STRENGTHENING THE COMPETITIVE POSITION OF HIGH-TECH ENTERPRISES

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Abstract
The study addresses the issue of strengthening the competitive position of modern high-tech companies. Theoretical considerations identify the main factors/activities that may have a potential impact on the competitiveness of companies and they are supported by empirical studies (using the CATI method). The research has been carried out in Polish service companies belonging to the high-tech knowledge-intensive services subsector (N=150). The study aims to demonstrate the most frequently undertaken actions by companies in terms of strengthening their competitive advantage, as well as to assess the complexity of the activities involved in strengthening the competitive position of this category of companies. The research problem is as follows – What actions most strongly determine the competitive position of high-tech companies in Poland, what is the average level of the complexity of the activities undertaken in strengthening the competitive position in this category of innovative enterprises? Two hypotheses were evaluated to achieve the goal of the study: (1) strengthening the competitive position of high-tech enterprises is primarily determined by financial and intellectual capital factors, and (2) strengthening the competitive position of high-tech enterprises has a high level of complexity. To verify Hypothesis No. 1 the basic descriptive statistics were analyzed, as well as Friedman's test (with the specification of average ranks for each factor), and to verify Hypothesis No. 2 the composite index was constructed – i.e. the Enterprise Competitiveness Strengthening Complexity Index – ECSCI. Conducted studies have shown that factors related i.e. to development of intellectual capital, quality, innovations, knowledge, and know-how, as well as competencies of employees, play a key role in strengthening competitive position in the surveyed companies. The much less "interest" in companies "enjoys" the area of production and financial management. What more, the average complexity of strengthening the competitive position of high-tech enterprises is at a relatively high level throughout the research sample.

Keywords
Management; enterprise; competitiveness; high-tech sector; the complexity of strengthening competitive position.

Introduction

The environment of modern enterprises is constantly evolving, it is increasingly complex and unpredictable (or difficult to predict). Therefore, managing the factors located in such an "ecosystem" of enterprises becomes a real challenge. The role and importance of environmental conditions are constantly increasing, exerting an increasing impact on the development potential and competitiveness of companies. Due to the dynamics of the environment, companies need to change the way they operate, to strengthen their competitive advantage.

The study aims to identify how today's enterprises – especially in innovative high-tech industries – can create and improve their competitive position. In other words, the research aims to demonstrate the most frequently undertaken actions by companies in

terms of strengthening their competitive advantage, as well as to assess the complexity of the activities involved in strengthening the competitive position of this category of companies. These considerations are also intended to highlight the need for an active and structured approach by managers and employees at different levels of management to create competitive advantages and strengthen the competitive position of companies in an evolving environment. The analyses contained in the study are both theoretical and empirical, as well as are aimed at presenting a new perspective on the issue of strengthening the competitive position of high-tech enterprises – mainly on Polish "ground".

The paper consists of four essential parts addressing the following issues: (1) specification of basic circumstances of the competitiveness of high-tech enterprises, (2) description of the research methodology, considering the frameworks of the selection of units within the research sample, as well as the specification of the research sample structure and research assumptions, (3) description of the basic results of the empirical research – exposing issues of interpretation of the average value of the ECSCI index, and description of profiles of the average assessment of the level of complexity of strengthening the competitive position of high-tech enterprises, (4) discussion and conclusions.

Circumstances of the competitiveness of high-tech enterprises

Circumstances of business activities and strengthening the competitive position of today's high-tech companies is difficult to capture in a simple, unambiguous classification. In few studies (see Zaskórski, 2012; Niemczyk, 2013; Pakulska, 2017; Jasiński, Głodek, & Jurczyk-Bunkowska, 2019; Pietrewicz, & Sobiecki, 2019) indicating that these conditions are complex networks of relationships with "blurred" borders, and should be considered on the principles of a holistic and systemic approach.

The main internal factors in companies, in particular those involved in innovation activities and belonging to the high-tech industries, that may influence their competitive position, include (Gautam, Muhanna, & Barney, 2005; Kaplan, & Norton, 2010; Hamel, 2012; Krzyżanowska, 2015; Poniatowska-Jaksch, 2017):

- changes in the way the customer perceives – the customer is a key resource;
- the application of prosumption;
- creation of transitional innovations and the use of knowledge resources;
- the increase in the role and importance of innovation in business management;
- shaping the networking relationships and building trust in business relationships;
- focus on identifying value by company's stakeholders;
- shaping social and leadership competencies, as well as IT competencies in employees mainly responsible for basic processes (creating value for stakeholders);
- development of procedures for managing information resources and creating knowledge;
- the continuous increase in the importance of the human factor – as a source of the innovation potential;
- the increase in the role and importance of risk management procedures in the development of enterprises.

On the other hand, the main external factors and conditions that may affect the competitive position of enterprises include (Gautam, Muhanna, & Barney, 2005; Pietrewicz & Sobiecki, 2017; Łobejko, Nowicka, & Szpringer, 2018; Kozielski, Olsztyński, & Sroczyński, 2018; Błaszczyk, 2019; Ilin, 2019; Wereda & Woźniak, 2019; Niedzwiedskaja, 2019):

- development of internet technologies and the processing of information resources (IoT, CC, Big-Data, etc.);
- change in regulatory conditions i.e. in the frameworks of the use of modern ICTs, and protection of intellectual property;
- the emergence of new generations of customers and employees – "millennials", "Z", "alpha";
- changes in the access to finance for innovative activities of enterprises, as well as in the way in which their development is financed;
- the evolution of new manufacturing techniques and technologies, as well as the provision of services;
- focus on standardizing business processes and standardizing management processes;
- the increase in the importance of institutional support for businesses in different sectors of the economy – including the terms of financing innovative activities;
- the emergence of modern forms of promoting innovative activities.

As shown above–example, but leading for business development – conditions state only a selective set. It is worth to remember this in case of developing an analysis of the environment for a particular company, especially innovative (Woźniak & Gemra, 2020). Also, the modern approach to understanding and strengthening the competitive position is due to the need for extensive integration (often in-depth) of environmental analysis into internal processes in enterprises (see Flak & Głód, 2012; Jones, Balle, Chaize, & Fiume, 2019). This is crucial for strengthening the entity's potential to create value for both employees, executives, and business owners (mainly in the form of profits and satisfaction from strengthening the brand's position on the market), as well as external stakeholders, i.e. co-operators, suppliers, intermediaries, and customers (by improving the quality of the market offer in general, and by increasing the level of matching of this offer to the needs, opportunities, requirements, and constraints of external stakeholders). The competitive position of modern high-tech companies is a kind of "mapping" of environmental conditions. Some factors can strengthen companies, increasing their competitive potential, and others, on the contrary, weaken them (Assylbekova, 2016, p.165). To properly prepare the "instrumentation" for creating and developing competitive advantages, it is appropriate to understand in which the "ecosystem" a company operates.

