event, as defined by the official definition of the food supply chain. This means that the algorithm set identifies the least-costly and the most agile prevention, mitigation intervention or interventions of rehabilitation in any given case of food chain collapse. The specification of the decision preparation model that I have adapted for the logistic risk analysis of food chain collapse is that each first-order explicate can be activated by exactly two twin primes and can be passivated by any prime explicant. This fact leads to the fact that - in this model - each case of food supply chain collapse produces a decision situation in which the optimal system management strategy, i.e. rehabilitation, can always be determined by exact mathematical methods. I have shown that the rehabilitation of the thirteen food chain collapses caused by active prime events identified by expert interviews can be optimally solved by only two passivations.

### 2. SCIENTIFIC KEY RESULT 2:

I conducted a simulation study using a novel agent-based modeling approach to a possible bioterror attack. This allowed a comparison of three scenarios. The scenarios demonstrated that there is a relatively simple way to quantify the risks of a bioterror attack and calculate the expected spread. Based on these results, I consider that agent-based modelling is an insightful tool for predicting the impact of bioterror attacks and provides a way for decision makers to manage the work of intervention staff with optimal efficiency. For example, when a terrorist attack threatens livestock, it is possible to apply geo-informatically optimal quarantine systems.

### 3. OTHER NEW SCIENTIFIC RESULTS (4):

1. *I have shown that those involved in higher education in the field lack the necessary information and preparation to deal with the food supply chain, in particular its safety issues, in a way comparable to the seriousness of the problem and that can be expected.*
2. *I have demonstrated the need to increase the theoretical and practical knowledge of operational capacity in order to prepare for the development and operation of a sustainable food chain.*
3. *I have developed a simplified logical risk management method for assessing the vulnerability of the food supply chain and demonstrated that it can be used to fully assess the possibility of a food supply chain collapse event.*
4. *I have developed an agent-based model to quantify the risks of bioterror that reaches the food supply chain and its expected spread, and demonstrated that it can be used to inform predictive decisions.*

Based on the research, the following table summarises the results of hypotheses tests:

	<b>Hypothesis</b>	<b>Status</b>
H1	The lack of sufficient information and preparedness is the reason why higher education participants of the field does not take particular interest in the problem area of food security.	confirmed
H2	A significantly greater emphasis must be placed on sustainable food supply chains addressing the areas of prevention, preparation, defense and rehabilitation in the educational system of the field.	confirmed
H3	Food security lacks a specific methodology regarding necessary protocols of restriction and policy-making in special legal order.	confirmed
H4	Building on adequate professional statement the methodology of operational logic risk assessment is applicable for modeling correlated, harmful events affecting the food supply chain.	confirmed

## 7. SUGGESTIONS AND FURTHER GUIDANCE

In my Phd dissertation I attempted to describe the food supply chain within all its complexities focusing on its structure and vulnerability.

My research clearly demonstrates that the food chain is one of the most complex critical infrastructures because of the complexity of its operation and the nature of the socio-economic needs it serves. This complexity results in a high degree of vulnerability. The developed and powerful European countries have long believed that the economic and military alliance system linking these countries provides the necessary guarantees to ensure not only supply but also the possibility of civil well-being for their citizens over a long period of time, even in chaotic and opaque situations. This kind of 'splendid isolation' from real world concerns has been reflected in the way in which European countries' relations with the Third World have been predominantly focused on short-term interests and the very deep problems of the Third World have been simplified into a kind of refugee issue. Both the 'brilliant' military successes of recent decades (e.g. Desert Storm, Iraqi Freedom) and the embarrassing failures of nation-building economic development (Afghanistan, Libya, Iraq, Islamic State) demonstrate that in the coming decades, European countries, both the European Union and NATO, will have to contribute with much greater attention and empathy to the creation of global security, including food security. Also, resources currently allocated for this purpose will have to be increased by up to two or three orders of magnitude, and that the development of institutions to ensure that they are used wisely will also be required to contribute to the maintenance of global security, including food security. Otherwise, the combined effects of population explosion, climate change and global economic realignment will create unforeseeable security risks.

Addressing the problems that have emerged over the last two years in the context of the pandemic has proved many things right. One of the most important lessons is that the European Union in its current form has limited capacity to manage crises effectively. In every country, the pursuit of short-term national interests has overridden the lofty European objectives. Consequently, a radical overhaul of the European Union's decision-making and governing system is the only way to equip it with the necessary mechanisms for responding flexibly to changing circumstances and ensuring its effectiveness.

Possibly, the most important insight of my work is that scientific methods and approaches can provide an effective toolset for protecting supply chains, because the models developed in advance of the epidemic with the help of my supervisor and colleagues proved to

be very applicable in the practice of decision-making during the crisis. Consequently, I consider it of the utmost importance to further develop this type of research, in particular in terms of quantitative approaches, including system dynamics modeling.

