

# The Technological Factors of Enterprise Innovation in a Strategic Perspective

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## Abstract

Enterprise innovation is currently becoming a recognized factor of the competitiveness, survival, and development of companies in the market economy. Managers still need recommendations on ways of stimulating the growth of innovation in their companies.

The objective of this paper is to identify the strategic factors of enterprise innovativeness in the area of technology, defined as the most important internal factors positively impacting the innovativeness of enterprises in a strategic perspective. Empirical studies were conducted using the Computer-Assisted Web Interview (CAWI) method on a purposive sample of  $N = 180$  small and medium-sized innovative industrial processing enterprises in Poland. Data analysis was performed using Exploratory Factor Analysis within the Confirmatory Factor Analysis framework (E-CFA) and Structural Equation Modeling (SEM). Empirical research shows that the strategic factor of enterprise innovativeness in the area of technology is technological activity. A technologically active company should (1) possess a modern machinery stock, (2) conduct systematic technological audits, and (3) maintain close technical cooperation with the suppliers of raw materials, consumables, and intermediates. The implementation of the indicated recommendations by managers should lead to increased innovativeness of small and medium-sized industrial companies. The author recommends the use of the presented research procedure and data analysis methods in further studies.

## Keywords

Innovativeness, Technology, Factor Analysis, Structural Equation Modeling.

## Introduction

In the European Innovation Scoreboard 2021 Poland was, once again, ranked 24<sup>th</sup> among 27 European countries (European Commission, 2021). The persisting distance separating Poland from the leaders of the European ranking of innovation, such as Sweden or Finland, serves as an inspiration to search for factors increasing the level of innovation in the economy. Among the various criteria considered, much emphasis is placed on the innovativeness of enterprises. In recent years, researchers directed their efforts to the search for factors promoting enterprise innovativeness, including both external and internal factors – in various areas, also including factors related to the area of technology. This search is frequently based

on a strategic approach to innovation, justifying the company's efforts to obtain a competitive advantage. The considerations and their results often focus on the selection and implementation of a technological strategy (Ivanova et al., 2009; Dogan, 2017; De Moraes et al., 2020). Researchers also emphasize the importance of digitization as a key enterprise development trend (Jasińska, 2021; Ilmudeen & Bao, 2020).

The article focuses on the strategic factors of enterprise innovation defined as the most important internal factors positively impacting the level of innovation – in a strategic perspective. The objective is to identify the strategic factors of enterprise innovation in the area of technology. For the purpose of achieving the objective the author used and presented the results of her own unpublished research, conducted in 2014 on a purposive sample of 180 small and medium-sized innovative industrial processing enterprises (from section C of the Polish Classification of Activities).

Quantitative empirical research was conducted with the use of a proprietary survey questionnaire. Data analysis was based on Exploratory Factor Analysis within the Confirmatory Factor Analysis framework (E-CFA) and the method of Structural Equation

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Modeling (SEM). The results of the conducted own research allowed for the identification of the strategic factors of enterprise innovativeness in five several selected areas, including in the area of technology (Rojek 2015; Rojek 2018a; Rojek 2018b).

Ongoing technological changes prompted the author to reflect on the validity of the identified factors in the area of technology in the age of Industry 4.0, which serves as a synonym for various changes including, among other things, the digitization of manufacturing processes, automation, robotization, industrial Internet of Things, and the use of Artificial Intelligence technologies in production processes. These considerations lead to the conclusion that it would be advisable to conduct renewed research on this matter. The results of this new research effort could allow for the identification of strategic factors of enterprise innovativeness in the field of technology, both in the age of Industry 4.0, and in the current period of reconstruction and development of enterprise resilience in conditions caused by an unexpected external event – the COVID-19 pandemic.

The results of the research presented in the article can serve as an important point of reference for comparisons and analyzes. The added value of the article also lies in the author's open approach towards the sharing of the adopted research methodology and data analysis methods, which will be used by the author in further work, and which are consistently recommended to other researchers for adaptation and use in their research efforts.

## Literature review

### Innovation and the innovativeness of enterprises

The concept of innovation, introduced by J.A. Schumpeter, is defined in the literature in a number of ways. For the purpose of statistical surveys dedicated to the collection and interpretation of data concerning innovation, Statistics Poland (GUS) adopted the definition that innovation is the implementation of a new or improved product (good, service) or business process in business practice, workplace organization, or in relations with the environment. The implementation of a new product occurs when it is introduced to the market. Meanwhile, a new business process is considered to be implemented when its use begins in the company's operations (GUS, 2020). The products and business processes may be new to the market in which the company operates, but this is not a necessary

condition. They must be a novelty at least for the studied enterprise, however. They don't need to be developed by the company itself and may instead be prepared by another entity (e.g., a different company, a research and development institute, a research and development center, a university, etc.). It should be noted that this approach departs from the previously applied classification of innovation in statistical surveys, which distinguished innovations within a product, but also innovations within a process, as well as organizational and marketing innovations (OECD and Eurostat, 2008).