At this point, it is also worth noting that ICTs and the technical "potential" of changes taking place in the environment (e.g. augmented and virtual reality, Web 3.0, mobile and wireless technologies, or the Internet of Things and Big-Data) can also constitute the so-called "foundation" to support the competitive empowerment processes of high-tech companies (based on Nambisan, Lyytien, Mjchrzak, & Song, 2017, pp.226 et seq.; Kelly, 2017, pp. 21 et seq.; Surma, 2017, pp. 12 et seq.; Wodecki, 2018; Kreft, 2019).

To sum up the above considerations, it can be assumed that business processes in high-tech enterprises (mainly innovative ones) should address the challenges that can be

connected with (based on Deschamps, 2011; Anthony, Johnson, Sinfield, & Altman, 2014; Bova, 2019; Woźniak & Gemra, 2020):

- obtaining funding for innovative processes;
- the integration of technological changes on a global scale with local innovations;
- the acquisition of external (global) resources and the potential of the sharing economy;
- managing the creativity of employees;
- understanding the peculiarity of the market in innovative processes;
- creating trust in business processes;
- ensuring decision-making efficiency and information resource management;
- the use of a visionary and long-term approach to creating innovation.

Thus, it can be seen that in today's high-tech companies – in terms of strengthening their competitive position – the following areas of factors, which are specific "challenges", can be observed (Figure 1) (based on Woźniak & Gemra, 2020, p. 63):

- manufacturing and market (ensuring the process continuity, commercialization of innovation, quality control, etc.);
- financial (optimizing the efficiency and costs, creating value, etc.);
- relational (the ability to network cooperation and maintaining the lasting relationships with stakeholders, the ability to trigger trust in business relationships, etc.);
- human resources (development of employees' creativity, seeking and improving their competences, etc.);
- technological, innovative, and knowledge-intensive (the ability to implement basic activities in innovative processes and the use of ICTs, the ability to create new knowledge useful in innovative processes, etc.).

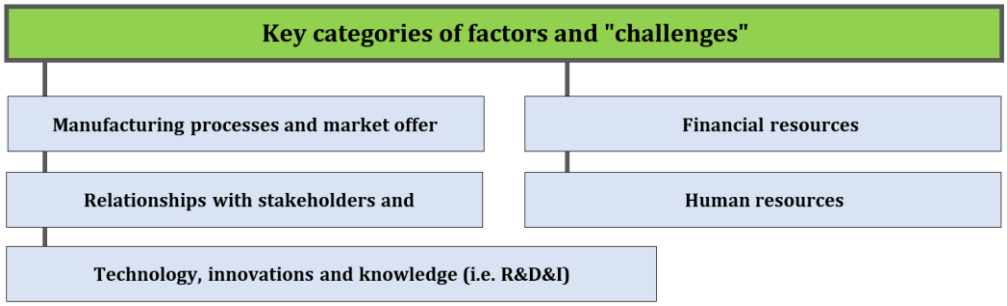

Figure 1. Key categories of factors and "challenges" for strengthening competitive position of high-tech enterprises
(based on Woźniak, & Gemra, 2020, p. 63)

The study will further provide quantitative analyses related to the identification of the basic actions taken by high-tech companies to strengthen their competitive position (using the potential of their environment) and to determine the average level of the complexity of activities in strengthening the competitive position in this class of enterprises.

The methodology of the research

This study will present selected results of the survey of activities (related to the implementation of statutory innovation activities) undertaken by companies belonging to the high-tech industries in Poland in terms of strengthening their competitive position. The study is also intended to demonstrate activities the most frequently undertaken by companies in terms of strengthening their competitive advantage, as well as the complexity of the activities involved in strengthening the competitive position of this class of companies. The research problem is as follows – What actions most strongly determine in the opinion of respondents the competitive position of high-tech companies in Poland, and at what average level is the complexity of the activities undertaken in strengthening the competitive position in this class of innovative enterprises?

Two hypotheses were evaluated to achieve the goal of the study:

- Hypothesis No. 1: Strengthening the competitive position of high-tech enterprises is primarily determined by financial and intellectual capital factors – according to the studies of Vargas-Hernández and Noruzi (2010), and Kianto, Andreeva and Pavlov (2013), suggesting that intellectual capital significantly increases the competitive potential of modern companies, as well as the researches of Gunasekaran, Rai, and Griffin (2011), López Salazar, Contreras Soto, and Espinosa Mosqueda (2012), and Ahmedova (2015), indicating that financial resources can, in a high level, manage the competitiveness of enterprises.
- Hypothesis No. 2: Strengthening the competitive position of high-tech enterprises has a high level of complexity – according to the studies of Cristelli, Gabrielli, Tacchella, Caldarelli, and Pietronero (2013), as well as Tacchella, Cristelli, Caldarelli, Gabrielli, and Pietronero (2013), suggesting that shaping the competitiveness of economic units (also enterprises) is a highly complex and multi-faceted action.

To verify Hypothesis No. 1 the basic descriptive statistics were analyzed, as well as Friedman's test (with the specification of average ranks for each factor), and to verify Hypothesis No. 2 the composite index was constructed – i.e. the Enterprise Competitiveness Strengthening Complexity Index – ECSCI.

The subject of the study is strengthening the competitive position of companies from high-tech industries in Poland. Respondents' opinions were used to assess the level of implementation of certain activities with a potential impact on the competitive position of enterprises. Service companies belonging to the high-tech knowledge-intensive services subsector were eligible for the study, marked with the following PKD numbering (i.e. the code list of classification of business activities in Poland): section 59 and section 60 (activities involved in the production of films, videos, television programs, sound, and music recordings, as well as the broadcasting of public and subscription programs), section 61 (telecommunications), section 62 (software and consultancy activities in the field of IT), section 63 (information service activities), as well as section 72 (research and development).

The empirical study was conducted in the CATI form (i.e. the Computer Assisted Telephone-Interviewing) on a sample of 150 innovative companies. The empirical study was conducted between December 2019 and January 2020. Respondents were business owners or managers responsible for risk management, innovation processes, or project

management. The research covered companies operating throughout Poland (16 voivodships). The study was carried out by "ASM – Centre for Market Research and Analysis Sp. z.o.o." located in Kutno (Poland).

The study used a random systematic selection (taking into account the criterion of the leading business activity profile in high-tech industries, according to PKD, i.e. the Polish Classification of Business Activities) in layers (layers were determined taking into account the size of the company according to the number of employees) – reflecting the quantitative structure of the enterprises in the population. The specification of the research sample is presented in Table 1.