Overall, the need for rethinking the whole system of disaster management knowledge transfer at all levels of training is strongly underpinned by the research. In particular, it is inevitable to reshape educational practices used for training future professionals of the industry, creating a system which is innovative, thought-provoking and exploits the benefits of experiential learning to the greatest degree.

## 8. PRACTICAL APPLICATIONS

In conclusion, the food supply chain proved to be an integral part of critical infrastructure. My research has clearly confirmed my hypothesis that the functioning of the food supply chain is not only a fundamental building block of satisfying the physical necessities at the bottom of Maslow's hierarchy of needs, but also plays a crucial role in the smooth functioning of the national economy as a whole, in social reproduction and important macroeconomic processes. However, an important feature of the food economy is a high degree of vulnerability. Consequently, arising from its open nature there are many areas where, for both natural and social reasons, serious failures and shortcomings in the functioning of the food supply chain can occur.

During the exploration of the literature, I have analysed in fine detail the Hungarian administrative and scientific background, knowledge hubs and legislative environment that enables the food supply chain as a whole to ensure safety and respond to emergency situations. By a critical examination of the concept referred to as "good state", I demonstrated that not only the law-making process but even the strategic thinking related to law-making has not reached a point where it is possible to provide adequate responses to the challenges of the 21st century and global problems.

I have also examined the relationship between deliberate attacks on the food supply chain, the threat of terrorism, based on reliable and reputable sources found in the academic literature. I have found that the security of the food supply chain has become a centre of attention in the most developed countries, but appropriate solutions are still to be identified due to the highly complex scientific, technological, legal, organisational and logistical aspects of the issue. The situation is particularly complex in Hungary, where we need to prepare for challenges that we have not faced in recent years. Looking at the issue in the light of the events of the last few months, the security of the food supply chain is particularly at stake in cases where extremist groups armed with incredibly primitive tools (such as simple knives) are able to cause significant panic. Given these circumstances, considering the continually changing security environment in our country and the challenges posed by the National Security Strategy, modern, complex thinking in defence policy is of particular importance. In my view, terrorism is also undergoing significant change, with the consequence that there is a probable chance that the possibility of attacking the food supply chain, for example, will become the preferred strategy of many extremist groups. One way of doing this could be to have members of the

group suffering from serious infectious diseases smuggled into the target country. Consequently, complex bioterrorism response strategies are ought to be developed and embedded in the overall national strategy for effectively tackling such biological emergencies.

## 9. PUBLICATIONS

### Book parts:

1. Bukovics, I., Kun, I., & Szendrő, É. (2021b). A járványkezelés számítógépes modellje. In Ünnepi tanulmányok a 80 éves Tamás András tiszteletére. (A computer model for epidemic management. In Festive studies in honour of András Tamás Tamás, 80 years old) *Semper ad perfectum* (p. 137).
2. Bukovics, I., Kun, I., & Szendrő, É. (2021a). A járvány logikai elmélete. In Ünnepi tanulmányok a 80 éves Máthé Gábor tiszteletére (p. 201) (Logical theory of the epidemic. In Festive studies in honour of the 80-year-old Gábor Máthé (p. 201).
3. Bukovics, I., & Szendrő, É. (2018). A fogyasztóvédelem kialakulása és fejlődéstörténete. In Ünnepi kötet a 65 éves Kiss György tiszteletére (pp. 187–203) (The development and evolution of consumer protection. In Festive volume in honour of György Kiss, 65 years old (pp. 187-203).
4. Bukovics, I., & Szendrő, É. (2015). A fenntartható „Jó állam” problematikája. In *Bolyongtam téveteg, soká Caesareában* (pp. 91–115) (The problem of a sustainable "Good State". In *I have wandered astray, long ago in Caesarea* (pp. 91-115).
5. Szendrő, É. (2015). Az élelmiszerlánc sebezhetősége, a bio-terrorizmus élelmiszerláncot fenyegető veszélyei. In *Nemzeti Közszerológiai Egyetem Közigazgatás-tudományi Doktori Iskola 2014/15-ös Kutatói Fórum tanulmánykötet* (pp. 277–294) (Vulnerability of the food chain, threats of bioterrorism to the food chain. In *National University of Public Service Doctoral School of Public Administration 2014/15 Research Forum Study Booklet* (pp. 277-294).
6. Szendrő, É. (2015). A bio-terrorizmus élelmiszerláncot fenyegető veszélyei. In *Doktoranduszok Országos Szövetsége által kiadott lektorált tanulmánykötet* (pp. 625-640) (The threats of bioterrorism to the food chain. In *Proofread volume of papers published by the National Association of Doctoral Students* (pp. 625-640)

### Thomson-Reuters Impact Factor accredited Journals

1. Kiss, A., Szendrő, É., & Lakner, Z. (2020). A génmódosított takarmánynövények szabályozásának fejlődése és dilemmái az Európai Unióban: Irodalmi összefoglaló. *MAGYAR ÁLLATORVOSOK LAPJA*, 142 (8), 489–499. (Development and dilemmas of the regulation on genetically modified forage crops in the European Union Literature review)
2. Lakner, Z., Szendrő, É., Kasza, G., Hajtós, I., & Ózsvári, L. (2016). Az etikától a taktikáig: a bio-terrorizmusról állatorvosi nézőpontból (From ethics to tactics: about bioterrorism from a veterinarian's point of view). *MAGYAR ÁLLATORVOSOK LAPJA*, 138 (1), 47–60.

