

CHAPTER 2

Flexibility of Enterprises in Era of Industry 4.0

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Summary. Contemporary organizations face the challenge called the Fourth Industrial Revolution, which determines the changes in their functioning. The flexibility of a company is a response that facilitates adaptation to these changes, in the business environment, but also in terms of technology, customer needs or business processes. The purpose of this chapter is to systematize the knowledge about flexibility of an organization and its role in the age of Industry 4.0; to identify and classify the attributes of enterprise flexibility and to learn the opinions of the management and experts from selected companies about the importance of flexibility in functioning and building a competitive advantage. The chapter is a review, supported by a bibliometric analysis and empirical research ($N = 71$). The conclusions of the conducted research indicate that managers agree that flexibility plays a key role in the functioning of modern enterprises enabling adaptation to changes. Entities also identify restrictions for a flexible operation.

Keywords: flexibility, enterprise flexibility, business flexibility, Industry 4.0, bibliometric analysis, interview questionnaire

1. Introduction

The Fourth Industrial Revolution called Industry 4.0 has introduced a number of changes in the functioning of enterprises. They face the challenge of processing large amounts of data, the speed and accuracy of decision making, and the flexibility of production processes. The aspect of flexibility, in particular, has gained a new meaning nowadays, as the nature of production is shaped by the paradigm shift from mass production to production on demand, more customer-driven. The expectations of employees and the environment in which enterprises operate change.

Industry 4.0 is currently one of the most-debated topics among practitioners and scientists. The direction of changes during the Fourth Industrial Revolution is clearly stressed and

pointed out by various institutions, including the institutions of the European Union (European Commission, 2010, p. 23).

The authors indicate that Industry 4.0 is characterized by flexibility, an efficient use of resources, as well as the integration of customers and business partners into the business process (Vuksanović et al., 2016, p. 294). Therefore, flexibility is the ability to change, which allows an organization to remain viable. It includes changes that:

- allow an adaptation to changes in the environment that cannot be programmed (predicted),
- can be used in organizational development; that will probably appear in the environment,
- cause actions that affect the environment of an organization, which allows it to avoid having to adopt (Krijnen, 1979, p. 64).

Although Industry 4.0 is often identified solely with industry, it should be noted that the Fourth Industrial Revolution has fundamentally changed the way we live, work, and create relationships. It will affect businesses, governments, and people. Therefore, it requires a comprehensive and integrated response from all concerned parties of global opinion: the public, private, academic, and civil society sectors (Schwab, 2016).

2. Theoretic background

Enterprise flexibility is a concept that is currently widely discussed in both the world of science and technology, which is a response to the growing demand for the ability to change (Grześ-Bukłaho, 2017, p. 403). However, flexibility is not just a philosophy, but a cultural requirement for an efficient functioning of modern enterprises (Singh et al., 2019, p. 41).

The concept of flexibility has been defined by scientists and practitioners from various fields. There are many definitions of organizational flexibility in the literature on the subject (Buła & Ziębicki, 2011, pp. 171–172; De Toni & Tonchia, 2005, pp. 526–527; Krupski, 2008, pp. 9–26; Leeuw & Volberda, 1996, pp. 121–122). In general, organizational flexibility means the “capacity to respond to environmental changes” (Palanisamy & Sushil, 2003, p. 262). Organizational flexibility can also be defined as “the ability of the organization to adapt to substantial, uncertain, and fast-occurring (relative to required reaction time) environmental changes that have a meaningful impact on the organization’s performance” (Aaker & Mascarenhas, 1984, p. 74).

Because the changes can have their source in both internal and external environments, Volberda (1999, p. 42) distinguishes internal and external flexibility (Fig. 1). At the same time, he defines internal flexibility as the ability of management to adapt to environmental requirements, while external flexibility is the ability of management to exert an impact on the environment, which makes an enterprise less sensitive to environmental changes (Volberda, 1996, p. 362).

According to Golden and Powell (2000, p. 373), organizational flexibility should be explored in four dimensions, including:

- temporal – related to the time during which an organization must respond to changes,
- range – related to the adaptation of individual elements of an organization to changes in the environment,
- intention – related to choosing the right way to respond to changes,
- focus – related to the selection of the appropriate area of the organization’s impact.