Table 1. Structure of the research sample – CATI study (N=150)

Basic criteria for specification of the research sample	Size of enterprise				Total	
	Micro (1-9 employees)		Small, medium, and large (≥10 employees)			
	N*	%**	N	%	N	%
Leading business profile (according to PKD)						
Section 59 and section 60	19	13	11	7	**30**	**20**
Section 61	18	12	12	8	**30**	**20**
Section 62	8	5	22	15	**30**	**20**
Section 63	15	10	15	10	**30**	**20**
Section 72	0	0	30	20	**30**	**20**
Total	**60**	**40**	**90**	**60**	**150**	**100**
Age of enterprise						
Less than 10 years ("relatively young")	20	13	18	12	**38**	**25**
10-15 years old ("mature")	11	7	19	13	**30**	**20**
More than 15 years ("relatively old")	29	19	53	35	**82**	**55**
Total	**60**	**40**	**90**	**60**	**150**	**100**
Scale of business operation						
Local (1 town/municipality/district)	11	7	8	5	**19**	**13**
Regional (1-8 voivodships in Poland)	12	8	6	4	**18**	**12**
Domestic (9-16 voivodships in Poland)	17	11	30	20	**47**	**31**
European (at least 1 country in Europe outside of Poland)	14	9	16	11	**30**	**20**
International (at least 1 country in the world outside Europe, including outside of Poland)	6	4	30	20	**36**	**24**
Total	**60**	**40**	**90**	**60**	**150**	**100**
Level of average annual turnovers						
Less than 40 million PLN	60	40	75	50	**135**	**90**
<40 – 100 million PLN)	0	0	11	7	**11**	**7**
<100 – 170 million PLN)	0	0	3	2	**3**	**2**
170 million PLN and more	0	0	1	1	**1**	**1**
Refusal to respond	0	0	0	0	**0**	**0**
Total	**60**	**40**	**90**	**60**	**150**	**100**

** Number of enterprises in the research sample.*
*** Percentage share of enterprises in the research sample.*

The main research tool was the CATI questionnaire. The data analyses were supported by the PS IMAGO PRO 5.0 software. The questionnaire applied a screening question if companies had successfully implemented at least 10 innovations for their customers in

the last 5 years of their activity on the market. During the CATI interview, respondents assessed each activity (see: Table 2) on a 10-point scale. If the respondent assessed the activity at "1", this meant that there was a lack of implementation (or the implementation is weak) of the action, and if it was assessed at "10" – the action was fully implemented. In the following parts of this work, the results of the study of strengthening the competitive position of high-tech enterprises from the high-tech knowledge-intensive services subsector in Poland will be presented – using the analysis of basic descriptive statistics, Friedman's test, factor analysis (i.e. Principal Components Analysis method – PCA), as well as cluster analysis (*k*-mean method).

Results of the empirical study

The empirical study took into account twenty-five specific factors that could have a potential impact on strengthening the competitive position of high-tech companies. These factors were detailed based on the following studies: Gautam, Muhanna, & Barney, 2005; Kaplan, & Norton, 2010; Hamel, 2012; Krzyżanowska, 2015; Pietrewicz, & Sobiecki, 2017; Poniatowska-Jaksch, 2017; Łobejko, Nowicka, & Szpringer, 2018; Kozielski, Olsztyński, & Sroczyński, 2018; Błaszczyk, 2019; Ilin, 2019; Wereda, & Woźniak, 2019; Niedzwiedskaja, 2019. Specific factors are included in five groups: (1) technology, innovations, and knowledge, (2) relationships with stakeholders and environment, (3) manufacturing processes and market offer, (4) financial resources, as well as (5) human resources (Table 2) (see also: Figure 1). This approach is determined by the desire to meet the basic principles of the systemic analysis (see: Zaskórski, 2012), as well as to identify those areas of activity of companies that can most strongly determine strengthening the competitive position.

Table 2. Main specific factors in the area of strengthening the competitive position of high-tech enterprises (N=150)

Specific factors / activities	Mean	Median	Dominant	Standard deviation	Variance	Skew	Coefficient of variation
GROUP I: Technology, innovations, and knowledge (i.e. R&D&I)							
Innovation and technological advancement of enterprises	7.95	8.00	10	2.103	4.421	-1.132	26%
Efficiency of the use of production resources	6.30	7.00	1*	3.229	10.426	-0.657	51%
Improvement of the productivity and efficiency of innovation processes	6.65	7.00	10	2.979	8.872	-0.682	45%
Knowledge of employees and managers about resources that can be used in innovative processes	8.21	9.00	10	2.175	4.729	-1.801	26%
Know-how derived (from the environment) or developed internally	**8.37**	**9.00**	**10**	**2.068**	**4.276**	**-1.869**	**25%**
Increase in the value of intellectual capital and intangible resources	8.16	9.00	10	2.095	4.390	-1.501	26%

Specific factors / activities	Mean	Median	Dominant	Standard deviation	Variance	Skew	Coefficient of variation
Effectiveness of informational and decision-making processes in companies and knowledge generation	7.73	8.00	10	2.287	5.230	-1.359	30%
GROUP II: Relationships with stakeholders and the environment							
Complexity and number of contacts with third parties and number of business partners	7.25	8.00	8	2.282	5.207	-0.693	31%
Quality and usability of relationships between companies and cooperating entities	**7.82**	**8.00**	**10**	**2.155**	**4.645**	**-1.162**	**28%**
Shaping the relevant industry system (by supporting and related industries)	6.34	7.00	8	2.783	7.743	-0.469	44%
Socio-economic policy of the government	6.98	8.00	10	2.806	7.872	-0.685	40%
Possibility of the company's impact on its market environment	6.46	7.00	5	2.711	7.351	-0.426	42%
GROUP III: Manufacturing processes and market offer							
Quality of products, services and/or projects	**8.73**	**9.00**	**10**	**1.697**	**2.881**	**-1.810**	**19%**
Size and structure of production resources in the environment that can be obtained and shared	5.59	6.00	1	2.981	8.887	-0.324	53%
Equipping the company with manufacturing factors (resources)	6.76	7.00	10	2.756	7.593	-0.776	41%
Offering new types of products, services and projects	7.61	8.00	10	2.326	5.408	-1.233	31%
Shaping production volumes	4.44	5.00	1	3.210	10.302	0.237	72%
GROUP IV: Financial resources							
Cost reduction	6.76	7.00	8	2.473	6.117	-0.597	37%
Prices of products, services and/or projects	**6.87**	**7.00**	**5**	**2.305**	**5.311**	**-0.435**	**34%**
Company's own (internal) investments and the possibility of raising external capital	6.71	7.00	8	2.731	7.457	-0.715	41%
Availability and methods of financing activities	6.73	7.00	10	2.659	7.072	-0.669	40%
GROUP V: Human resources							
Competences and capabilities of employees involved in innovative processes	8.55	9.00	10	1.989	3.954	-2.115	23%
Competences and capabilities of managers in enterprises	**8.59**	**9.00**	**10**	**1.984**	**3.935**	**-2.151**	**23%**

