EXAMINING THE CORRELATIONS BETWEEN INDUSTRY 4.0 ASSETS, EXTERNAL AND INTERNAL RISK FACTORS AND BUSINESS PERFORMANCE AMONG HUNGARIAN FOOD COMPANIES

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Abstract

The current maturity of enterprises has a significant development potential for the introduction of new technologies, and requires significant physical, mental and material resources. In this research, we examined the impact of the risk factors of Hungarian food production companies, Industry 4.0 tools, and the supporting and hindering factors affecting the companies, and how they affect changes in business performance. The questionnaire survey took place between 2019 and 2020, during which time we collected data from 276 food companies. The data were then analysed using a number of statistical methods: Cronbach's alpha index, factor analysis, PLS pathway analysis, indicator reliability index, composition reliability index, mean explained variance index, Fornell-Larcker criterion, heterotrait-monotrait ratio, magnitude of effect, fit goodness, predictive relevance, and road model coefficients. In this study we formulated three hypotheses related to Industry 4.0 tools, external and internal risk factors, and business performance, which we were able to accept during the study. By analysing the risk factors, we try to identify the types of external and internal risks that are most characteristic of companies, so that they can react to them as efficiently and quickly as possible, thus making the company effective and efficient at the same time.

Keywords: risk factors, Industry 4.0 assets, business performance

JEL Classification: F23, G32, L26, M16

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Introduction

Newer technologies also carry risk factors that influence the decisions of company executives. It does not matter whether companies have an influence on the factors that cause the risks, or whether the risks affect the companies. In this sense, we can distinguish between internal and external hazards. We speak of external risk when the company has little, if any, influence over the factors that trigger the risk, which is why it is important for the company to develop a strategic plan to manage such risks. Examples of such are a unfavorable changes in demand, changes in the regulatory environment of the industry, and unexpected moves by competitors. Interior (internal) risk is when the company can influence various risk factors within its competence, such as obsolescence of equipment and technologies, lack of maintenance, lack of interior (internal) procedures and regulations, and the use of unskilled labor. In the research we pay attention to the analysis of both external and interior (internal) risks, and we also examine the risk factors that food service providers may face as a result of technological changes.

The goal is to assess the strategies, developments and new technologies of the Hungarian food production companies, which may have an impact on the business performance of the companies and on changes in risk factors.

In section 1 we present in detail the characteristics of Industry 4.0 technology tools, external and internal risk factors, and the factors most influencing business performance examined in the research. In section 2 we present in detail the territorial location of the Hungarian food production companies studied, as well as a detailed description of the methods used in the analysis.

In section 3 the results, namely the direct and indirect effects included in the model were investigated and the regression equations written by using the PLS-SEM method. With the help of the path model set up based on the bootstrapping result, we determined the direction and strength of the relationship between the variables. The hypotheses formulated in the introduction were confirmed in the results section.

In section 4 we compare the results with the results of other researchers and literature sources, and finally in the last section we discuss the conclusions.

1. Literature review

1.1. Risk grouping in the food industry

According to Nolden and Feeney (2020) risk means that we do not know the future. In terms of the expected effects, the risk can be divided into two major groups: we speak of simple or pure risk in the case of risks threatening damage or loss. There are only two possible outputs here: either loss, damage, or the status quo. We talk about speculative risk when there are three possible outcomes: a loss occurs, the current state remains unchanged, and the result is a profit.

The economic consequences of damages can be twofold: either they cause additional cost or they reduce revenue. The costs of risk management consist of the costs of risk management activities and measures. The most important rule of risk management is that risk management expenditures must always be in proportion to potential losses (Moschini and Henessy, 2001).

In the food industry, risk management methods can be divided into 3 main groups (production, finance and market) according to which area of farming they are related to. Methods also include asset protection and insurance underwriting, which are generally accepted risk management methods (Tomchuk et al., 2018).

Moktadir et al. (2021) divides the risks into two parts. Systematic risk is the part of the risk that affects all companies and the company-specific risk that can only be eliminated by individual companies and diversification. The main components of risk, more specifically financial risk, are transactional and operational risk. The other two parts of transaction risk are price risk and credit risk. Operational risk arises from the activities of the company.

In addition, we can even talk about liquidity risk, which is related to the liquidity of the company. According to another division, we can mention value risk, currency risk and interest rate risk (Vlahos, 2001), which are actually part of the divisions according to Nagy et al. (2018). Again, in addition to the risks mentioned above, other sources also refer to country risk (Just, 2003), including political and economic policy risk (Oláh et al., 2017).