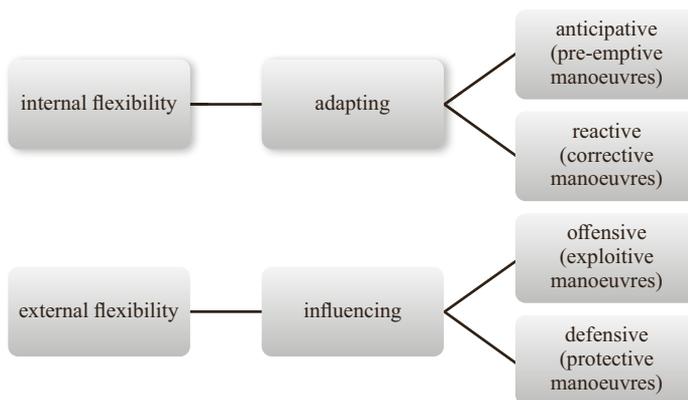


Fig. 1. Distinction of internal and external flexibility

Source: (Volberda, 1999, p. 42)

As Sushil (2013, p. 128) indicates, various types of flexibility can be distinguished in an enterprise, among others: strategic flexibility, organizational flexibility, operational flexibility, financial flexibility, marketing flexibility, production flexibility, IT systems and supply chain flexibility, technology management flexibility, etc. In addition, each of these categories can be further divided into specific types, for example, production flexibility includes product flexibility, process flexibility, work flexibility, tool flexibility, etc.

When analysing the importance of flexibility for enterprises operating in the era of the Fourth Industrial Revolution, one can refer to the opinion of Brillman (2002, p. 391), according to which a perfectly flexible organization must have the following features:

- the ability to keep up with changes in the environment and the ability to progress faster than competitors,
- an effective feedback system from customers, as well as a quick response to their expectations,
- short decision-making processes resulting from flattening the structure and strengthening the position of employees,
- employees accustomed to changes, although, as the author indicates, this feature is the most difficult one to implement.

3. Methods

The conducted research was carried out in two stages. The first stage included a bibliometric analysis. Its purpose was to identify the attributes of flexibility of modern enterprises.

There are different approaches to conducting research based on bibliometric analysis. For the purposes of this study, the approach presented by Glińska and Siemieniako (2018, p. 47) was adopted, covering the following stages: (1) a selection of the research subject, (2) a bibliometric analysis of papers selected as the research subject, (3) a frequency analysis of keywords indicated by authors of selected papers, (4) a content analysis – examination of connections/links between keywords. The research process is presented in Figure 2.

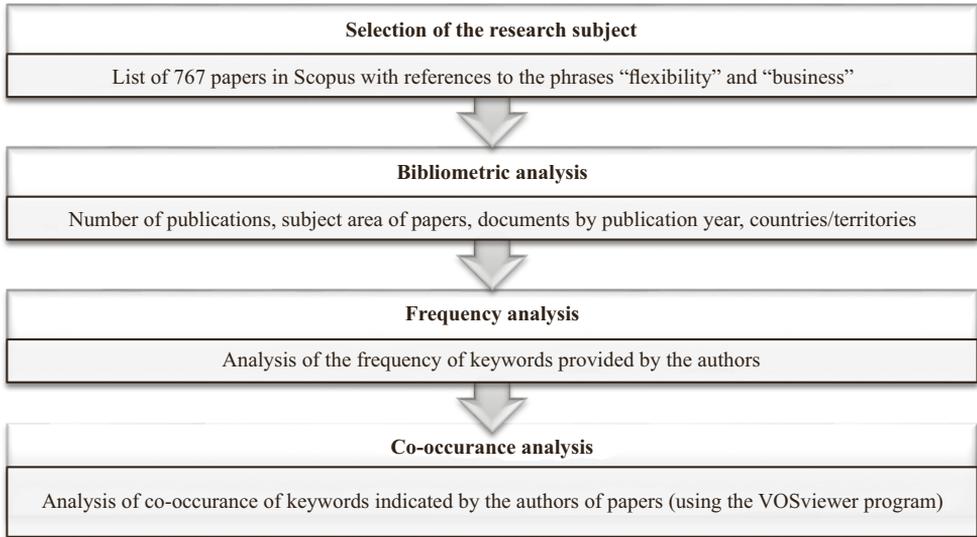


Fig. 2. Stages of research process of bibliometric analysis
 Source: own study based on (Glińska & Siemieniako, 2018, p. 47)

A bibliometric analysis is now a well-established concept in science and an integral part of the research assessment methodology (Ellegaard & Wallin, 2015, p. 1809). It is a general interdisciplinary tool that can be used by researchers from various fields of science (Glänzel, 2003, p. 5).

