

Analysis of Types, Intensity, Methods and Effects of Process Innovations

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ABSTRACT

Purpose: The purpose is to provide knowledge about the intensity and types of process innovation in the business sphere, as well as the representation of entities involved in creating innovation, and about the effects of process innovation.

Methodology/Approach: Data from the statistical survey on innovation activities carried out by the Czech Statistical Office according to the Eurostat methodology were used, supplemented by some results of the own questionnaire survey. Methods of sorting, size arrangement, structure analysis, comparison, context analysis were used.

Findings: The large enterprises were significantly more active than SMEs in implementing process innovations, as well as foreign affiliates were more active than domestic enterprises. Besides typical competitive advantages of process innovation benefits the benefits in ecology, occupational safety and reduced labour demand have also proved to be numerous. Co-operation of enterprises with universities has proved to be low. The lack of skilled workers and financial resources were the main obstacles to the innovation activity of enterprises.

Research Limitation/implication: The research is focused on companies in the Czech Republic.

Originality/Value of paper: The actual contribution of the article lies in the purpose-oriented comparison of process innovations between fields of enterprise activities, especially in the area of logistics innovations, in some aspects the comparison of process-innovation activities according to the size of the company and the ownership of the company.

Category: Research paper

Keywords: innovation activity; process innovations; collaboration on innovation; effects of innovation; innovation in logistics

1 INTRODUCTION

Innovation is a prerequisite for a successful business in a highly competitive business environment (Tidd and Bessant, 2013; Veber et al, 2016). Given the growing competition, only a reduction in costs is losing momentum. On the other hand, to survive and gain a significant market position, businesses undertake innovative activities that focus on product, process or marketing and organization (Zelený, 2012). The term “process innovation” means according to the Oslo Manual (OECD, 2005) the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and / or software. The Czech Statistical Office methodology (CZSO, 2018) adds that this involves the introduction of a new or substantially improved method of production or service provision, including their distribution, storage, and the provision of business support activities such as maintenance, purchasing, accounting or information systems used. It involves a significant change in the technology, equipment or software used to improve the quality, efficiency or flexibility of production or supply activities, or to reduce the environmental burden or security risks.

Process innovations are defined in the domestic and foreign professional literature in a similar way as in the Oslo manual (OECD, 2005), while the author's point of view is emphasized. Veber et al. (2016) emphasize the introduction of technically new or significantly improved production methods, Tidd and Bessant (2013) the change the way the products are produced, services provided and delivered. Schumpeter (1987) defines the introduction of a new production process into production or type of sale or purchase. The theoretical principle of chaining innovation according to Valenta (2001) implies that the need for technological innovation is caused either by the innovation of the relevant product created by the technology or by the need to address the inefficiency of production of existing products.

In the area of process innovation, there is an urgent societal demand for green solutions, and there is a need for improved but also more cost-effective technologies and processes, as well as technologies that will help address labor shortages and improve productivity. Current directions of development of process innovations are digitization, automation, use of biotechnology and nanotechnology, use of renewable energy sources. For some products, the principles underpinning their functions are changing dramatically, which again requires the emergence of new production technologies. As stated by Mařík et al. (2016), cybernetics and artificial intelligence are key technologies for addressing systems called Industry 4.0.

Process innovations concern not only production but also logistics and support processes. Logistics innovations offer great potential benefits not only for supply flexibility but also for ecology. For example, Björklund and Forslund (2018) examined good logistics practices and suggested the classification of sustainable logistics innovations.

Creating process innovations has high demands not only on knowledge but also on research infrastructure, which can be difficult for companies to access, especially for SMEs. That is why cooperation with other companies, research institutes and universities is appropriate. Technology platforms within regions whose potential is being addressed by Urbančíková (2011) can become beneficial.

In this article specially the process innovations realized in the business sphere in the Czech Republic will be analyzed. The research will be mainly focused on comparing the relative frequencies of process innovation in selected branches of the economy, as well as on the representation of individual types of process innovation, analysis of cooperation in innovation development and identification of areas where the effects of process innovation are manifested.