In this paper enterprise innovativeness is understood as the ability to create and implement innovations as well as to absorb innovations. This ability is associated with involvement in innovative processes. In the statistical studies conducted by Statistics Poland it is assumed that the category of innovative companies covers enterprises that implemented at least one innovation during a three-year period. As part of the research process, it is necessary to provide a broader definition of the effects as the measures of an enterprise's innovativeness. These measures were adopted in the research and presented in the empirical part of the paper.

### Small and medium-sized industrial enterprises in the structure of the Polish economy

Given the fact that the share of industry in the GDP structure of the European Union (EU) is unsatisfactory, attempts at raising the innovativeness of industrial enterprises, including small and medium-sized companies, are in line with the objectives of the EU. The European Commission has announced that it would seek to revitalize European industry whose share in the European Union's GDP is still far below the pursued target of 20%.

The author's interest in the strategic factors of innovation in relation to small and medium-sized industrial enterprises fall in line with the strategic assumptions of the EU. The objective of the EU policy relating to SMEs is to ensure that the European Union's activities will be favorable for both microenterprises as well as small and medium-sized enterprises. Table 1 presents the general criteria for the classification of small and medium-sized enterprises, introduced via EU regulations, and adopted into Polish law (Journal of Laws, 2021, item 162).

In light of data from Statistics Poland, in 2018 enterprises operating in Poland generated nearly three-quarters of the Polish GDP (72.7%). Small and medium-sized enterprises, referred to above, had a total share of 20.2% in the GDP (9.1% for small

Table 1  
Criteria for the classification of small and medium-sized enterprises

Enterprise category	Number of persons employed	Annual turnover	Annual balance sheet total
Small enterprise	< 50	≤ EUR 10 million	≤ EUR 10 million
Medium-sized enterprise	< 250	≤ EUR 50 million	≤ EUR 43 million

Source: Own elaboration based on (Journal of Laws, 2021, item 162).

enterprises and 11.1% for medium-sized enterprises) Meanwhile, the share of small and medium-sized companies in the structure of Polish enterprises in 2018 amounted to 2.2% and 0.7%, respectively (PARP, 2021).

Due to the business profile of industrial enterprises, technical issues play an important role in their activity. The processes of transforming raw materials and consumables into products require the companies to develop (design) the appropriate technology. Technology determines both the technical facilities intended for use as well as the operational course of the production processes. Conditions of rapid technological progress give rise to expectations of new objects and streamlined processes. However, not all companies are introducing innovative solutions. In the years 2017–2019 innovations (in the scope of new or significantly improved products or business processes) were introduced by 18.9% of industrial enterprises. In this group (100%) small enterprises accounted for 11.2%, and medium-sized enterprises accounted for 34.3% (PARP, 2021).

### Technology, resources, links – as dimensions in the search for the strategic factors of enterprise innovation in the area of technology

Technological factors relate to an enterprise's technological capacity to generate, implement, and absorb innovations. These factors include, among others, the possession of material and financial resources, production technologies corresponding to the requirements, as well as the technologies necessary at the stage of designing and prototyping new products (e.g., design equipment, research equipment). The following dimensions were deemed the most important within the discussed area: (1) resources, (2) technology, (3) links.

As part of the dimensions briefly discussed below, the author then designated factors (observed primary variables) that became the core of the research tool used in the framework of own quantitative research presented in the next sub-chapter.

### Resources

The resource-based view of the firm was developed in the mid-1980s, mainly through the work of B. Wernerfelt (Lockett et al., 2008). According to that approach, a company's ability to obtain a sustainable competitive advantage is conditioned upon the possession of key resources and the ability to use them effectively in the manufacture of products. Resources can be divided into visible resources and invisible resources – associated with people and organizational culture. Another classification distinguishes tangible, intangible, and human resources (Marek & Białasiewicz, 2008).