There are also two main procedures for a bibliometric analysis: a performance analysis and science mapping (Gaviria-Marin et al., 2019, p. 196). For the purposes of the current research, a performance analysis was carried out against the background of information in the Scopus database.

Science mapping is a general process of the analysis and visualization of domains (Chaomei, 2017, p. 3) that allows for presenting dynamic and structural aspects of research, showing the relationships of various documents, entities, authors, and fields (Cobo et al., 2011, pp. 1382–1383; Small, 1999, p. 799). For this purpose, various techniques and software are used. For the needs of the current research, the VOSviewer software tool was chosen, one which is used to create, visualize, and explore bibliometric science maps (Van Eck & Waltman, 2011)

The second stage of the research included empirical research. The literature on the subject indicates that flexibility is a managerial task (Sharma et al., 2010, p. 51). At the same time, it is also emphasized that Industry 4.0 contributes to rapid changes in the management systems and competences of an enterprise and its environment (Umachandran et al., 2018, p. 140).

Therefore, the subject of the empirical research in this chapter were the opinions of the management and experts from selected companies about the role of flexibility in the functioning of modern organizations, the impact of flexibility on building their competitive advantage and restrictions on the flexible functioning of an enterprise.

The study included managers and experts of companies operating in Poland in the Podlaskie Voivodeship. The respondents were employed in companies having the head office in the voivodeship, as well as in branches operating in the indicated area of the country.

The research tool used was an interview questionnaire, the technique is classified as a standardized technique based on direct communication between the researcher and the respondent. The first step in organizing the study was to conduct a pilot study. This study was conducted in October 2019. Five entrepreneurs participated in it. The proper tests were conducted in October-December 2019. The analysed research sample amounted to 71 people, top, middle and lowest level managers as well as experts from selected companies.

4. Results

4.1. The attributes of enterprise flexibility in scientific literature

One of the goals assumed in the study is to identify and classify the attributes of enterprise flexibility in the scientific literature. The study is exploratory and has been carried out using the bibliometric analysis technique, using the VOSviewer software (www.vosviewer.com). The references were obtained from the Scopus database (www.scopus.com).

The keywords ‘flexibility’ and ‘business’ were used for the purposes of the research. A total of 767 publications matched the filters. A retrospective of the thematic scope began in 1974. However, the interest of researchers began to grow in the early 2000s. As Figure 3 shows, in 1974–2000 the number of publications ranged from 0 to 6 a year; in the years 2001–2007 it ranged from 7 to 35; from 2008 to 2013 it clearly increased and ranged from 52 to 62; from 2014 to 2019 it remained at 39 to 49 publications a year.

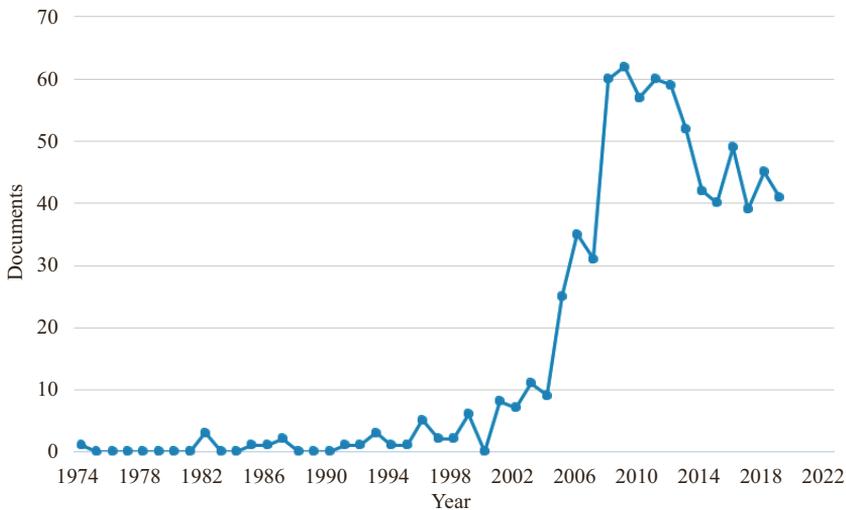


Fig. 3. Distribution of documents (articles, conference papers, reviews, book chapters, short surveys, books, conference review) by publication year