Specific factors / activities	Mean	Median	Dominant	Standard deviation	Variance	Skew	Coefficient of variation
Employee attitudes resulting from the company culture, mainly in terms of promoting innovation processes and creativity of employees	7.83	8.00	10	2.273	5.164	-1.368	29%
Motivational systems for employees	7.29	8.00	8	2.531	6.407	-1.161	35%

** There are many modal values in Table 2. The smallest value is given.*

Based on respondents' assessment, the degree of implementation of the various activities related to strengthening the company's competitive advantage on a 10-point scale, for each of the five groups of factors, the dominant factor was specified (Table 2). For the Group I this is "know-how derived (from the environment) or developed internally" (mean at the 8.37 level). For Group II this is "quality and usability of relationships between companies and cooperating entities" (mean at the 7.82 level). In Group III, there dominates the factor aimed at "quality of products, services and/or projects" (mean at the 8.73 level). The leading place in the Group IV takes the factor combined with "prices of products, services and/or projects" (mean at the 6.87 level). For Group V the leading factor is "competencies and capabilities of managers in enterprises" (mean at the 8.59 level).

Based on the above results, it can be noted that the activities of companies, related to the strengthening of competitive position, are mainly aimed at increasing the quality in general – both in terms of products, competencies, and relationships. Such observations – although much simplified – can be satisfying. It follows that Polish entrepreneurs are focused on strengthening their competitive position by implementing a broadly understood quality strategy, not a strategy for reducing costs and optimizing the efficiency of manufacturing processes. This approach seems to meet the requirements of modern markets, shaped e.g. by generations of customers such as: "millennials", "Z", "alpha" (Wereda & Woźniak, 2019).

It is also worth noting here that twenty-four of all twenty-five specific factors have a left-sided skew, which shows that a major proportion of the respondents in the research sample rated the implementation of a given action at a higher level than the average mean for the action/factor. It is also worth highlighting here that the means for individual factors are high and almost all are above 6.30 points (except for two means: 5.59 and 4.44). This is a positive situation, as it indicates that respondents are more likely than average to implement actions relating to improving their competitiveness. Relatively weak positive skewness occurs only for the "shaping production volumes" factor – which is not an unfavorable situation, but merely highlights the fact that respondents do not put such action at the forefront to increase their competitiveness. The median value for each factor is also relatively high (Table 2).

However, the listed factors are characterized by relatively high values of the coefficient of variation (Table 2). The smallest value of this ratio is 19%, and the largest is 72%. This shows that the respondents' assessment of for almost every specific factor is relatively diverse. This indicates that the sample included respondents providing

"extreme" and "detached" assessments. Furthermore, this shows that, despite the high values of means, dominants, and medians for the whole research sample (*N*=150), not all companies are involved in the specific competitive strengthening activities.

The above analysis of the basic descriptive statistics for the twenty-five specific factors has been extended to the Friedman's test (Table 3). The Friedman test was used to assess the degree of compliance of the uniform ranking of given factors.

Table 3. Statistics of Friedman's test for specific factors aimed at strengthening the competitive position of high-tech enterprises (N=150)

Chi-square	811.972
df	24
Significance	0.000

Based on Friedman's rank test, it is possible to specify those specific factors which, in the opinion of respondents, most strongly influence the strengthening of the competitive position of companies (Figure 2). Within all twenty-five factors/actions, the highest rank values have: "quality of products, services and/or projects" (rank 18.31), "competences and capabilities of managers in enterprises" (rank 17.86), "competences and capabilities of employees involved in innovative processes" (rank 17.59), "know-how derived (from the environment) or developed internally" (rank 16.86), "knowledge of employees and managers about resources that can be used in innovative processes" (rank 16.37), as well as "increase in the value of intellectual capital and intangible resources" (rank 16.12). In contrast, the smallest rank values have: "the possibility of the company's impact on its market environment" (rank 10.03), "shaping the relevant industry system (by supporting and related industries)" (rank 9.71), "size and structure of production resources in the environment that can be obtained and shared" (rank 8.03), as well as "shaping production volumes" (rank 5.98) (Figure 2).

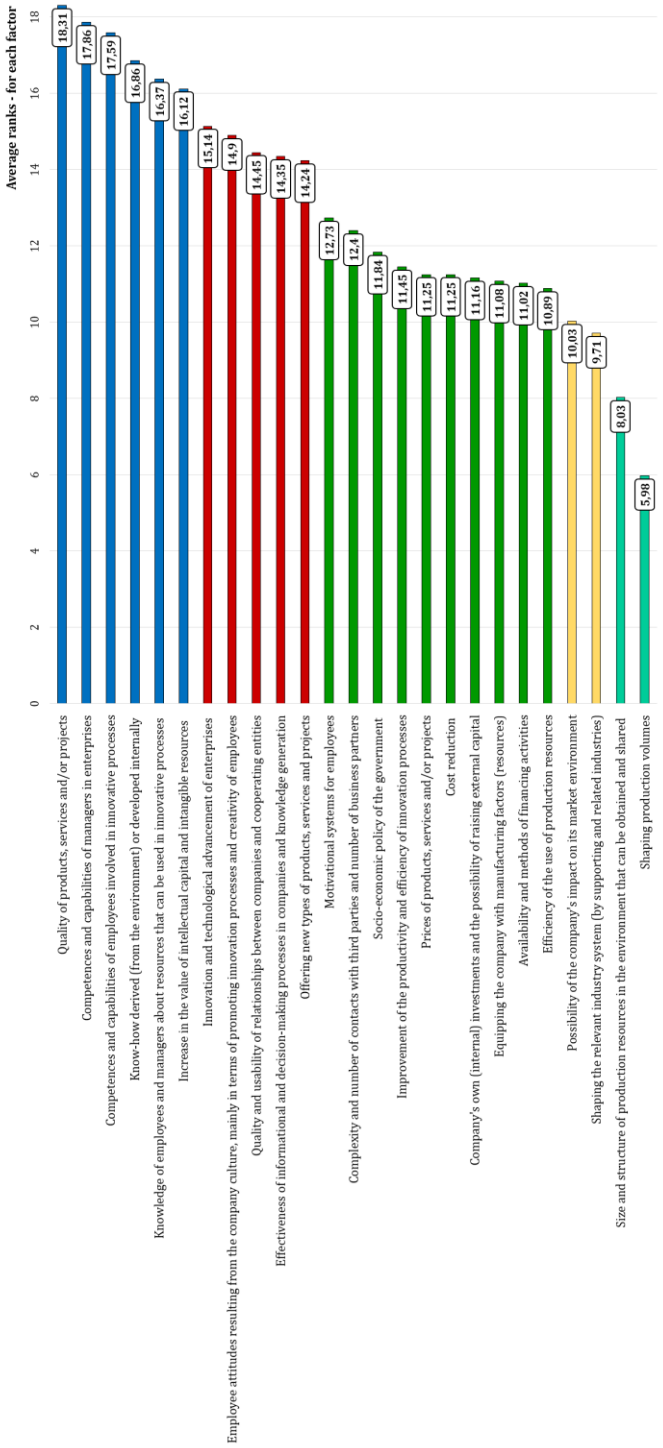

Figure 2. Average ranks for each specific factor aimed at strengthening the competitive position of high-tech enterprises (based on Friedman's rank test) (N=150)

Comparing the above results of Friedman's rank test with the average respondents' values (Table 2), it can be seen a relatively high convergence of results. Particular attention should be paid to the emergence of focusing of respondents on a pro-quality approach, competence development, and know-how at "leading" locations in both analyses. Much less "interest" of companies "enjoys" the area of production and financial management.