Even a separate investment risk can also be listed, as all the risk factors of companies also appear as a component of an investment risk. The number of factors influencing risk can be very large per area, including those that cannot be directly quantified. How many of these and which ones we select to prepare a decision is to some degree arbitrary and may also depend on the development of our knowledge and individual agreements (Pocol et al., 2021).

In particular, the main sources of risk for food businesses are (Colacito et al., 2018): Production risk, Market risk, Financial risk, Obsolescence risk, Accidental loss risk, Legal risk and Human risk factors.

Nagy et al. (2018) identifies another possible grouping, namely strategic and operational risks. Operational risk in the traditional sense is business and financial risk. Business risk is usually identified with the inherent uncertainty of financial performance. The main sources of risk in all product cycles are the following: price, costs, productivity, production uncertainty.

Risk sources can be very diverse, although all risk sources cannot be incorporate into our decisions, we must strive to take into account risk factors whose probability of occurrence is not negligible in our risk calculations (Oláh et al., 2019).

1.2. The relationship between corporate performance and innovation

Published foreign studies present the positive effects of risk management on information quality, risk-influenced decision-making, increasing corporate value, ensuring competitiveness, and achieving and preventing continuous improvements to ensure the smooth operation of the business (Kovács, 2017).

The market is constantly changing. Adaptation is essential for service providers and industrial companies to maintain or improve their current market positions. The market position of a company largely depends on its efficiency, competitiveness, customer focus, and flexibility and its role in the supply network (Takács and Toyserkani, 2014).

Maintaining a lasting competitive advantage is closely linked to the internal operation of the company. The basis of a company's success depends on its essential abilities, i.e. the abilities of the company based on the experience gained over the years, which its competitors cannot adapt to, or can only do so by working for many years (Vasa et al., 2020).

As defined by Slusarczyk et al. (2020), performance measurement is the process of measuring the efficiency and economy of an activity. The definition illustrates the two main dimensions of performance: Efficiency or effectiveness, which refers to meeting business objectives (or, according to others, meeting consumer needs); and economy, which means the economics of using the resources associated with achieving the goals.

Research into the relationship between corporate performance and innovation has examined the impact of R&D spending, and researchers have in most cases found a positive correlation between the two variables. Hasnan and Yusoff (2018) analysed data from American companies and found that increasing R&D expenditures could increase firm productivity.

An international survey based on the "Oslo Manual" allows the analysis of the relationship between company performance and innovation. In Hungary, Halpern and Muraközy (2010) investigated innovation activities and their impact, using the CIS (Community Innovation Survey) database.

Judgments about the productivity of new technologies are influenced by firm-level calculations that show that Industry 4.0 investment has significantly increased investor productivity (Bughin, 2016). It is worth considering the finding that performing the study at different times may skew the conclusions drawn from the results. In 2010, the majority of investors were companies with high capital and productivity, meaning that these observations are not generalizable and are not suitable for macro-level forecasts, either. In addition, the researchers performed calculations at the level of the national economy, including a study of 17 countries by Graetz and Michaels (2015), which clearly showed the impact of the use of industrial robots on economic and productivity growth. Using IT investments, companies are introducing new tools to increase production and thereby achieve revenue and profit as well as higher quality and performance (Popp et al., 2018).

1.3. Risks of digitization of food companies

According to expert data, 80% of the problems of food companies could be solved with the help of Industry 4.0 technologies, but most of the players in the industry are not even aware of the new tools and the developers are not aware of the problems in the sector (Bai et al., 2020).

An important challenge is to learn about new technologies as quickly as possible and to renew training. Society reacts significantly more slowly and adapts to the changes brought about by digitalisation (Corallo et al., 2018).

In the case of food companies, do not ignore safety issues either. The importance of data security is growing as companies produce huge amounts of data due to digital operation, which, if properly analyzed, can lead to better decisions. However, some of this information is sensitive data, so it is important to protect it (Javaid et al., 2020).

Digitization and artificial intelligence offer great opportunities and risks as well. Of course, the competition that can be characterized by the digital transformation can not only be a winner but also a loser at all levels: individuals, professions, companies, sectors, countries and societies. Managing challenges and risks is a shared responsibility of all stakeholders (Goti et al., 2022).