Source: Scopus database

Considering the subject area (Fig. 4), the documents concerned: “Computer Science” (30.0%), “Engineering” (17.9%), “Business, Management and Accounting” (17.5%), “Decision Sciences” (10.5%), Mathematics (8.8%), “Social Sciences” (4.7%), “Economics, Econometrics and Finance” (3.0%), “Energy” (1.9%), “Environmental Science” (1.3%), “Material Science” (1.2%), “Other” (3.2%).

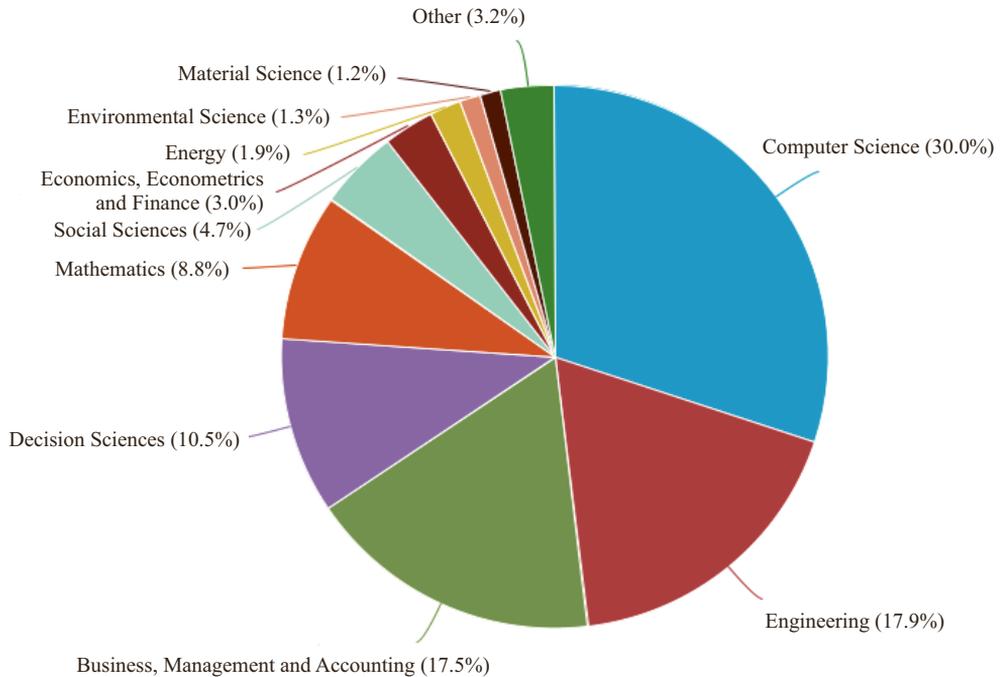


Fig. 4. Distribution of documents by subject area

Source: Scopus database

The largest number of publications in the topic of business flexibility relates to Germany (123 publications), United States (112 publications), followed by China (88 publications). In general, the top-10 countries represent European and Asian countries plus Australia (Fig. 5).

Within the analysed area, the Scopus database contains the publications from about 62 countries/territories of origin plus undefined in the topic of business flexibility.

The option of a co-occurrence of a keyword was chosen for further research using the VOSviewer tool. In total, 5494 keywords were generated. In order to place the analysis in the scope of Industry 4.0 to a greater extent, the decision was made to narrow down the analysed period to 2011–2019, i.e., the time after the concept of the Fourth Industrial Revolution had been presented. As a result, 430 publications matched the filters, and 3350 keywords were generated.