Tangible resources include natural, physical, and financial resources while intangible resources – realized by the people and by the company – include, among others, technology, patents, licenses, know-how, competences. Human resources relate to the competences and personality traits of the employees. The components of tangible resources are – as the name suggests – tangible and visible, as opposed to intangible resources. The latter include human resources, relational (market) resources and structural (organizational) resources. From the point of view of enterprise innovation, perceived as a source of strategic advantage, it is important to emphasize that only some of the resources are strategic in nature. Resources are of strategic importance if they render the company permanently unique, and thus provide it with a long-term competitive advantage (Obłój, 2002). Superior business performance can be achieved when these company-specific resources are rare, valuable, unique, and have no equivalent substitutes (Dogan, 2017).

In order to finance the necessary resources (assets), a company must obtain adequate capital. Physical capital is a technologically determined quantity of goods, which are used for the production of other goods, and financial capital is the sum of funds allocated towards investment (Janasz, 2005). Physical capital includes machines and devices, the equipment of laboratories and other research and development units, as well as the technical infrastructure (Pichlak, 2012).

The importance of physical and financial capital as a factor of enterprise innovation is pointed out by many researchers who argue that these types of capital determine a company's ability to generate, imple-

ment and adapt innovations. The value of expenditures on research and development activities is used as a measure of enterprise innovativeness. The investigation of the relationships between financial factors and the innovativeness of enterprises is the subject of numerous scientific papers. Researchers confirm the existence of a positive relationship between the intensity of expenditures on innovative activities and enterprise innovativeness (Pichlak, 2012; Xu et al., 2009).

## Technology

Chen and Yuan argue that the scale of expenditures on the purchase of domestic or foreign technology determines to a significant extent the innovativeness of high-tech companies, which are implementing a strategy of acquiring external technology through the purchase of so-called embodied technology – innovative machines and equipment necessary for the implementation of new processes or the production of new goods – or the purchase of disembodied technology – e.g., patents, licenses (Chen & Yuan, 2007).

At present, technology not only fulfills service functions in an organization but is also seen as a major strategic factor that shapes the company's potential for competitiveness and innovation, and provides the basis for its development (Gierulski et al., 2020). In the resource-based approach, technology is both an intangible resource – as an element of knowledge – and a tangible resource. This resource is treated as a component of strategic resources because its possession could enable a company to obtain a long-term competitive advantage. Companies are interested in accessing efficient technologies, i.e., ones that allow for greater product output based upon the same inputs. Implementing changes in technology that are new for the given company, constitutes an example of innovation, which could result, among other things, in increased productivity, improved quality, reduced consumption of time, materials or energy, as well as a new value offer for the customer.

Another important issue for enterprise innovativeness is also the method in which the companies acquire the new technology. It may be derived from internal sources, external sources (technology transfer), as well as mixed sources. Technologies derived from internal sources are the result of research and development activities (R&D) carried out by the company itself. Meanwhile, the transfer of technology can be defined as the transfer of specific technical and organizational knowledge (know-why) as well as practical knowledge (know-how) for the purpose of its practical utilization (commercialization) (Matusiak & Guliński, 2010).

Technology transfer can take place between companies, between a scientific institution and a company, or between scientific institutions. Mixed sources of technology occur when the acquisition of technologies from external sources is accompanied by internal research and development activities. One important element of enterprise innovativeness is the company's technological potential, which encompasses both the possessed technology, as well as the ability to apply it. Technological potential was mentioned (alongside marketing potential) as an element of the strategic factors of innovativeness in the meta-analysis presented by Hauschildt (2004). The technological potential increases from the emergence of a technology, through the development phase (in which the technology requires improvements and investments), all the way to the maturity phase. The assessment of a given technology's competitiveness from the company's point of view involves the identification of the technologies that are important for maintaining or strengthening its competitive position. The objective of technological audits is to assess the degree of the technology's maturity, the current phase of its life cycle, as well as to identify new technologies that may be applicable in the enterprise and may impact the company's ability to compete in the given sector.

The technological revolution associated with information and communication technologies (ICT) is a driver of changes taking place in the contemporary economy. In relation to enterprise innovation, it is necessary to recognize the importance of ICT, among other things, for the fast exchange, selection and analysis of information, for supporting research and development works as well as implementation works, and for controlling manufacturing processes.

## Links

Capabilities relate to specific tangible and intangible assets created as a result of interactions between the resources of the enterprise. This view inspires closer attention to the links influencing the ways in which resources are used.

For an enterprise to be successful, it has to both possess strategic resources and use these resources more efficiently than its competitors. One of the main tasks of the managers is to procure, develop and appropriately distribute the resources of an organization (Dogan, 2017). This approach is consistent with the view of Bielski (2007), who believes that an enterprise's innovativeness lies in its ability to efficiently allocate resources in order to achieve the optimal configuration of competitive advantages. Developing – independently or in cooperation with the environment



– or purchasing the documentation concerning a new product or a new technology requires the company to allocate the appropriate resources and to collaborate with the stakeholders.