As a result of digitalisation, the following sources of risk for food companies can be distinguished (Santos et al., 2020):

- Data Management and Encryption: From a security perspective, it is key for companies to be aware of how sensitive their data is and how to properly encrypt and protect it.
- Zero trust: The essence of this method is that users only have access to sensitive data if they have verified their identity, which is a prerequisite for companies to use identity and access management systems that can handle both biometric identifiers and tokens.
- Vision of the entire environment: With the introduction of an intelligent, centralized corporate governance system, it is necessary to monitor events and filter out suspicious activities.
- Analytics and automation: Automation can be used to eliminate human error, but care must be taken to ensure that individual processes can be modified to perform malicious activities.

2. Material and methodology

2.1. Presentation of the research work and delimitation of the research area

The collection of secondary information was based on international literature sources. Industry 4.0 technologies, risk factors, and business performance literature and research address only specific areas of the topic. In the course of the literature search, we compared the statements formulated in international sources.

During the research we examined the following hypotheses:

H1: External and internal risk factors affecting the food company directly affect the use of Industry 4.0 technology tools.

H2: Industry 4.0 devices clearly have a positive, direct impact on business performance. The more Industry 4.0 tools a company uses, the more its business performance will increase.

H3: The extent of Industry 4.0 developments is negatively and significantly affected by the high cost of technologies, a lack of its own resources and a lack of skilled labour.

During the primary data collection, we conducted interviews at Hungarian food industry companies. The questionnaire survey was typically conducted between 2019 and 2020 at online professional events, as well as by personal and telephone inquiries.

Some of the topics and structure of the questionnaire, as well as the relationships between the topics are illustrated in figure no. 1, which is also the initial model of PLS road analysis.

The structure and composition of the questions were structured based on the literature read and collected during the research and prior consultation with five company executives in the food industry; thus, it was possible to draw attention to the less studied factors. As a result, we assessed the factors hindering and supporting the development of companies, the strategic goals of companies, the willingness of Industry 4.0 to use assets, external and internal risk factors, and the expected business performance and efficiency of companies in their development.

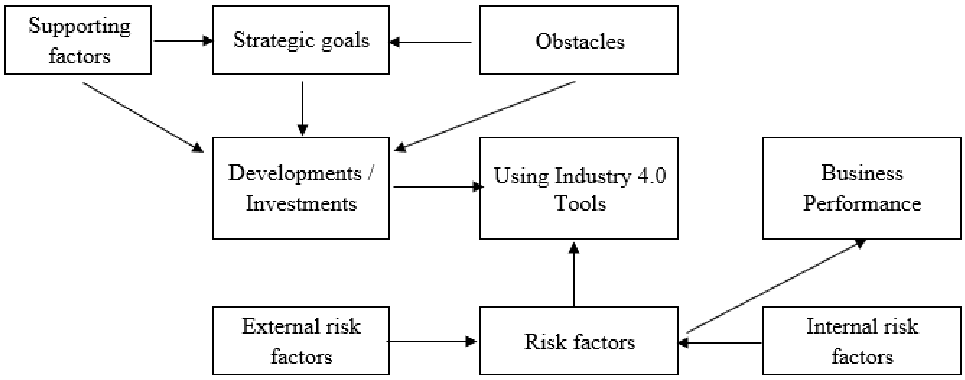

Figure no. 1. Theoretical framework of the questionnaire and initial model of the PLS path analysis

In Hungary, there are only a total of 1,157 companies categorised as food companies, of which 276 filled in the questionnaire after the survey; this number was reduced to 259 during the data cleaning. For the seven main topics of the questionnaire (barriers, supporting factors, strategic goals, developments, use of Industry 4.0 tools, risk factors, and business performance), we assigned statements, the consistency of which was established by a reliability test. Of the 97 statements made, two had to be removed from the model because the Cronbach's alpha value was too low to reduce the alpha value of the entire area.

The Cronbach's alpha values of the examined factors in the research are above 0.7 in all cases, therefore their reliability based on internal consistency is adequate for further research.

2.2. Methods used in the research

Statistical methods were used to process the collected data, as shown in figure no. 2. Reliability tests were performed to determine the internal consistency of the questionnaire. Cronbach's alpha is a measure of internal consistency. This metric divides the scale items into two possible ways and calculates a correlation between the two parts each time. The Chronbach's alpha index is the average of all correlation values thus obtained. This is the most commonly used indicator of internal consistency, which should reach a minimum of 0.6 (Cronbach, 1990).