A minimum occurrence of 8 was selected; as a result, the number of keywords was limited to 91. Then, keyword filtering was used to sort the information obtained in the Scopus

database. Keywords excluded from the list were those not related to the area being analysed, and related to the type of study, field of study, which had little impact on the topic of another search.

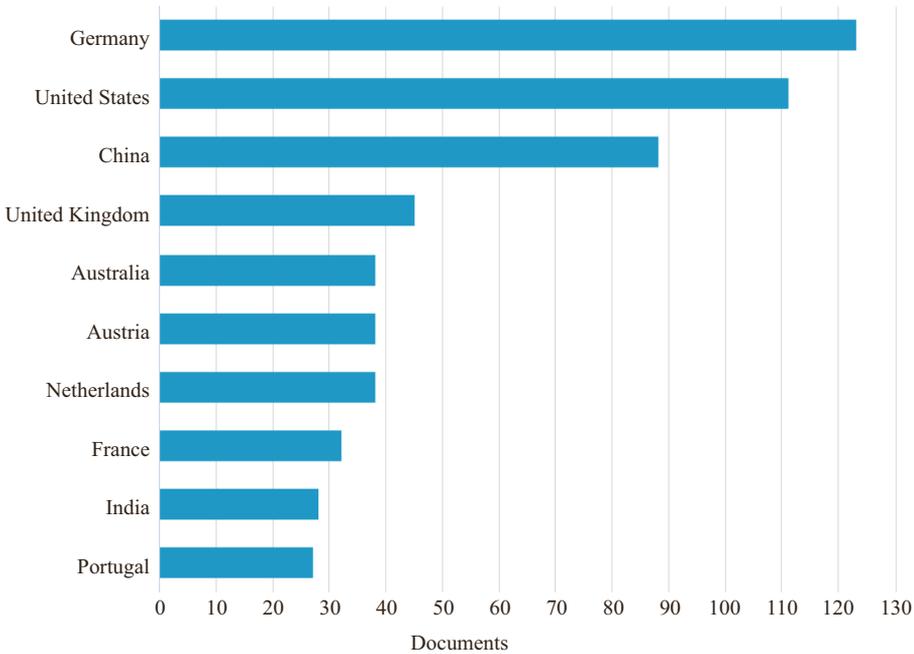


Fig. 5. Distribution of documents by country of origin

Source: Scopus database

As shown in the figure below (Fig. 6), the most common keywords were flexibility, business process, business process management. Four clusters were then identified, all closely linked.

The keywords mapping shows that though business flexibility is supposed to be the carriers of specific attributes, in the scientific literature they are rather approached from the general perspective. According to VOSviewer analysis (Tab. 1), five clusters can be formed with the total of 72 items. The first cluster contains 34 items, the second – 14 items, the third – 14 items, the fourths – 10 items.

All clusters contain differences and similarities. It can be assumed that the first cluster is focused on business models, flexibility, and competition. The second cluster is thematically oriented on business process and process flexibility, management, and web services. The third cluster covers issues of process flexibility, systems, data processing. The fourth cluster is information oriented.

The analysis of science mapping shows that the research focuses on managing business flexibility in various areas of an enterprise and refers to technology, information, data processing, IT systems, i.e., areas that are also the focus of Industry 4.0.

Table 1 cont.

3 (blue)	14	administrative data processing, artificial intelligence, business process flexibilities, business process flexibility, business process management, business process model, degree of flexibility, enterprise resource management, modelling languages, process design, process engineering, process flexibility, systems analysis, systems engineering
4 (yellow)	10	business flexibility, information management, information systems, information use, it infrastructure flexibility, it infrastructures, knowledge management, management science, outsourcing, project management

Source: own elaboration based on Scopus database

4.2. Results of empirical research

Qualitative research focuses around inquiring into “what?”, “how?” and “why?”. Thus, the questions allow to develop explanations that apply to a given environment, in a given situation and time.

In the conducted interviews, the respondents were asked to specify the role of flexibility in the functioning of companies in the industry they operate in. The selected opinions are presented in Table 2.