Based on the above analyses, Hypothesis No. 1 can be partially confirmed – because of the fact, that the research has indicated, that strengthening the competitive position of high-tech enterprises is primarily determined by a broadly understood intellectual capital, but not financial factors.

A specific compliment to the above conclusions is the analysis of profiles of mean's values for all groups of specific factors aimed at strengthening the competitive position of high-tech enterprises (Figure 3). For the factors assigned to groups I, II, IV, and V, all specific factors are characterized by average values of respondents' ratings above the average (i.e. median) for the full response/evaluation scale of respondents. This average is 5.5 points – it is a specific "limit value". Only for Group III, one factor ("shaping production volumes") has an average value of less than 5.5.

To verify Hypothesis No. 2, a composite indicator was constructed, i.e. ECSCI – Enterprise Competitiveness Strengthening Complexity Index. The methodology of constructing the ECSCI index, referring to specific factors (Table 2), will be presented. These factors (as specific generalizations of various activities) have been specified based on the analysis of the current literature on the subject, addressing the problem of strengthening the competitive position of high-tech enterprises. The composite index of ECSCI was used in the study because (Nardo, Saisana, Saltelli, & Tarantola, 2005):

- they offer the opportunity to include a large number of activities that can potentially be undertaken as part of creating a competitive position;
- they enable an attempt to undertake a holistic analysis of the complexity of strengthening the competitive position in innovative enterprises;
- they provide the basis for reliable quantification and assessment of the complexity of strengthening the competitive position;
- they enable the reduction of the dimensions of the analysis of the level of complexity of strengthening the competitive position in the enterprises surveyed.

Factors included in the study were designed to measure (on a 10-point scale) the approach of enterprises to the implementation of individual activities as part of strengthening the competitive position in the enterprises surveyed. A value of "1" meant that the activity is very rarely implemented, and the value of "10" meant that the activity is very often implemented. The reliability of the scale was analyzed using Cronbach's alpha coefficient to verify the quality of the data (Table 4). For a full list of twenty-five factors, describing the complexity of strengthening the competitive position, the value of the coefficient was 0.934. Taking into account the methodological recommendations, the obtained value can be considered sufficient.

Table 4. Alfa Cronbach factor for ECSCI (N=150)

Alfa Cronbach	Number of specific factors
0.934	25

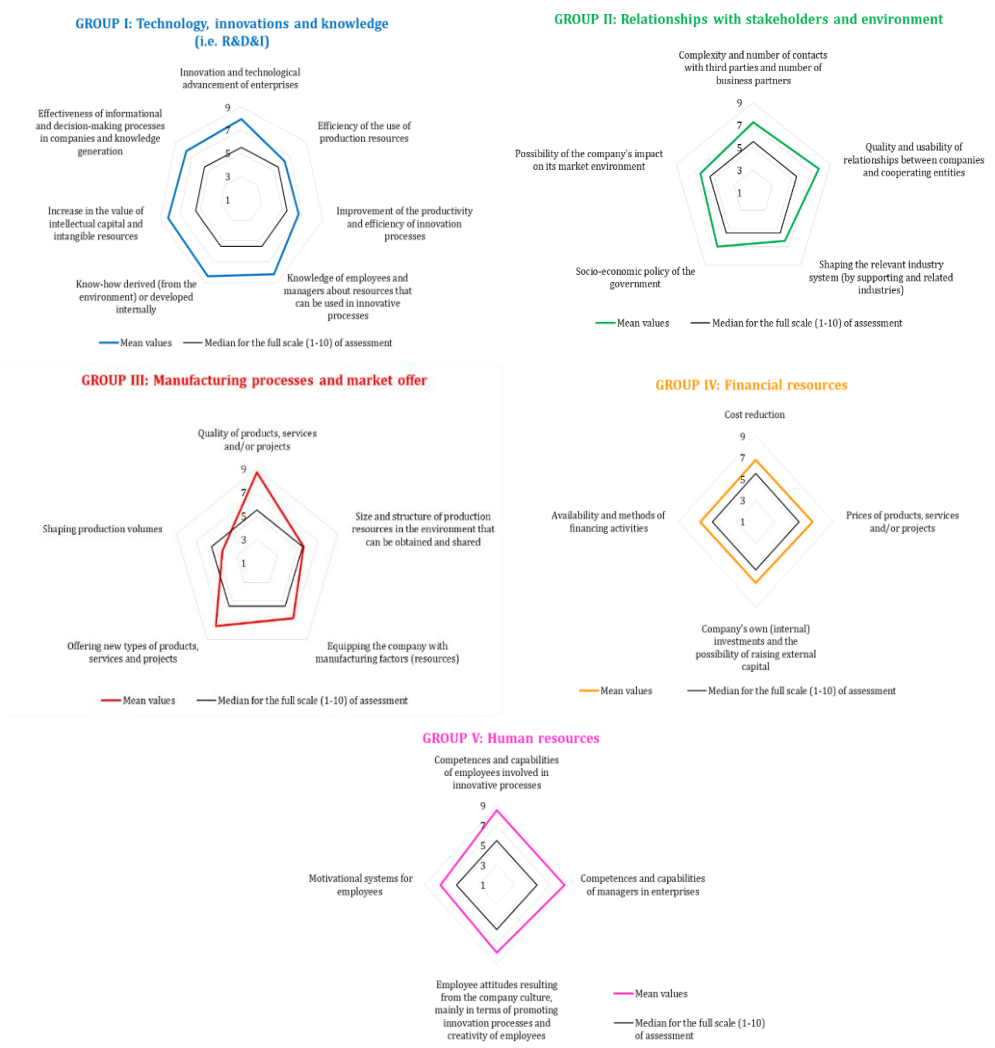

Figure 3. Profiles of mean's values for all groups of specific factors aimed at strengthening the competitive position of high-tech enterprises (N=150)

For the Enterprise Competitiveness Strengthening Complexity Index (ECSCI) construction, methodological recommendations for the development of composite indices, developed by OECD (2008), were used. The adopted ECSCI construction methodology included the following stages (Nardo, Saisana, Saltelli, & Tarantola, 2005):

1. determining the scope of measurement and the legitimacy of using the composite indicator;
2. selection of partial factors;
3. evaluation of the quality of empirical data;
4. assessment of the relationship between partial factors;
5. giving weights to the partial factors and their aggregation to the composite indicator.