When using PLS regression, the latent variable scores and the coefficients (parameters) associated with the latent variables are calculated in an iterative process. In the first step, latent variables can be created as a linear combination of (standardized) manifest variables.

During the first iteration, weights can be determined in a pseudo-random way for the manifest variables, which represent unit values, respectively. In the second step, the road coefficients are estimated for the internal model. in the third step, the latent variables can be estimated with internal weight coefficients (calculated in the second step), and in the fourth, the path coefficients are estimated for the external (measurement) model, thereby modifying the initial weights and restarting the whole process. PLS path analysis can also be applied to relatively small number of samples (Nagy et al., 2018; Aranyossy and Kulcsár, 2020).

Standardized factor weights (> 0.5), average variance extracted (AVE)> 0.5, and composition reliability (CR)> 0.7 can be used to check convergence validity (Hair et al., 2020).

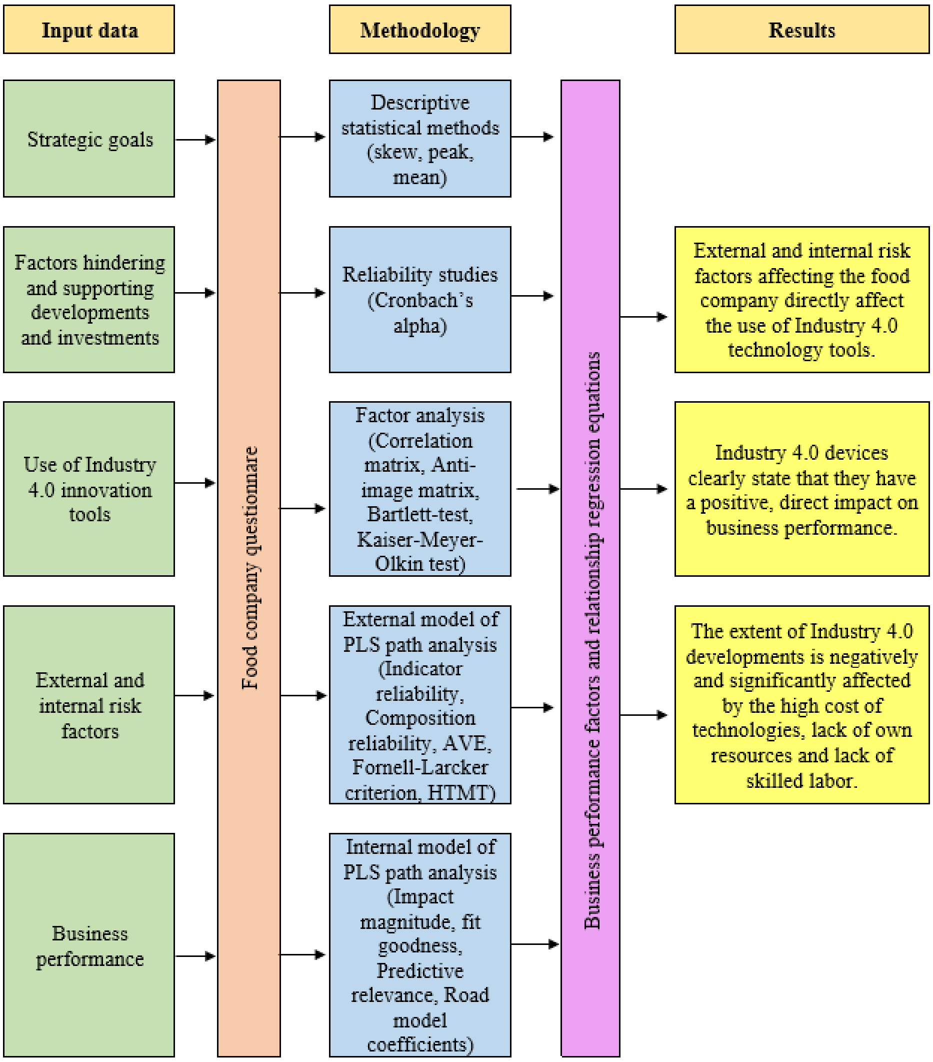

Figure no. 2. Summary diagram of the applied methods

The discriminative validity of the study constructs was tested by the method of Fornell and Larcker (1981), according to which the external, reflective model is valid in a discriminatory sense if the AVE square root of each construct exceeds the correlation between the elements and all other elements. The HTMT correlation ratio (heterotrait-monotrait) shows the quotient of the average of the pairwise correlation coefficients between the manifest variables associated with two latent variables and the average of the pairwise correlation coefficients between the manifest variables associated with the same latent variable. Henseler et al. (2015), it is sufficient to assume discriminant validity if the values of the HTMT indices are below 0.9.