Table 2. Role of flexibility in the functioning of modern enterprises

“The organization I work for is flexible for changes, constantly strives to improve the systems employees us to work with, adapts to rapidly changing legal regulations, strives to improve customer satisfaction with the services offered, strives for technological progress, constantly extends the offer for both individual and institutional customers” (expert; service sector; banking industry; medium-sized enterprise)
“Flexibility in the company is about adapting all processes to the needs of customers” (mid-level manager; service sector; call centre industry; small enterprise)
“The flexibility of my company plays the most important role. I make a profit in a company manufacturing and selling windows, each order may be different, and the company must be able to complete each individual order to stay on the market” (mid-level manager; production sector; construction industry; medium enterprise)
“In my company, flexibility consists of responding to changes introduced by monitored competition” (mid-level manager; service sector; call centre industry; small enterprise)
“A company should be able to adapt to changes in the market [...] flexibility in my company plays a very important role, because it must meet new expectations of our customers and be ready for changes introduced by the competition” (head of the lowest level; trade sector; drugstore industry; large enterprise)
“Flexibility in the trade sector plays an important role. Many times, thanks to the flexibility of sales conditions, it is possible to achieve a higher margin, higher sales” (expert; sector handle; industrial products industry; large enterprise)
“Flexibility plays a very important role, allows freedom of thought and action, new ideas are created, we act more creatively” (expert; production sector; medium enterprise)
“Flexibility is an instrument for reducing risk and uncertainty about the success of an investment/activity. It affects the organization of production, human resource management, finance, information flow system” (mid-level manager; production sector; construction industry; micro enterprise)

Summing up the statements of the respondents, they mostly agreed on flexibility playing a key role in the functioning of modern enterprises. They have repeatedly pointed out that “a flexible enterprise can grow faster and make more profits”. Flexibility:

- “[...] is important due to frequent changes in the range of manufactured products”;
- “[...] is the basis for staying on the market”;
- “allows a company to grow, respond to crises and opportunities from the environment”;
- “enables meeting customer expectations”;
- “contributes to increasing competitiveness on the market”.

The respondents were also asked to express an opinion on the extent to which flexibility contributes to building a competitive advantage in the respective industries. The selected opinions are presented in Table 3.

Table 3. Role of flexibility in building competitive advantage of enterprises

“We are able to achieve greater customer satisfaction through flexibility. Flexible companies are able to meet customer expectations in a competitive market through punctuality, product specification, personalization” (lowest level manager; production sector; plastic processing industry; large enterprise)
“Flexibility enables adaptation to the changing regulations, customer expectations and technological development” (mid-level manager; service sector; insurance industry; large enterprise)
“Flexibility provides the ability to react faster to changes in external and internal environment. It gives a better chance to cope with crises” (expert; trade sector; e-commerce industry; medium enterprise)
“If we are able to complete an unusual order from a customer, we are ahead of the competition that focuses on standard production” (mid-level manager; production sector; industry: machinery production; medium enterprise)
“Flexibility allows production processes to be streamlined” (lowest level manager; trade sector; catering industry; large enterprise)
“The flexibility of setting production processes allows for quick production shifts and a quick response to changes” (top manager; production sector; industry: furniture production; large enterprise)
“Flexibility in my industry builds a competitive advantage to a large extent because the company knows how to make changes based on what customers will want in the future. It allows us to predict their preferences and flexibility in this case helps a lot” (lowest manager; trade sector; drugstore industry; large enterprise)
“Flexibility affects product quality and production time compared to competitors” (expert; manufacturing sector; industry: agricultural machinery; large enterprise)

In addition, the respondents pointed out that thanks to flexibility:

- “we don’t just limit ourselves to serial orders”;
- “the company adapts to the needs of the market and customers”;
- “order processing times are shortened”.

The respondents also expressed an opinion on restrictions (dangers) for a flexible operation of an enterprise, indicating that there could be:

- “financial restrictions”,
- “[...] conservative approach of the board”,
- “a lack of willingness to introduce a new idea by companies that do not want change, are afraid of them (they are afraid of employees’ reactions)”,
- “restrictions in the area of the organizational structure”,
- “lack of specialized staff”,
- “reluctance to change”,
- “legal regulations”,
- “lack of stock”.

In addition, they pointed out that pre-emptive flexibility runs a greater risk and that the company could “overdo” with the adapting to individual customer expectations, which would have a significant impact on costs.