2 METHODOLOGY

According to the broader concept of innovation described in the Oslo manual (OECD, 2005), we distinguish four main types of innovation: product, process, marketing and organizational. Product and process innovations are collectively called technical innovations. Marketing and organizational innovation are non-technical innovations.

2.1 Subject of the Research

Research activities are focused on innovation activities in the area of process innovations. Process innovations are divided according to CZSO (2018) into the following three groups. The first group consists of innovations in production and service delivery. The second group includes innovations in supply, storage, distribution, and other logistics activities, and finally, the third group includes innovations in business support activities (see Fig. 1).

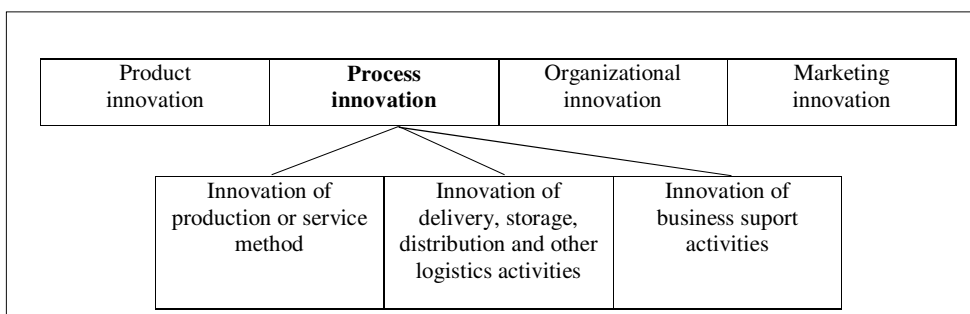


Figure 1 – Innovation Classification And Process Innovation Categories (Author's Elaboration According to Classification of OECD, 2005)

2.2 Input Data

As the basis for the analysis, the authors of the article used data collected by the Czech Statistical Office as part of a regular survey conducted according to a methodology unified across the EU in two-year cycles. Based on these data, partial sorting and purpose-oriented probes were carried out, the subject of which are process innovations. The last survey concerned the period 2014-2016 and its results were published by the Czech Statistical Office in June 2018. The results of a more recent survey dealing with innovation activities in 2017-2018 have not yet been published by the Czech Statistical Office.

The conduct of this inquiry is mandatory and coordinated by Eurostat. The Czech Statistical Office used a harmonized model questionnaire of Eurostat to collect data on business innovation activities, which the Czech Statistical Office translated into a national (brief) version of the questionnaire with several national questions. 6,638 reporting units of the business sector from selected areas of industry and services (financial and non-financial) with at least 10 employees based in the Czech Republic were addressed (CZSO, 2018). The net rate of return (number of reports used) was 85% (CZSO, 2018).

The questionnaire and the results prepared by the Czech Statistical Office in tabular form (showing mostly the shares of enterprises with the given response in %) are published in CZSO (2018) broken down by the following aspects: CR as a whole, by business ownership, by enterprise size according to number of employees, by field of business (sections by CZ-NACE) and by region of cohesion (CZ-NUTS).

The above-mentioned data source was supplemented in some investigated aspects by selected results of our own research questionnaire survey, which was carried out in 2019. In the research sample were 60 enterprises from Moravian and Silesian region of the Czech Republic

2.3 Methodology of Data Processing

The analysis carried out by the authors of this article sought answers to the following research questions:

1. What is the proportion of enterprises that have carried out a process innovation and whether these shares differ according to the ownership of the enterprise and the size of the enterprise?
2. How were individual types of process innovation and especially logistic innovations in individual sectors or branches represented?
3. In which areas did the results of process innovations show and how they differ according to the field of business?
4. Who participated in the development of the innovated processes and how does the representation of individual actors differ according to the ownership, size or field of activity of the company?