The Goodness of Fit (GoF) index can be calculated as the mean of the mean explained variance and the mean R2. Previous research by Fornell and Lacker (1981) showed that the

Goodness of Fit index should be around 0.10 for a small sample, 0.25 for a medium sample, and 0.36 for a large sample. When testing predictive relevance (Q2), the Q2 value should always be greater than zero Chin (1988).

In the PLS-SEM, the path model coefficients can be used to determine the extent to which the target variable is affected by each variable. The estimated values of the latent variable can even have different signs for each sample. If the value of p for the path model coefficients for bootstrap sampling is less than 0.05, then the regression line is acceptable, i.e., the explanatory variables actually affect the target variable. The recommended number of bootstrap samples to be generated is 5000 (Hair et al., 2020).

The goal of Importance Performance Matrix Analysis (IPMA) is to identify historical variables that are relatively important for target constructs, but also relatively low-performing.

3. Results

3.1. Demographic and sectoral characteristics of food companies

Using the EMIS database, it can be said that most food companies are based in Budapest and Pest County. In the second place is Bács-Kiskun county, followed by Szabolcs-Szatmár-Bereg county, then Hajdú-Bihar county. Based on the data, it can be stated that in 2020 there were companies engaged in food production in every county in Hungary. More than 30% of food companies are engaged in the production of bakery products and pasta, and nearly 25% are engaged in meat processing, preservation and production. A total of two companies are engaged in fish processing and preservation in Hungary, and 11 companies are active in the production of vegetable and animal oils.

More than 70% of the respondents came from Central Hungary and the Northern Great Plain region. The fewest responses came from Central Western and Southern Transdanubia (Figure no. 3).

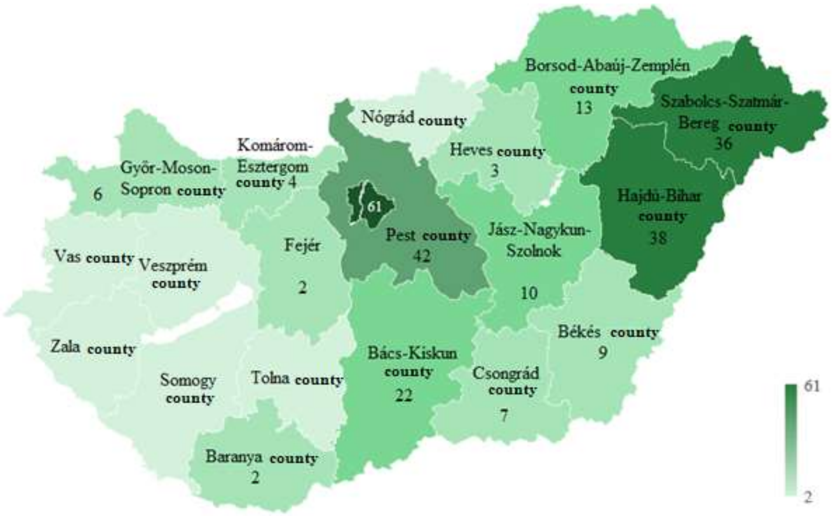

Figure no. 3. Distribution of the number of respondents by county

Most responses came from meat processing and canning companies (97), followed by bakery and pasta companies (60) and then from fruit and vegetable processing and preservation companies (46). The fewest responses came from companies involved in fish processing and preservation, as well as in the production of vegetable and animal oil, which is due to the fact that very few companies in Hungary carry out their main activities in this field.

3.2. Analysis of factors of food production companies, and results

In accordance with the interest of validating the indicators included in the questionnaire, we performed a factor analysis on the data. The validity of the principal components was analyzed with the latest available version of IBM SPSS Statistics 23. Indicators with low values in the model included in the questions were removed after performing the factor analysis. It is important for the study to know what distribution the variables follow. For each variable, we expected the discovery of a normal distribution, the graphical representation of which is shown in figure no. 4.