5. Conclusions

This chapter was intended to widen the knowledge on organizational flexibility and its role in the era of the Fourth Industrial Revolution. The chapter reviewed literature in the area of the analysed issues and performed a bibliometric analysis, which enabled the identification and classification of the attributes of flexibility of modern enterprises. The results obtained with scientific mapping indicate that the research focuses on managing business flexibility in various areas of an enterprise and refers to technology, information, IT systems, data processing, i.e., the areas that Industry 4.0 also focuses on.

The analysis of literature and the bibliometric analysis were also supported by empirical research. The research tool used was an interview questionnaire. The study was addressed to top, middle and lowest level managers as well as experts from selected enterprises ($N = 71$).

Based on the results of the research, the following conclusions were made:

- the respondents mostly agreed that flexibility plays a fundamental role in the functioning of modern enterprises, both in the production, trade and services sectors,
- they pointed to various areas of the operation of an enterprise in which flexibility plays an important role, including: technology, information flow, systems, production, adaptation to customer expectations, human resource management, etc.,
- they saw the role of flexibility in building a competitive advantage through a faster adaptation to technological development, customer requirements (also in the area of atypical, individual orders), and changing legal regulations,
- the respondents also pointed to limitations for a flexible operation of an enterprise, mainly in the internal environment, such as: reluctance to change, conservative approach, lack of qualified employees.

It is recommended that enterprises in this area not only take individual actions in response to competition, but that they focus on analysing areas that require flexibility, and then develop ways to implement and increase them. It is also recommended to prepare employees and ensure their participation in the process of making an enterprise more flexible.

References

- Aaker D., Mascarenhas B., 1984. *The need for strategic flexibility*. “Journal of Business Strategy”, vol. 5(2), pp. 74–82; <https://doi.org/10.1108/eb039060>.
- Brilman J., 2002. *Nowoczesne koncepcje i metody zarządzania*. Warszawa, Polskie Wydawnictwo Ekonomiczne.
- Buła P., Ziębicki B., 2011. *Organizational flexibility as a challenge of contemporary management. Determinants and methods of measurement*. “Acta Commercii”, vol. 11(1), pp. 171–180; <https://doi.org/10.4102/ac.v11i1.159>.
- Chaomei Ch., 2017. *Science Mapping: A Systematic Review of the Literature*. “Journal of Data and Information Science”, vol. 2(2), pp. 1–40; <https://doi.org/10.1515/jdis-2017-0006>.
- Cobo M.J., López-Herrera A.G., Herrera-Viedma E., Herrera F., 2011. *Science Mapping Software Tools: Review, Analysis, and Cooperative Study Among Tools*. “Journal of the American Society for Information Science and Technology”, vol. 62(7), pp. 1382–1402; <https://doi.org/10.1002/asi.21525>.
- De Toni A., Tonchia S., 2005. *Definitions and linkages between operational and strategic flexibilities*. “Omega. The International Journal of Management and Science”, vol. 33(9), pp. 525–540; <https://doi.org/10.1016/j.omega.2004.07.014>.
- Ellegaard O., Wallin J.A., 2015. *The bibliometric analysis of scholarly production: How great is the impact?*. “Scientometrics”, vol. 105, pp. 1809–1831; <https://doi.org/10.1007/s11192-015-1645-z>.
- European Commission, 2010. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Digital Agenda for Europe*. Brussels 2010, COM (2010) 245, pp. 1–48.
- Gaviria-Marin M., Merigó J. M., Baier-Fuentes H., 2019. *Knowledge management: A global examination based on bibliometric analysis*. “Technological Forecasting & Social Change”, vol. 140, pp. 194–220; <https://doi.org/10.1016/j.techfore.2018.07.006>.
- Glänzel W., 2003. *Bibliometrics as a research field: A course on theory and application of bibliometric indicators*. Course Handouts.
- Glińska E., Siemieniako D., 2018. *Binge drinking in relation to services – bibliometric analysis of scientific research directions*. “Engineering Management in Production and Services”, vol. 10(1), pp. 45–54; <https://doi.org/10.1515/emj-2018-0004>.
- Golden W., Powell P., 2000. *Towards a definition of flexibility: In search of Holy Grail?*. “Omega. The International Journal of Management”, vol. (28)4, pp. 373–384; [https://doi.org/10.1016/S0305-0483\(99\)00057-2](https://doi.org/10.1016/S0305-0483(99)00057-2).
- Grześ-Bukłaho J., 2017. *The importance of flexibility in the functioning of enterprises in the construction industry*. [In:] V. Potocan, P. Kalinic, A. Vuleti (eds.), *Economic and Social Development: 26th International Scientific Conference on Economic and Social Development – “Building Resilient Society”, Zagreb, 8–9 December 2017* [Book of Proceedings], pp. 403–411.
- Krijnen H.G., 1979. *The Flexible Firm*. “Long Range Planning”, vol. 12(2), pp. 63–75; [https://doi.org/10.1016/0024-6301\(79\)90074-8](https://doi.org/10.1016/0024-6301(79)90074-8).
- Krupski R., 2008. *Elastyczność organizacji*. Wydawnictwo Uniwersytetu Ekonomicznego, Wrocław.