The number of factors that need to be considered is too high. Furthermore, their impact on enterprise innovativeness varies. The impact of some is negligible and can be ignored, while other factors have a decisive influence (Hamrol, 2016).

In the paper they were referred to as the strategic factors, and in the study the efforts aimed at their identification were narrowed down to the technological area within the enterprise.

## Materials and methods

The aim of quantitative empirical research was to identify the strategic factors of enterprise innovation – understood as the most important internal factors positively impacting the innovativeness of enterprises in a strategic perspective. The research process presented in the article relates to the area of technology.

### Sampling and course of research

The selected purposive sample covered 550 small and medium-sized innovative industrial enterprises operating in Poland whose core business activity falls within Section C of the Polish Classification of Activities 2007 – Manufacturing. The category “innovative enterprise” was assigned to companies that introduced at least one innovation within the product, within the process, or a marketing or organizational innovation, in the studied three-year period. The author adopted the definition of small and medium-sized enterprises on the basis of the staff headcount criterion (10-49 and 50-249 employees, respectively).

Quantitative research was carried out using the Computer Assisted Web Interview (CAWI) technique in the second quarter of 2014. The respondents were individuals managing the studied enterprises: management board members, directors, owners. As a result, 180 correctly completed survey questionnaires were obtained ( $N = 180$ ), and the achieved response rate was 31%. In the studied group of enterprises, there were 76 small enterprises (accounting for 42.2% of the sample), and 104 middle-sized companies (accounting for 57.8%). The implementation of the basic Computer-Assisted Web Interview (CAWI) study was carried out by the Warsaw-based research company EMAR Marketing Research, in cooperation with the author of the paper.

### Research tool

The development of the research tool – a survey questionnaire – was preceded by the results of literature studies, as well as the author’s own qualitative research – Individual In-Depth Interviews (IDIs) with members of the companies’ management boards.

The core element of the questionnaire survey is a set of 15 (observed) primary variables, marked by the author with the symbols T1–T15.

The respondents were asked to identify the strategic importance of these variables on a scale of 1 to 5 wherein: 1 – the factor is of no strategic importance for enterprise innovation, 2 – the factor is of little strategic importance, 3 – it’s hard to tell, 4 – the factor is of considerable strategic importance, 5 – the factor is of great strategic importance.

Another important element of the research questionnaire were also the questions concerning the effects of innovative activities, used as the measures of enterprise innovativeness, and presented as part of the structural equation modeling (SEM) description.

### Methods of Empirical Data Analysis

In addition to descriptive statistics, the author used the method of Exploratory Factor Analysis within the Confirmatory Factor Analysis framework (E-CFA), the use of which is promoted, among others, by Asparouhov and Muthen (2009), followed by Structural Equation Modeling (SEM).

Stage 1. Exploratory Factor Analysis – the Principal Component Analysis method: narrowing down the number of primary variables to a smaller set of “variable groups”, that is, latent (hidden, unobserved) variables.

Stage 2. Confirmatory Factor Analysis: selection from among the latent variables of the potential strategic factors of enterprise innovation in the area of technology.

Stage 3. Structural Equation Modeling: construction of a structural equation model; analysis of the nature and strength of the relationships between the identified potential strategic factors in the area of technology and enterprise innovation (described with a set of primary variables). The model includes: a measurement component for the exogenous latent variables, a measurement component for the endogenous latent variables, and a structural component – linking both parts of the model (Januszewski, 2011; Konarski, 2009).

Stage 4. Identification of the strategic factors of enterprise innovativeness in the area of technology as the most important (in terms of the strength of rela-

tionships) among the potential strategic factors. Data analysis was performed using the IBM SPSS Statistics software.

## Results – Descriptive statistics and the results of Exploratory Factor Analysis within the Confirmatory Factor Analysis framework (E-CFA)

The results of the respondents' assessment of the individual indicators are presented in Table 2.