### Foreign scientific journals:

1. Z. Lakner<sup>1</sup>, Éva Szendrő<sup>1</sup>, Gy.Kasza<sup>1</sup>, I. Hajtós<sup>2</sup> und L. Ózsvári (2017) Von der Ethik bis zur Taktik: Ansichten des Tierarztes bezüglich Bioterrorismus From Ethics to Tactics: Opinions of a Veterinarian concerning Bioterrorism *Amtstierärztlicher Dienst und Lebensmittelsicherheit*, 2017, 24.(1)., p.112-121.

### Peer-reviewed domestic journals:

1. Szendrő, É. M. (2020a). A fogyasztóvédelem kialakulása és fejlődéstörténete „Legyen hiteles a mérleged, súlyod, hiteles a mértéked és a vékád” (Leviták könyve 19. fejezet, Erkölcsi és istentiszteleti előírások) (The development and evolution of consumer protection "Let your scales be true, your weights, your measures and your measures of weight be true" (Leviticus 19, Moral and Worship Standards). *Jogtörténeti Szemle*, 18(2), 34–40.

### Published journalé articles:

1. Szendrő, É., Lakner, Z., (2022). The long-range macroeconomic effects of Sars-Covid-19 pandemic in Hungary: a conceptual framework and methodology - focusing approach. *Acta Polytechnica Hungarica* (angol nyelvű tudományos folyóirat)
2. Szendrő, É., (2022). Az élelmiszerlánc, mint kritikus infrastruktúra védelmére történő felkészítés kérdései a felsőoktatásban (Preparing for the protection of the food chain as critical infrastructure in higher education). *Gazdálkodás c. agrárökonómiai tudományos folyóirat*



## 10. PROFESSIONAL-ACADEMIC BIOGRAPHY

Éva Mónika Szendrő graduated as a certified preserving engineer in 1990 from the Faculty of Food Sciences at the Budapest University of Horticulture and Food Sciences. Her first job was at the State Farm in Kiskőrös, where she was responsible for market research, market analysis and foreign trade management of farm.

Between 1991-1992, she completed a joint Master's degree programme in Human Resources at the University of Agricultural Sciences in Gödöllő and the École Supérieure de Gestion Centre de Formation Continue in Paris, and then in 1992 she joined the Food Industry Directorate of the State Property Agency, later State Privatisation and Property Management Corporation. She was involved in the development of sectoral strategies in cooperation with the Ministry of Agriculture, furthermore, participated in the screening and transformation of state companies into private, capitalist firms, meanwhile organising negotiations between ministries and other relevant stakeholders. She also completed a course in Corporate Management at the European Business School in 1994 and obtained a degree in International Commercial Law from the Centre de Droit du Commerce International de l'Université in Tours in 1998.

Between 1995-1997, he graduated from the Eötvös Loránd University Law School with a degree in Engineering and Law.

Since 2012, she has been working as an assistant professor at the Department of Agricultural and Food Business Economics at the Institute of Agricultural and Food Economics of the former Szent István University, now known as the Hungarian University of Agricultural and Life Sciences. Her duties include professional activities related to the teaching and research tasks of the Department. She is also involved in the teaching of Economics for Engineering studies, Food Industry Management, Business Economics, Project Management, Food Process Management. The PhD candidate's professional activity, spanning more than 20 years, is closely linked to the food industry and food economics. Her commitment to the utilisation and transfer of her professional and legal experiences, drawn from both public and private sides of the agricultural industry, has complemented his teaching activities. She is highly motivated of undertaking an active role in preparing the food professionals of the future, nurturing talent, showcasing career prospects and involving students in academia. She actively engages in the organisation of professional forums, updating the curricula, and partakes in other professional and public activities of the university. She regularly participates in the professional presentations organised by the technology departments and their evaluation, in final

examinations, and is the thesis and dissertation supervisor for a number of theses. She is a core member in the organisation and running of the respective TDK (OTDK).

In recent years, she has also been continuously involved in various tasks in the field of talent management in public education, where she held positions of team leader and as a founder during the development of the selection mechanism and evaluation system of the annual award "Bonis Bona - From Good to Good", given to secondary school teachers and intellectual workshop leaders by the Ministry of Human Resources (EMMI).

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