- Leeuw A.D., Volberda H.W., 1996. *On the concept of flexibility: A dual control perspective*. "International Journal of Management Science", vol. 24(2), pp. 121–139.
- Palanisamy R., Sushil, 2003. *Achieving Organizational Flexibility and Competitive Advantage Through Information Systems Flexibility: A Path Analytic Study*. "Journal of Information & Knowledge Management", vol. 2(3), pp. 261–277; <https://doi.org/10.1142/S0219649203000358>.
- Schwab K., 2016. *The Fourth Industrial Revolution, what it means and how to respond*; <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond> [20.01.2020].
- Sharma M.K., Sushil, Jain P.K., 2010. *Revisiting Flexibility in Organizations: Exploring its Impact on Performance*. "Global Journal of Flexible Systems Management", vol. 11(3), pp. 51–68; <https://doi.org/10.1007/BF03396587>.
- Singh R., Modgil S., Acharya P., 2019. *Assessment of Supply Chain Flexibility Using System Dynamics Modeling*. "Global Journal of Flexible Systems Management", vol. 20(4), pp. 39–63; <https://doi.org/10.1007/s40171-019-00224-7>.
- Small H., 1999. *Visualizing science by citation mapping*. "Journal of the American Society for Information Science", vol. 50(9), pp. 799–813; [https://doi.org/10.1002/\(SICI\)1097-4571\(1999\)50:9<799::AID-ASI9>3.0.CO;2-G](https://doi.org/10.1002/(SICI)1097-4571(1999)50:9<799::AID-ASI9>3.0.CO;2-G).
- Sushil, 2013. *Strategic Flexibility: The Fountainhead*. [In:] Sushil (ed.), *Flowing Stream Strategy: Leveraging Strategic Change with Continuity*. Springer, India, pp. 25–35; https://doi.org/10.1007/978-81-322-0726-9_3.
- Umachandran K., Jurčić I., Corte V., Ferdinand-James D., 2018. *Industry 4.0: The New Industrial Revolution*. [In:] N. Dey, S. Tamane (eds.), *Big Data Analytics for Smart and Connected Cities*. IGI Global, India, pp. 138–156; <https://doi.org/10.4018/978-1-5225-6207-8>.
- Van Eck N., Waltman L., 2011. *Text mining and visualization using VOSviewer*. ISSI Newsletter; https://www.researchgate.net/publication/51936810_Text_mining_and_visualization_using_VOSviewer [22.01.2020].
- Volberda H.W., 1996. *Toward the Flexible Form: How to Remain Vital in Hypercompetitive Environments*. "Organization Science", vol. 7(4), pp. 359–374; <https://doi.org/10.1287/orsc.7.4.359>.
- Volberda H.W., 1999. *Building the Flexible Firm: How to Remain Competitive*. Oxford University Press, USA; <https://doi.org/10.1093/acprof:oso/9780198295952.001.0001>.
- Vuksanović D., Ugarak J., Korčok D., 2016. *Industry 4.0: the Future Concepts and New Visions of Factory of the Future Development*. [In:] Sinteza 2016 International Scientific Conference on ICT and E-Business Related Research [Conference Paper], pp. 293–298; <https://doi.org/10.15308/Sinteza-2016-293-298>.