The results of the implementation of the first three stages are included in Tables 2 and 4. In the assessment of the relationship between partial factors and their aggregation to

the ECSCI composite index, the factor analysis method was used (by means of the principal component analysis – PCA) (Hudrliková, 2013). The Kaiser-Mayer-Olkin coefficient and the Bartlett sphericity test were used to verify the correctness of the PCA analysis. The limit value of the KMO coefficient is commonly adopted at the level of 0.5 to 0.7 (Williams, Brown, & Onsman, 2012). In the analyzed case, the KMO coefficient assumed a value of 0.879. Bartlett's sphericity test showed that the hypothesis of uncorrelated coefficients can be rejected – the statistic of the test is 2358.001 with a significance level of less than 0.001. Further PCA analyses are justified and methodically correct (Table 5).

Table 5. KMO sample adequacy and Bartlett test (N=150)

KMO sample adequacy		0.879
Bartlett test	**Approximate chi-square**	2358.001
	df	300
	Significance	0.000

In further analysis, the method of distinguishing main component factors with Varimax rotation was applied. However, the selection of components was based on the Kaiser criterion, which assumes that the eigenvalues of factors will be greater than one. Factor analysis (matrix of rotated components – Table 6) offered the basis for qualifying twenty-five factors to six components: the sum of squares of charges after rotation was approximately 70% (Table 7).

Assigning individual factors to the components made it possible to name all components of the ECSCI indicator and to assign component weights (Table 7). The weights were normalized by the sums of the squares of charges that correspond to the part of the variance explained by the given component. The developed composite indicator ECSCI adopted the formula:

$$\mathbf{ECSCI=[0,29(C1)/8]+[0,19(C2)/5]+[0,17(C3)/4]+[0,15(C4)/4]+[0,1(C5)/2]+}$$
$$\mathbf{+[0,1(C6)/2]=[0,29(F15+F16+F17+F18+F19+F20+F21+F22)/8]+}$$
$$\mathbf{+[0,19(F7+F11+F12+F13+F14)/5]+[0,17(F8+F9+F10+F23)/4]+}$$
$$\mathbf{+[0,15(F1+F2+F3+F5)/4]+[0,1(F4+F6)/2]+[0,1(F24+F25)/2].}$$

Table 6. Matrix of rotated components (N=150)

Specific factors	**Components**					
	C1: Intellectual capital	**C2: Manufacturing processes**	**C3: Financial relationships**	**C4: Business relationships and innovations**	**C5: Market offer**	**C6: Relationships with**
F1 – Innovation and technological advancement of enterprises	0.126	0.233	0.083	**0.666**	0.125	0.270
F2 – Complexity and number of contacts with third parties and number of business partners	0.034	0.223	0.469	**0.517**	0.113	-0.031
F3 – Quality and usability of relationships between companies and cooperating entities	0.243	0.306	0.192	**0.713**	0.090	-0.054

Specific factors	Components					
	C1: Intellectual capital	C2: Manufacturing processes	C3: Financial relationships	C4: Business relationships and innovations	C5: Market offer	C6: Relationships with
F4 – Prices of products, services and/or projects	0.037	0.141	0.138	0.320	**0.777**	0.028
F5 – Quality of products, services and/or projects	0.207	0.040	0.037	**0.750**	0.292	0.140
F6 – Offering new types of products, services and projects	0.065	0.218	0.391	0.315	**0.397**	0.265
F7 – Shaping production volumes	0.140	**0.777**	0.136	0.031	0.155	0.063
F8 – Cost reduction	0.225	0.051	**0.371**	0.249	0.360	0.175
F9 – Company's own (internal) investments and the possibility of raising external capital	0.174	0.116	**0.833**	0.159	0.080	0.098
F10 – Availability and methods of financing activities	0.267	0.194	**0.805**	-0.003	0.078	0.136
F11 – Efficiency of the use of production resources	0.271	**0.769**	0.066	0.284	-0.134	0.123
F12 – Improvement of the productivity and efficiency of innovation processes	0.220	**0.656**	0.216	0.360	0.125	0.212
F13 – Size and structure of production resources in the environment that can be obtained and shared	0.227	**0.799**	0.161	0.161	0.241	0.074
F14 – Equipping the company with manufacturing factors (resources)	0.233	**0.384**	0.364	0.282	-0.008	0.047
F15 – Knowledge of employees and managers about resources that can be used in innovative processes	**0.811**	0.192	0.075	0.059	0.096	0.147
F16 – Know-how derived (from the environment) or developed internally	**0.739**	0.195	0.259	0.296	-0.205	0.139
F17 – Competences and capabilities of employees involved in innovative processes	**0.882**	0.130	0.187	0.119	-0.037	0.067
F18 – Competences and capabilities of managers in enterprises	**0.755**	0.167	0.291	0.267	-0.132	0.036
F19 – Increase in the value of intellectual capital and intangible resources	**0.642**	0.061	0.441	0.207	0.038	0.291
F20 – Employee attitudes resulting from the company culture, mainly in terms of promoting innovation processes and creativity of employees	**0.770**	0.270	0.166	-0.001	0.370	-0.008
F21 – Motivational systems for employees	**0.634**	0.217	0.097	0.054	0.438	0.030

Specific factors	Components					
	C1: Intellectual capital	C2: Manufacturing processes	C3: Financial relationships	C4: Business relationships and innovations	C5: Market offer	C6: Relationships with
F22 – Effectiveness of informational and decision-making processes in companies and knowledge generation	**0.654**	0.185	-0.097	0.180	0.376	0.178
F23 – Shaping the relevant industry system (by supporting and related industries)	0.260	0.428	**0.437**	0.118	0.155	0.335
F24 – Socio-economic policy of the government	0.178	0.113	0.084	0.095	-0.001	**0.851**
F25 – Possibility of the company's impact on its market environment	0.132	0.235	0.419	0.170	0.202	**0.639**

Method of extracting factors – principal components. Rotation method – Varimax with Kaiser's normalization. Rotation reached convergence in 7 iterations.