Stage 1. The conducted Exploratory Factor Analysis based on the Principal Component Analysis method allowed for the extraction of five main components, that is, new, uncorrelated “groups of factors” that have eigenvalues greater than 1 and explain a total of 61.8% of the factor variance. The significance of the major components is illustrated by the “scree”

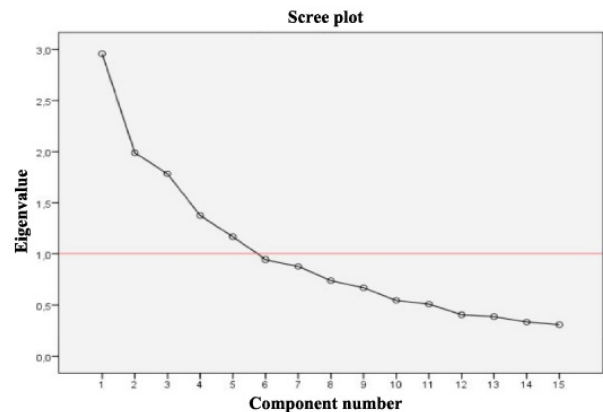


Fig. 1. Scree plot – the main components in the area of technological factors. Source: Own elaboration based on the results of the carried-out research ( $N = 180$ )

plot shown in Fig. 1. The horizontal cutoff line plotted on this chart shows that for the subsequent components starting from the 6<sup>th</sup> component there are al-

Table 2

Assessment of the strategic importance of technological factors (primary variables) for enterprise innovativeness

No.		Technological factors – primary variables	Average assessment	Standard deviation
1	T 6	Possession of modern machinery stock	4.18	1.116
2	T 12	Possession of modern production technologies	3.86	1.209
3	T 15	Close technical cooperation with the suppliers of raw materials, consumables, and intermediates	3.84	1.103
4	T 1	Independent conduct of research and development activities on new products, processes, organizational/marketing solutions	3.69	1.211
5	T 7	Own technical and laboratory facilities	3.59	1.236
6	T 8	High level of expenditures on research and development activities	3.48	1.106
7	T 13	Use of modern information technology (IT)	3.47	1.226
8	T 2	Conducting research and development activities in cooperation with research units, institutes, and universities	3.32	1.288
9	T 14	Conducting technological audits	3.26	1.154
10	T 9	Possession of own patents/patent applications	3.22	1.283
11	T 5	Taking advantage of support provided by technology transfer centers	3.21	1.299
12	T 3	Conducting research and development activities together with other companies	2.87	1.299
13	T 11	Purchase of patents/licenses	2.54	1.261
14	T 4	Outsourcing research and development activities to external entities	2.52	1.244
15	T 10	Sale of own patents/licenses	2.30	1.200

Source: Own elaboration based on the results of the carried-out research ( $N = 180$ ).

ready minimal declines in the eigenvalues, so they are not retained.

Summary of the total variance explained after the separation of the main components and after Varimax rotation is presented in Table 3.

The created factors form the unobserved (latent) variables. They were designated as the preliminary potential strategic factors of enterprise innovativeness – technological factors, all of which group specific primary variables (Table 4).

The greater the value of the factor loading (correlation coefficient), the greater the impact of the primary variable on the preliminary potential strategic factor of enterprise innovativeness.

Stage 2. The conducted Confirmatory Factor Analysis confirmed the significance of three factors: CT1,

CT2 and CT3. They constitute important factors positively affecting enterprise innovativeness and were therefore recognized as the potential strategic factors of enterprise innovativeness in the area of technology (Table 4).

The primary variables, explaining each of the designated potential strategic factors of the innovativeness of enterprises – technological factors, are presented in Table 4 in order from the strongest to the weakest link with the given factor.

Stage 3. Results – the results of Structural Equation Modeling (SEM). In the framework of Structural Equation Modeling the author tested many models, searching for those that best reflect the complex cause and effect relationships, that is, the impact of strategic technological factors on enterprise innova-

Table 3

Matrix of Rotated Components in the Exploratory Factor Analysis of the strategic factors of enterprise innovativeness – technological factors

Technological factors – primary variables		Preliminary potential strategic technological factors				
		1	2	3	4	5
T 9	Possession of own patents/patent applications	<b>0.794</b>	0.018	0.163	0.115	0.001
T 2	Conducting research and development activities in cooperation with research units, institutes, and universities	<b>0.706</b>	0.185	-0.151	-0.017	0.054
T 8	High level of expenditures on research and development activities	<b>0.545</b>	0.171	0.445	0.206	-0.302
T 11	Purchase of patents/licenses	<b>0.419</b>	0.361	-0.147	0.032	0.354
T 3	Conducting research and development activities together with other companies	0.144	<b>0.787</b>	-0.051	0.147	-0.036
T 10	Sale of own patents/licenses	0.382	<b>0.585</b>	-0.053	-0.338	-0.125
T 13	Use of modern information technology (IT)	-0.275	<b>0.584</b>	0.513	-0.050	0.087
T 4	Outsourcing research and development activities to external entities	0.209	<b>0.582</b>	0.055	-0.576	0.072
T 15	Close technical cooperation with the suppliers of raw materials, consumables, and intermediates	0.047	-0.076	<b>0.748</b>	-0.028	-0.072
T 14	Conducting technological audits	0.008	0.056	<b>0.709</b>	0.054	0.228
T 6	Possession of modern machinery stock	0.431	-0.292	<b>0.446</b>	-0.127	0.350
T 1	Independent conduct of research and development activities on new products, processes, organizational/marketing solutions	0.081	-0.031	-0.046	<b>0.824</b>	0.162
T 7	Own technical and laboratory facilities	0.426	0.174	0.185	<b>0.569</b>	-0.311
T 5	Taking advantage of support provided by technology transfer centers	-0.118	-0.118	0.117	-0.123	<b>0.718</b>
T 12	Possession of modern production technologies	0.139	0.137	0.065	0.289	<b>0.640</b>