The results of the questionnaire survey of 60 MSK enterprises will be used in this article to only find answers to questions concerning the innovation strategy of enterprises, the ways of innovation development, and barriers to innovation activities.

The following methods were used for data analysis: sorting and size arrangement according to the degree of representation of innovative enterprises, according to the size of benefits, etc., comparison method, context-specific analysis along the main supply chain and in selected fields of activity.

3 RESULTS OF THE ANALYSIS

The results of the statistical survey of innovations for the period 2014-2016 show that the share of enterprises in the Czech Republic carrying out all types of innovation activities reached 46.3%. It means that the share of innovative enterprises in the Czech Republic is below the EU average.

In-house research has shown that to achieve business innovativeness, partial changes are made to a product or process that is new to the business (42.6%) than new to the market.

According to CZSO data, the process innovations addressed in this article were implemented in 27.7% of companies in 2014-2016.

3.1 Frequency Analysis of Enterprises with Process Innovation

As shown in Fig. 2, the relative frequency of process-innovating enterprises owned by foreign entities (33.6% of enterprises) is more pronounced than for enterprises with domestic owners (26.1%). The share of innovative enterprises also varies considerably according to the size of enterprises (Fig. 3). While only 23.3% of enterprises introduced process innovation in the category of small enterprises, it was more than half (57.1%) in the case of large enterprises.

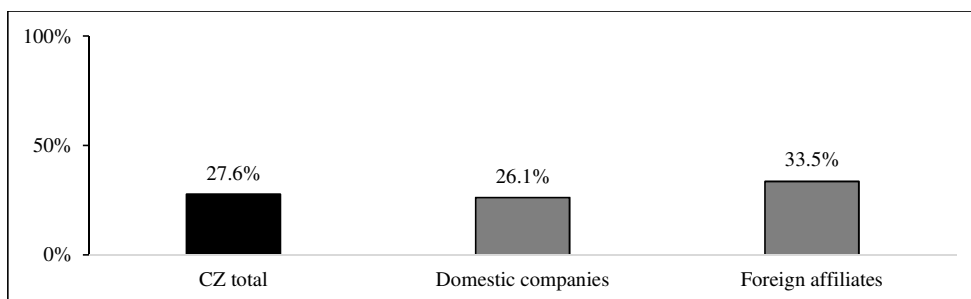


Figure 2 – The Share of Enterprises with Process Innovation in the Total Number of Enterprises – by Ownership of Enterprise (Author’s Elaboration Based on Data from CZSO, 2018)

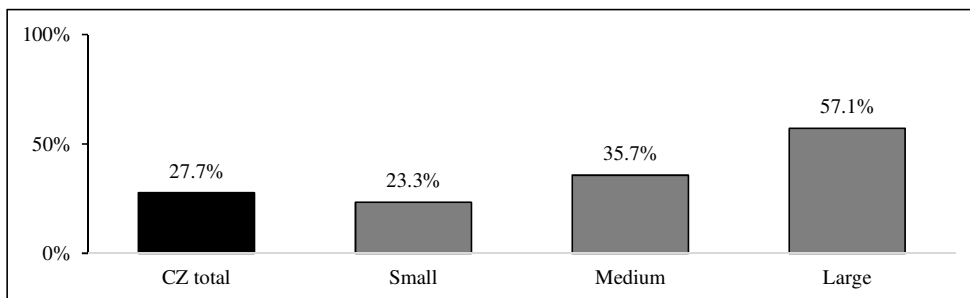


Figure 3 – The Share of Enterprises with Process Innovation in the Total Number of Enterprises – by Size of Enterprise (Author’s Elaboration Based on Data from CZSO, 2018)

Fig. 4 shows the differences in the representation of enterprises with process innovation by sector of the economy and compares it with the national average. In the graph, the sectors are arranged in descending order according to the shares of enterprises with process innovation in the total number of enterprises in the sector.