Table 7. Six main components of the Enterprise Competitiveness Strengthening Complexity Index (N=150)

Component	Name of component	Defined % of variance after rotation	Cumulated % of variance after rotation	Weight for ECSCI
C1	**Intellectual capital**	20.110	20.110	**29%**
C2	**Manufacturing processes**	13.039	33.148	**19%**
C3	**Financial relationships**	11.806	44.954	**17%**
C4	**Business relationships and innovations**	10.775	55.729	**15%**
C5	**Market offer**	6.990	62.720	**10%**
C6	**Relationships with the environment**	6.825	69.545	**10%**

The distribution of ECSCI values is characterized by quite weak left-sided skewness, which means that the majority of values were above average (Table 8). Considering the fact that each of the twenty-five factors included in the ECSCI structure was assessed on a 10-point scale ("1" means occasional use of the action, and "10" very frequent use), the average value of the indicator of 7.19 indicates that the average complexity of strengthening the competitive position is at a relatively high level throughout the sample. Moreover, the dominant value is at the level of 10.00, as well as the coefficient of variation is moderate – 22% (Table 8).

The "limit" (median) value in the 10-point scale is 5.5. Generally, it can be assumed that the low level of complexity of strengthening the competitive position is for the ECSCI values in the range <1; 4), the average level in the range <4; 7>, and high in the range (7 ; 10>. However, this is a contractual and standardized division, because a precise indication of the level of complexity of strengthening the competitive position requires the identification of the needs and capabilities of the given company in this respect.

Table 8. Descriptive statistics for the Enterprise Competitiveness Strengthening Complexity Index (N=150)

Descriptive statistics	Value
Mean	**7.19**
Median	7.28
Dominant	**10.00**
Standard deviation	1.55192
Variance	2.408
Coefficient of variation	**22%**
Skew	**-0.709**
Minimum value	1.14
Maximum value	10.00

Based on the above analysis, Hypothesis no. 2, which states that strengthening the competitive position of high-tech enterprises has a high level of complexity, can be positively verified (i.e. confirmed).

Taking into account the fact that the average level of complexity of strengthening the competitive position of high-tech enterprises in the whole research sample is at a relatively high level, it can be carried out a stratification of the surveyed companies (*N*=150) into three clusters: (1) low level of ECSCI, (2) average level of ECSCI, as well as (3) high level of ECSCI. For this purpose, the *k*-means analysis (including the ECSCI variable's standardization) has been applied. The study has also used the hierarchical cluster analysis – agglomerative method (tree diagram, Ward method, Euclidean distance) and has distinguished three clusters of enterprises (based on Hartigan, & Wong, 1979; Pietrzykowski, & Kobus, 2006; StatSoft, 2006; Kajstura, 2019). The multiplicity of each of the three clusters is contained in Table 9. It is worth noting, that the most numerous is the cluster of enterprises with an average level of ECSCI (81 enterprises), and the least numerous is the cluster of entities with a low level of ECSCI (11 enterprises).

Table 9. Three clusters of enterprises according to the value of ECSCI (N=150)

	Clusters		
	1: Low level of ECSCI	**2: Average level of ECSCI**	**3: High level of ECSCI**
Number of enterprises	11	81	58
Stand(ECSCI)	-2.20311	-0.36831	0.93220

Figure 4 presents the basic characteristics of enterprises for all three clusters of ECSCI. All three clusters are dominated by micro and small enterprises with the annual turnovers of up to 10 million PLN – what is rather due to the structure of the companies in the research sample. In addition, each cluster (and especially medium- and high-leveled ECSCI clusters) is dominated by entities characterized by either national or European or International scale of operation – what may indicate that the high-tech companies surveyed are focused on expanding their activities and are not "limited" to local or regional scale.

Each of the three clusters is dominated by "relatively old" enterprises. That is rather evident in the "average level of ECSCI" and "high level of ECSCI" clusters, because "mature" and developed players on the market are geared towards systematically

increasing the complexity of their competitive position. On the other hand, the significant dominance of "relatively old" enterprises in the "low level of ECSCI" cluster may be puzzling. It would seem that this cluster should be dominated by "relatively young" enterprises with a weak competitive position and only "building" their "market power". However, the dominance of "relatively old" enterprises in this cluster suggests that it is made up of players with weak market power, while at the same time being oriented towards implementing cost reduction strategies and narrowing the scale of development activities. The "high level of ECSCI" cluster is dominated by entities involved in the production of films, videos, TV programs, sound, and music recordings, research and development, software and computer sciences, as well as the IT consultancy activities. A similar situation can be noted in the "average level of ECSCI" cluster, with the difference that in this case the activities related to telecommunications and information services are at the forefront. This shows that such high-tech activities are associated with a relatively strong competition in the market and entrepreneurship is even forced to take the broad-based activities to strengthen competitive position.

The analysis of enterprises' clusters in terms of the complexity of strengthening the competitive position should also be extended by an attribute of the impact of risk management on business activities (Figure 4). This is mainly important because increasing the complexity of business competitiveness activities involves risks (e.g. in terms of market, human resources, information, finance, etc.), as well as competitive positioning, should be aimed at reducing negative risk factors in the business environment. In the following study (N=150), respondents assessed on a 10-point scale the potential impact of risk management on the development of their businesses. A value of "1" meant a very weak impact (or even no impact), and value of "10" was treated as a very strong impact. In the "low level of ECSCI" cluster, it can be observed that respondents assess the impact of risk management on the development of their businesses at a relatively low level. On the other hand, the "high level of ECSCI" cluster is the opposite– respondents' ratings are relatively high. This situation may indicate that companies that assess the potential impact of risk management on the development of the company at a higher level, take broader actions to strengthen their competitive position on the market. This may be because, on the one hand, this category of enterprises wants to reduce the negative impact of risk factors on the state of their businesses and, on the other hand, by increasing the complexity of improvement actions, they seek to create factors of opportunity for development.