Factor extraction method – Principal Components Analysis. Rotation method – Varimax with Kaiser normalization. Rotation converged in 15 iterations.

Source: Own elaboration based on the results of the carried-out research ( $N = 180$ ).

Table 4  
 Preliminary potential strategic factors of enterprise innovativeness – technological factors, obtained on the basis of the carried out Exploratory Factor Analysis

<b>Factor CT1. Research and development facilities</b>	
T 9	Own patents/patent applications
T 2	Conducting research and development activities in cooperation with research units, institutes, and universities
T 8	High level of expenditures on research and development activities
T 11	Purchase of patents/licenses
<b>Factor CT2. The enterprise's external activity in the area of research and development</b>	
T 3	Conducting research and development activities together with other companies
T 10	Sale of own patents/licenses
T 13	Use of modern information technology (IT)
T 4	Outsourcing research and development activities to external entities
<b>Factor CT3. The enterprise's technological activity</b>	
T 15	Close technical cooperation with the suppliers of raw materials, consumables, and intermediates
T 14	Conducting technological audits
T 6	Possession of modern machinery stock
<b>Factor CT4. The enterprise's internal activity in the area of research and development</b>	
T 1	Independent conduct of research and development activities on new products, processes, organizational/marketing solutions
T 7	Own technical and laboratory facilities
<b>Factor CT5. Possession of modern production technologies</b>	
T 5	Taking advantage of support provided by technology transfer centers
T 12	Possession of modern production technologies

Source: Own elaboration based on the results of the carried-out research ( $N = 180$ ).

tion. The three potential strategic factors of enterprise innovativeness designated on the basis of the confirmatory analysis of the organizational factors – (CT1) Research and development facilities, (CT2) The enterprise's external activity in the area of research and development, (CT3) The enterprise's technological activity – were used for the construction of a Structural Equation Model. The objective here was to assess the impact of these factors (as the exogenous latent variables) on enterprise innovativeness (as the endogenous latent variable). The structural model presents the cause-and-effect relationships between these variables. Meanwhile, the measurement models represent the relationships between the latent variables and the observable variables that explain them.

### Markings

The Structural Equation Model can be presented in the form of a set of equations or a graphical scheme (Xu et al., 2010). In the paper the author adopted a

graphic presentation, and the following markings were used in the model diagram:

- observable variable,
- unobservable (latent) variable,
- cause and effect relationship,
  - the value over the arrow means the path coefficient,
  - the value next to the observable variable means the coefficient of determination  $R^2$ ,
  - INN means the INNOVATIVENESS of the enterprise,
  - $e$  means the random component of the variable.

It was assumed that innovativeness of enterprises (as the endogenous latent variable) is explained by three factors: F1, F2 and F3, wherein:

- the variable F1, signifying the results of the enterprise as measured by the number of innovations implemented in the years 2011–2013, is explained by:
  - P1.1 – the total number of product innovations,
  - P1.2 – the total number of process innovations,



- P1.3 – the total number of organizational innovations,
- P1.4 – the total number of marketing innovations;
- the variable F2, signifying financial activity in the scope of innovation as measured by the average share of expenditures on innovation in the enterprise’s revenues in the years 2011–2013, is explained by:
  - P2.1 – the average percentage share of overall expenditures on innovative activities in the enterprise’s revenues,
  - P2.2 – the average percentage share of expenditures on research and development activities in the expenditures on innovative activities;
- the variable F3, signifying intellectual property, as measured by the total number of patents, industrial design registration rights, protective rights for utility models obtained in the years 2011–2013, is explained by:
  - P3.1 – the total number of patents obtained,
  - P3.2 – the total number of industrial design registration rights obtained,
  - P3.3 – the total number of protective rights for utility models obtained.