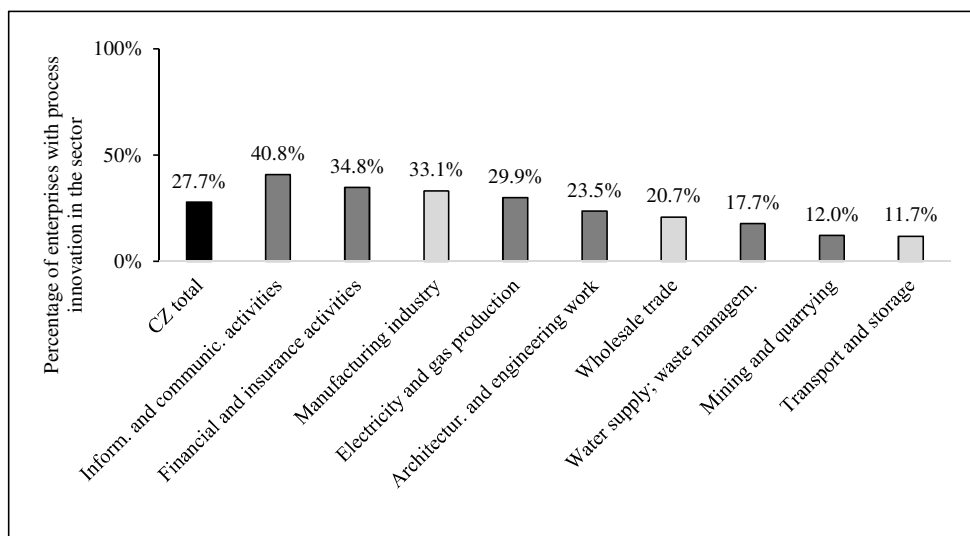


Figure 4 – Percentage of Enterprises That Have Introduced Process Innovation – by Economic Sector (Author’s Elaboration Based on Data from CZSO, 2018)

According to sectors of the economy, ICT dominates, with 40.8% of enterprises in the sector implementing process innovation. This is followed by financial and insurance activities (34.8% of enterprises) and manufacturing (33.1% of enterprises). In these three sectors, the share of enterprises with process innovation significantly exceeds the national share. On the other hand, process innovation in mining and quarrying (12%) and transport and storage (11.7%)

represented the least share (deeply below the total share of process innovating enterprises in the Czech Republic).

With the data in this chart, we can more closely notice the relationship between the shares of process innovation along the main supply chain, which is made up of companies from the following three sectors: manufacturing - wholesale - transport and storage (by light colour indicated). This comparison shows a decreasing share of process innovating enterprises from manufacturing (33.1% of enterprises) through intermediary cells towards the end customer (wholesale 20.7%, transport and storage 11.7%).

Furthermore, the shares of enterprises with process innovation in individual branches of the manufacturing industry were examined in more detail. The results are shown in Fig.5, re-organized according to the size of the proportions and supplemented by comparison with the overall result for the manufacturing industry.