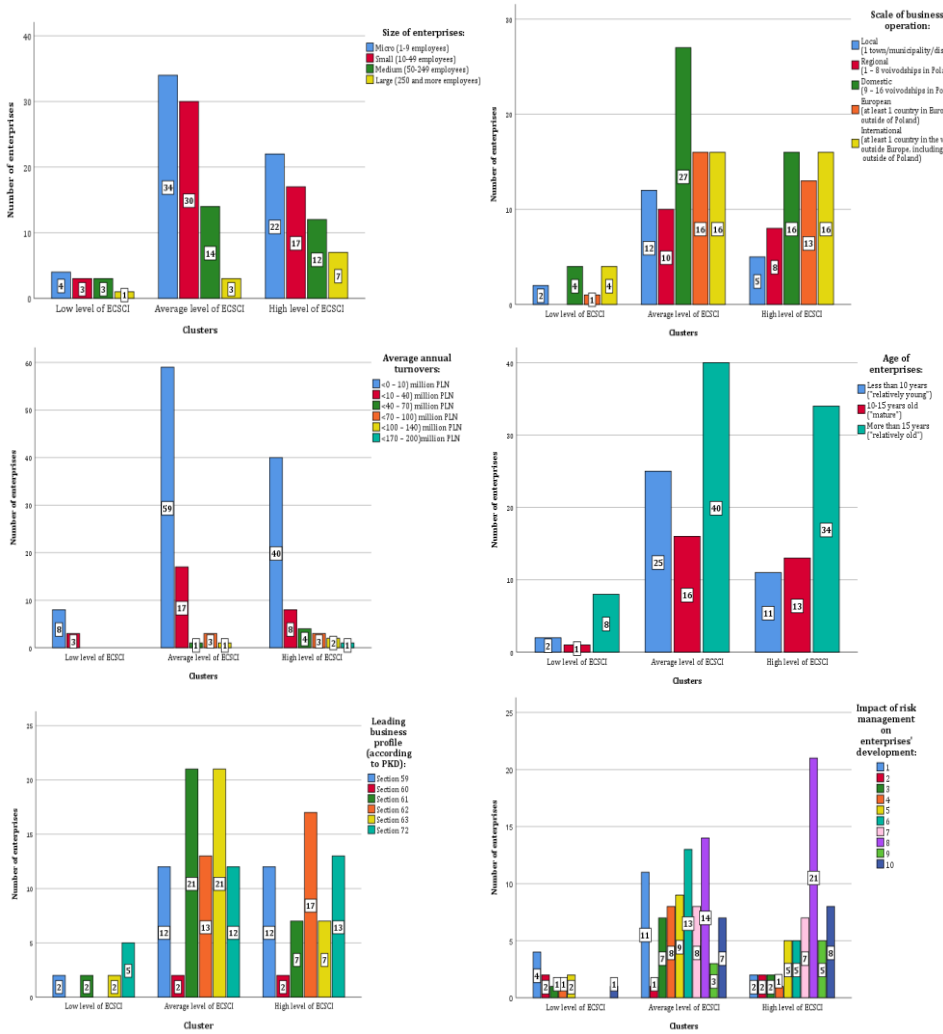

Figure 4. Characteristics of enterprises for all three clusters of ECSCI (N=150)

On the basis of the above analyses, it can be concluded that each of the three clusters is composed of a variety of enterprises. Nevertheless, it can be assumed that a higher level of the ECSCI is mainly characterized by the longer-term market players, focused on relatively large-scale activities, with a higher annual turnover, as well as perceiving the potential for risk management (Figure 4).

Discussion and conclusions

Strengthening the competitive position of today's companies – especially in high-tech industries – is not a simple and unambiguous action. It is linked to the need for these companies to "keep up" with changes in the environment and to take action reflecting the requirements and potential of that environment. Moreover, strengthening the competitive position should take the form of systemic/holistic actions.

Conducted studies have shown that factors related i.e. to development of intellectual capital, quality, innovations, knowledge, and know-how, as well as competencies of employees, play a key role in strengthening competitive position in the surveyed companies. This is consistent with the results of the researches carried out e.g. by Vargas-Hernández and Noruzi (2010), Hamel (2012), Kianto, Andreeva and Pavlov (2013), Jones, Balle, Chaize and Fiume (2019), as well as Kozielski, Olsztyński and Sroczyński (2018) – suggesting that e.g. intangible resources, knowledge and human potential significantly increase the competitive potential of contemporary enterprises.

The much less "interest" in companies "enjoys" the area of production and financial management – e.g. on the contrary to the researches of Gunasekaran, Rai and Griffin (2011), López Salazar, Contreras Soto and Espinosa Mosqueda (2012), as well as Ahmedova (2015), indicating that financial resources (and also production capacities) can, in a high level, manage the competitiveness of enterprises.

Moreover, the average complexity of strengthening the competitive position of high--tech enterprises are at a relatively high level throughout the research sample – which is consistent with the researches of Cristelli, Gabrielli, Tacchella, Caldarelli, and Pietronero (2013), as well as Tacchella, Cristelli, Caldarelli, Gabrielli, and Pietronero (2013), suggesting that shaping the competitiveness of economic units (also enterprises) is a highly complex and multi-faceted action. This can be satisfactory and shows that the surveyed high-tech companies use a rather "modern" approach to shaping competitive advantage and are aimed at systematically increasing their market position (by increasing the complexity of strengthening the competitive position).

At this point, however, it should be noted, that in the literature, there is exposed – in terms of strengthening the competitive position of high-tech enterprises – an approach aimed mainly at the managing of financial resources and shaping of manufacturing processes (see e.g. López Salazar, Contreras Soto, & Espinosa Mosqueda, 2012) – what seems to be important for the implementation of innovative processes. Moreover, contemporary shaping of the competitive position of innovative entities is combined with the development and requirements of the Revolution 4.0, mainly related to the wide use of modern ICTs in management (see e.g. Kelly, 2017; Niedzwiedskaja, 2019; Ilin, 2019). However, no such situation was reported in the companies surveyed. This may come as a surprise, but it is mainly because the majority of the entities examined operate in the broadly understood IT area (Table 1) – and thus the processes related to the development and application of ICTs are treated as a core business activity and not an action "specifically" responsible for strengthening the competitive position.

The study carried out can give practical implications – mainly in terms of specification of the list of simple guidance for managers in planning, implementation, and evaluation of activities aimed at shaping and strengthening the competitive position of high-tech companies (both in Poland and in other countries). The study indicates which types of activities companies should focus on, and what are the "secondary activities". Such knowledge can provide a basis for optimizing operations aimed at shaping the competitiveness of high-tech units in a dynamic environment, as well as for specifying a simplified catalog of management methods and techniques in this area.

The research limitations of the following study are also presented. First of all, the sample is relatively small and the surveyed enterprises have been located only in Poland – so

this study can be regarded as a pilot study and merely a substantive and methodological basis for further studies. Therefore, the results obtained cannot be extended to the whole population, neither can they constitute a basis for constructing complex "best practices" in shaping the expected level of complexity of strengthening the competitive position of high-tech enterprises. It is also worth remembering that high-tech enterprises are diverse (subjectively, thematically, and spatially) set of enterprises. These are dynamic, rapidly changing innovative enterprises – so it is difficult to specify complex "best practices" for strengthening the competitive position of high-tech enterprises. Furthermore, only respondents' opinions were examined, which may have had an impact on distorting the actual state of the situation (respondents may have shown a tendency to inflate responses in favor of a good image of the company). The study also focused solely on selected aspects of strengthening the competitive position of high-tech enterprises, mainly due to research costs. Thus, the results' analysis may seem selective and substantively narrow.

In conclusion, an attempt can be made to outline further research recommendations in the area of strengthening the competitive position of high-tech enterprises. The leading direction of research should be identifying and analyzing the basic barriers associated with strengthening the competitive position. An important research issue could also include the identification of cause and effect relationships between individual activities determining the level of complexity of strengthening the competitive position of high-tech enterprises.

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