A comparison of quality assessments of the estimated model with the assessments of the saturated model (best model) and the independence model (worst model) facilitates a general assessment of quality of the estimated model.

In light of the indicators adopted for the assessment of the model, it was assumed that the model is sufficiently matched. Fig. 2 shows the resulting structural equation model developed using the IBM SPSS Statistics AMOS software.

In the MODEL (Fig. 2), in the framework of the measurement models there are relatively strong and statistically significant relationships – between each of the exogenous variables (CT1, CT2, CT3) and the primary variables explaining them. It is also possible to positively interpret the relationship between the innovativeness of an enterprise (the endogenous latent variable) and its factors F1, F2, F3 (the adopted measures of innovativeness), explained by the observable variables describing the innovativeness of the enterprise.

The structural model refers to the main problem of modeling, i.e., the potential impact of strategic technological factors on the innovativeness of enterprises, reflecting the causal relationships between each of the factors – CT1, CT2, CT3 – and the innovativeness of an enterprise.

Stage 4. Analysis of these relationships leads to the conclusion that factor CT3 – “The enterprise’s tech-

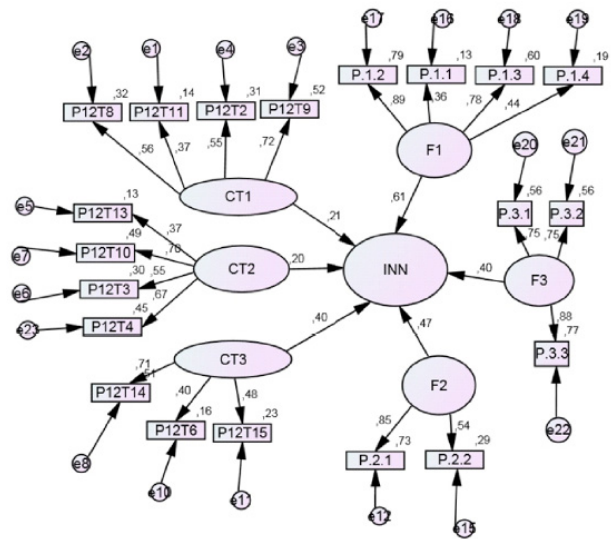


Fig. 2. MODEL – The impact of potential strategic technological factors on the innovativeness of enterprises. Source: Own elaboration based on the results of the carried-out research ( $N = 180$ ), with the use of the IBM SPSS Statistics AMOS software

nological activity” – has the most significant positive impact on the innovativeness of enterprises (path coefficient 0.40). Factors CT1 (research and development facilities) and CT2 (enterprise’s external activity in the area of research and development) show a smaller impact (the path coefficients amount to, respectively, 0.21 and 0.20).

## Discussion

Based on the obtained results it should therefore be assumed that in the area of technological factors, the strategic factor of the innovativeness of enterprises, that is, the factor that has the most significant positive impact on innovativeness, is:

- CT3 – “The enterprise’s technological activity”, described by the explanatory variables: conducting technological audits, close technical cooperation with the suppliers of raw materials, consumables and intermediates, possession of modern machinery stock.

An analysis of the relationship between factor CT3 and its explanatory variables shows that the variable T14 – conducting technological audits – has the greatest significance for its description, reflected with a path coefficient of 0.71. Variable T15 – “Close technical cooperation with the suppliers of raw materials, consumables, and intermediates” – has a significance reflected with a path coefficient of 0.48, variable T6 –

“Possession of modern machinery stock” – has a significance reflected with a path coefficient of 0.40.

The strategic factor for the innovativeness of enterprises in the area of technology, identified as the enterprise’s technological activity, concerns, on the one hand, the possession of modern machinery stock as an element of the company’s assets. On the other hand, this factor is associated with close technical cooperation with the suppliers of raw materials, consumables, and intermediates, and above all – with the conduct of technology audits. A systematic process of assessment of the enterprise, its existing technological capacity, procedures, and principles for the conduct of its ongoing operations, should provide its management with knowledge on the company’s position in terms of technology and the market.

## Conclusions

The contemporary market is characterized by high competitiveness of the products (goods and services). Polish small and medium-sized industrial processing enterprises that want to capture global markets must be increasingly innovative. Innovation is a multidimensional phenomenon, requiring a comprehensive approach at every level of enterprise management. The consideration of the factors of enterprise innovation in a strategic perspective is related to the pursuit of a competitive advantage in the market economy.

Technology now represents one of the basis of strategic planning, guiding the fundamental question of how to establish a competitive advantage and how to ensure the survival of the company (De Moraes et al., 2020).