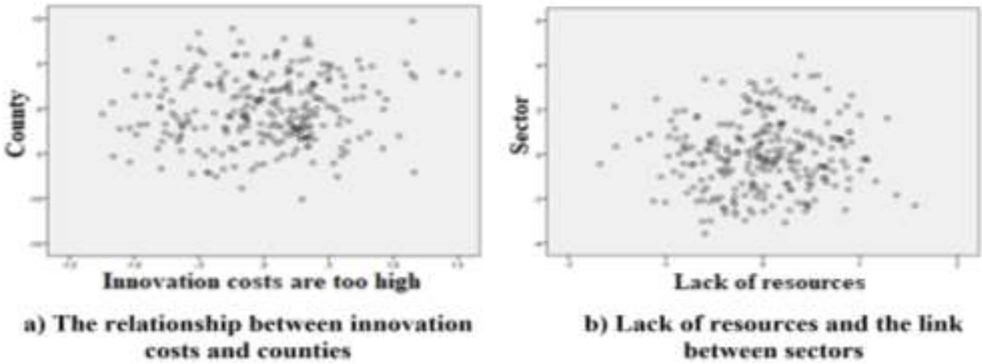

Figure no. 4. Relationships and distributions between variables

Figure no. 4.a shows the classification by county and the relationship between counties and innovation costs. Based on this, it can be said that the cost of innovation to respondents varies widely by county. Figure no. 4.b shows that each sector has a completely different view of the financial risks of Industry 4.0 technologies. In the case of financial risk, we highlight the risk of a lack of funds, to which there have been several extreme responses, i.e. the company is either not at all, or alternatively, very afraid of a lack of funds. The lack of funds is related to the existence of the current cash position and the annual net sales of the company.

3.3. Evaluation of external and internal models of PLS-SEM results

Using the PLS algorithm, we calculated the Composite Reliability Index (CR), which also takes into account the factor weight values assigned to the variables, so its value already needs to exceed 0.7. In the model, these expected values are met, i.e., for all factors, the composite reliability index is higher than the Cronbach's alpha index.

Based on the results of the Fornell-Larcker criterion, it can be said that financial risk was given the highest value among the risk factors (0.672), which means that the main obstacle can be identified most closely. factor. Furthermore, the results also show that the AVE square roots of the model are higher in all cases than the correlation of all reflective constructs, thus meeting the criterion of discriminant validity. The result shows that the value of all HTMT indices is below 0.9, which means that the validity of the discrimination is fulfilled.

Exogenous variables range from 1.163 to 2.792, which means that there is no multicollinearity between the factors.

To evaluate the magnitude of the effect, we used the 5000 subsample bootstrap sampling, thanks to which we determined the small, medium, and large effects of the variables on the target variable. Based on this, it can be said that there is a strong relationship between supporting factors and strategic goals, between risk factors and Industry 4.0 assets, and between Industry 4.0 assets and business performance. The results of the direct effect of bootstrapping are summarized in table no. 1.

Table no. 1. Internal model bootstrapping results: direct effect

	Routes	Direct and indirect effect	Sample mean	t statistic value	p-value
Direct effect	Obstacles → Developments / investments	-0.145	-0.144	2.009	0.045
	Obstacles → Strategic goals	0.033	0.038	0.556	0.579
	Developments / investments → Industry 4.0 assets	0.112	0.109	2.036	0.042
	Industry 4.0 Tools → Business Performance	0.187	0.190	2.054	0.040
	Industry 4.0 Risk Factors → Industry 4.0 assets	0.184	0.185	2.960	0.003
	Strategic goals → Developments / investments	0.156	0.158	1.898	0.058
	Supporting factors → Developments / investments	0.032	0.038	0.379	0.705
	Supporting factors → Strategic goals	0.545	0.560	10.501	0.000
Indirect effect	Supporting factors → Strategic goals → Developments / investments	0.094	0.097	2.486	0.013
	Risk → Industry 4.0 Tools → Business Performance	0.034	0.037	1.597	0.111

Based on the analyses, it can be established what affects the Industry 4.0 devices in the model, and what affects business performance, and how it does so:

Strategic goals = 0.545 x Supporting factors

The results of mediation analysis show that there is a significant, indirect relationship between the constructs examined. The supporting factors affect the strategic goals, and the strategic goals have a positive effect on the developments and investments made. The supporting factors do not directly (p = 0.705), but only indirectly, affect development and investments through the strategic goals.

Development and investments = -0.145 x Obstacles + 0.156 x Strategic goals

The opposite sign of the obstacles suggests that they have an effect on developments and investments, but the effect is negative (-0.145). The more barriers there are, the less companies will invest in new technology tools. Obstacles directly affect developments, but do not affect the development of strategic goals (p = 0.579). Developments and investments are also influenced by the company's strategic goals.