In light of the presented research results the strategic factor of an industrial enterprise’s innovativeness in the area of technology is technological activity. A technologically active company should possess a modern machinery stock, conduct systematic technological audits, and maintain close technical cooperation with the suppliers of raw materials, consumables, and intermediates. The objective is not so much to acquire technological leadership, but to reach the same technological level as the market competitors.

These recommendations are confirmed by the views of researchers.

In terms of technology audit, “from the strategic management point of view, a technological structure analysis of the enterprise should be included featuring not only technologies within a current time horizon, but also those technologies which might influence the functioning of the enterprise and its competitive position in the future” (Dogan, 2017).

Technology audit methods may relate, i.e., to the assessment of the company’s technology potential in the following areas (Łunarski, 2016):

- technological leadership – indicating that the upper management is aware of technology’s key role in improving the organization’s competitiveness,
- technological competences of the personnel – the ability to generate or absorb new technologies,
- advancement of the utilized technologies – e.g. measured by the structural share of the applied technologies in particular life cycles within the overall technology portfolio,
- technological infrastructure – reflecting a number of features of the utilized technologies,
- technological activity related to research and development,
- efficiency of the technological preparation of production,
- ability to optimize design and manufacturing processes,
- technological benchmarking – utilizing the experience of other organizations.

When it comes to the forecasting of technological needs, the following methods can be distinguished (Łunarski, 2016):

- extrapolation of parameters, characteristics or typical features observed in the development of the currently used technology (assuming that further development will follow similar patterns),
- analyses: correlation analysis, regression analysis, econometric analysis, morphological analysis, multivariate analysis, patent trend analysis,
- methods: Delphi method, scenario method,
- algorithmic methods, interviews, checklists, SWOT analysis,
- forecasting of the demand for a new technology.

Close technical cooperation with the suppliers of raw materials, consumables and intermediates becomes a necessity.

The life span of products, processes and technologies is rapidly shortening and the demands revealed by the time pressure push companies to find new creative ways and methods while making innovation. In this regard, they need to be flexible enough to respond to any change that may arise in the environment and develop a strategic view of innovation in order to sustain their existence (Dogan, 2017).

Modern machinery stock is linked to technical progress and solutions characteristic for Industry 4.0, including information technologies. The goals of digitization should be adapted to the competences and degree of digital maturity of the enterprise (Jasińska, 2021). Information systems are a resource that is highly rated in terms of its utilization by nearly half

of small and medium-sized industrial processing enterprises.

The following technological areas of interest were indicated in 2019 by the surveyed industrial processing companies that had been investing in modern technologies: development of e-commerce – 15% of respondents; modern production technologies – 15%; databases – 8%; software – 8%; Robotic Process Automation (RPA) software – 11% (Nowak & Wieteska, 2021).

The presented recommendations for the practice of company management, derived from the carried out analyzes, indicate the ways in which managers should stimulate the growth of enterprise innovation.

In the author's opinion, the implementation of the indicated recommendations by managers, company board members, should promote the growth of innovativeness of small and medium-sized industrial processing enterprises. Higher levels of enterprise innovativeness will allow for the survival and expansion of companies and will contribute to the elimination of the gap between Poland and the European Union's most innovative countries.

According to the author, in the age of Industry 4.0 the recommendations stemming from the empirical studies seem to be valid and up to date. Meanwhile, close cooperation with suppliers takes on a new dimension in conditions caused by an unexpected external event, that is, the COVID-19 pandemic. Supply chains should be more resilient to the risk of losing operational ability. The conclusions drawn from the conducted studies inspire further research in this area. The confirmation of the correct selection of research methods implies their suitability for further empirical research.

However, the carried out analysis concerning the strategic factors of enterprise innovativeness in the area of technology doesn't exhaust the topic. The results of the data analysis obtained in the course of empirical research confirm the author's expectations, although the nature of the adopted research project does not allow for the generalization of these results. This is because purposive sampling eliminates the assumption of statistical representativeness.

The obtained results provide a basis to formulate recommendations for further research projects in the area of the strategic factors of enterprises innovation. These studies should be continued, among other things, through an expansion of the set of internal factors (primary variables) of enterprise innovativeness in the area of technology in the age of Industry 4.0, but also in the conditions of an unexpected external event (COVID-19). It would also be interesting to pursue further research aimed at the identification of

strategic factors of enterprise innovativeness in a sectoral arrangement, also covering industrial companies from sections of the Polish Classification of Activities other than Section C – Manufacturing.

The topic of strategic factors of enterprise innovation remains an open question and requires further studies, which could be inspired by the research procedure and the research results presented in the article.

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