Industry 4.0 Assets = 0.112 x Development Developments + 0.184 x Risk Factors

H1: External and internal risk factors affecting the food company directly affect the use of Industry 4.0 technology tools.

As the direct impact coefficient is 0.112, it can be stated that developments and investments have a direct impact on the use of Industry 4.0 tools, which means that if a food company thinks about developing its individual areas, there is a significant chance that one of the Industry 4.0 tools will receive investment. Risk factors affect new technological assets.

Business Performance = 0.187 x Industry 4.0 Assets

Industry 4.0 devices clearly have a positive, direct impact on business performance. The more Industry 4.0 tools a company uses, the more its business performance will increase.

H2: Industry 4.0 devices clearly have a positive, direct impact on business performance. The more Industry 4.0 tools a company uses, the more its business performance will increase.

Examining the nine main risk factors, we concluded that these factors directly affect the use of Industry 4.0 tools. Interestingly, risk factors only affect business performance through Industry 4.0 tools, not directly.

In the final model, directly or indirectly, five factors explain the factor related to the use of Industry 4.0 assets, and six factors explain the corporate business performance factor: supporting factors, impediments, strategic goals, developments/investments, Industry 4.0 assets, and risk factors.

3.4. Interpretation of the model results

The factors in the model and the direct and indirect effects between the factors are shown in figure no. 5.

It can be stated that the supporting factors significantly influence the strategic goals and indirectly influence the development of the company and investments. Obstacles affecting the company have a negative effect on developments, meaning that the more obstacles a company faces, the less development it undertakes. Among the obstacles are the lack of own resources and the high costs for companies following investing in innovation tools. However, if a company has sufficient own resources to invest in innovation tools, they may be less bothered by the high costs involved. Among other obstacles, the lack of a skilled workforce should be mentioned, as this factor also has a significant impact on investment.

H3: The extent of Industry 4.0 developments is negatively and significantly affected by the high cost of technologies, a lack of its own resources and a lack of skilled labour.

This result is consistent with the finding of Bughin's (2016) research that new technologies and Industry 4.0 investments clearly increase investor productivity.

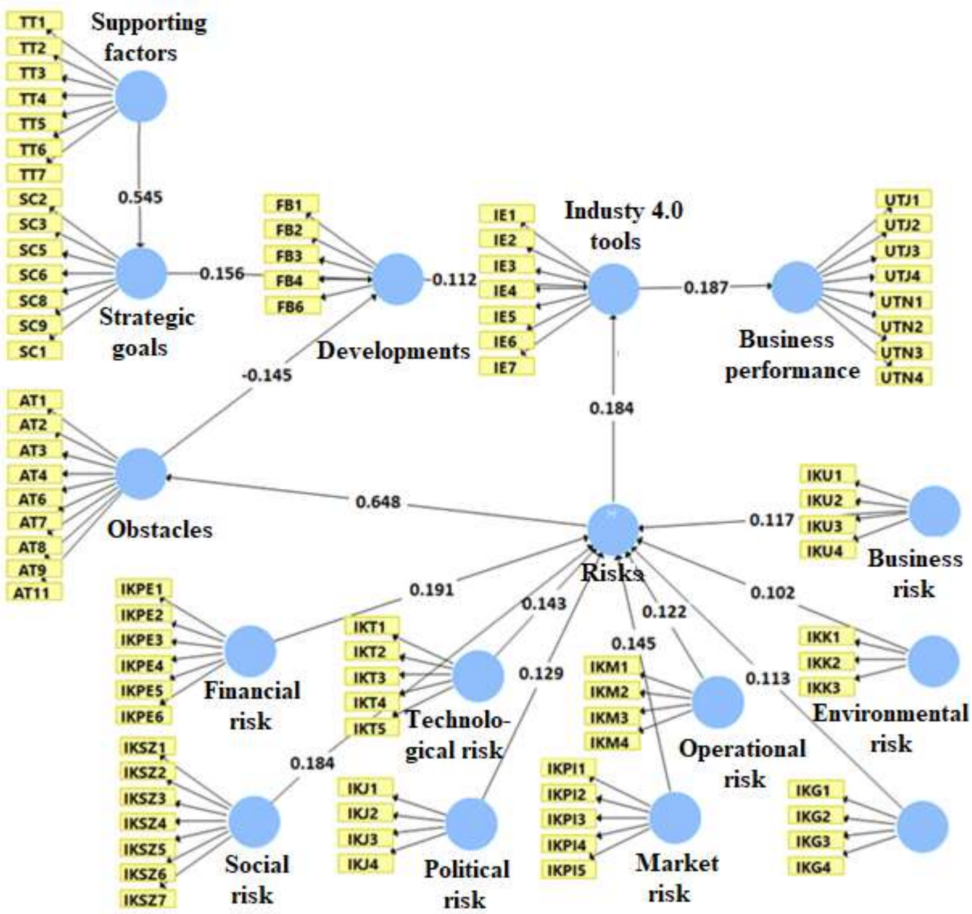

Figure no. 5. Direct and indirect effects in the model

4. Discussion

Some international studies have shown a positive effect of process and product innovations on productivity. It is believed that IT tools improve the efficiency of mechanisms as well as the quality of service, which is related to the size of service providers (Freagán et al., 2018). This was also supported by our research, as we found that the companies that use the new technological devices the most have been engaged in food production for more than 5 years. Another segment of the study addresses the disadvantages of improvements; service providers believe that the introduction of new tools will increase the invisible costs incurred, and system protection and data security will become even more important in the future (Nagy et al., 2018).

We continued the literature search on the relationship between corporate business performance as well as innovation, as one of the main objectives of the study was to examine the relationship between these two factors. Several authors describe in their paper that the market position of firms is significantly influenced by the endowments and capabilities of the firm that it accumulates over many years over time based on experience (Bughin, 2016). Studies on the relationship between corporate performance and innovation have mostly shown a positive relationship between the two variables (Moraes et al., 2020).

Our results include the statement that the extent of Industry 4.0 developments is negatively impacted by high technology costs, companies' lack of resources and the lack of skilled manpower. Other researchers include unexpected high costs, insufficient demand, a lack of skilled labour or knowledge, and the introduction of tax laws and regulations that negatively affect the company (Hashi and Stojcic, 2013; Ferraris et al., 2020).

Based on the results, we can formulate a number of practical suggestions that can be used to improve the business performance of food companies. In conclusion, after reviewing all these studies, the long-term threats and opportunities associated with implementing Industry 4.0 are still uncertain, and the technologies involved have not yet been fully explored by researchers.

We found that nine sources of risk are worth examining and including in the questionnaire, namely: economic, financial, operational, technological, social, political and legal, environmental, market, and business risks. In the case of food companies, the consideration, analysis and appropriate level of risk management are of paramount importance. In the course of the study, we sought the opinions of and data from Hungarian food industry companies. The data collection was carried out with the help of a questionnaire; we received 276 completed questionnaires, a number which was reduced to 259 during the data cleaning.

The results of the mediation analysis show that supportive factors indirectly influence developments through strategic goals. Industry 4.0 risk factors influence the use of Industry 4.0 innovation tools through barriers as well as developments / investments. Risk factors influence the development of business performance through Industry 4.0 tools. In the final model, six factors directly or indirectly explain corporate business performance: barriers, supporting factors, strategic objectives, developments / investments, Industry 4.0 assets, in addition to Industry 4.0 risk factors.

The hypotheses formulated in the introduction were proved in the research results section.

Conclusions

The main objective of the research was how the following indicators directly and indirectly affect business performance: supporting factors, obstacles, implementation of strategic goals, use of Industry 4.0 tools and risk factors.

We found that 9 sources of risk are worth examining and including in the questionnaire: financial, technological, operational, economic, social, political and legal, environmental, market, business risk. In the case of food companies, the consideration, analysis and appropriate level of risk management are of paramount importance.

The results suggest that Industry 4.0 risk factors directly affect the use of Industry 4.0 assets, but also indirectly through barriers and developments / investments. This relationship is a negative one, as the higher the risk and disincentives, the less the company invests in Industry 4.0 assets.

The aim is to expand domestic and international publications and research related to the topic, as well as to learn about the methods and results used in several scientific journals and to utilize them in our further research. Authors intend to continue the research, another goal is to further improve the business performance of the Hungarian food companies, as well as to examine the practical possibilities of the technological development of food companies and the Industry 5.0 technologies.

The hypotheses formulated in the introduction have been confirmed in the results section. As not all Hungarian food companies completed the questionnaire, the results are not suitable for generalization.

The activity of publications in recent years shows that innovation and efficiency will continue to be a key issue in the production of companies, and various publications and debates will contribute to the further development of theoretical and practical developments in these areas.

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