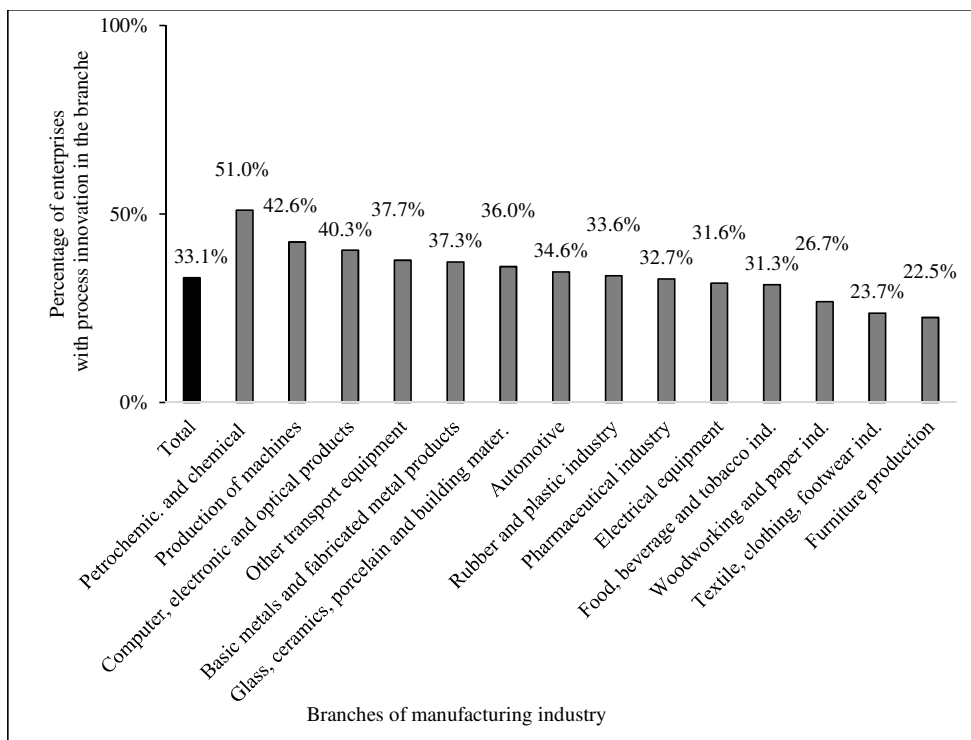


Figure 5 – Share of enterprises in particular branches of manufacturing industry, that introduced process innovation (Author's Elaboration Based on Data from CZSO, 2018)

Within the manufacturing industry, process innovations were most represented in the petrochemical and chemical industries, where more than half (51%) of the companies in this sector introduced process innovation. This is followed by the engineering industry with 42.6% of enterprises and the manufacture of

computers, electronic and optical equipment (40.3% of enterprises). In these three sectors, the share of process-innovating enterprises is significantly higher than that of the manufacturing industry as a whole. For other industries, the share of process-innovating enterprises ranged between 30 and 40% (note, for example, the automotive industry with a share of 34.6% of process-innovating enterprises), except for the woodworking, textile, clothing, leather and furniture industries, where the share of enterprises with process innovation did not reach 30% and is below the average.

3.2 Analysis by Types of Process Innovation

The relative frequencies of enterprises with different types of process innovation (broken down into process or process innovation, logistics innovation, and support activity innovation) as a percentage of enterprises that have introduced process innovation are shown in Fig. 6. Enterprises could list multiple types of process innovation and therefore the sum of relative frequencies does not give 100%.

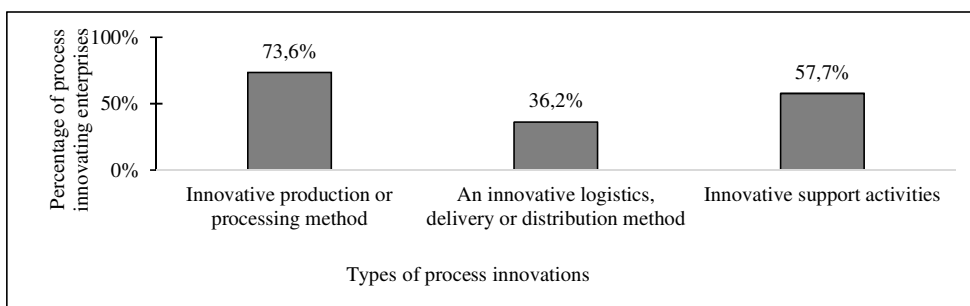


Figure 6 – Shares of Innovating Enterprises by Type of Process Innovation – CZ as a Whole (Author's Elaboration Based on Data from CZSO, 2018)

Process innovative enterprises most often experienced innovations in production or processing methods (73.6% of process innovation enterprises reported the introduction of this type of innovation), almost 60% of process innovation enterprises (57.7%) introduced innovation in support activities. Less than 40% of process innovators (36.2%) reported innovations in logistics.

The fields of activities listed in Tab. 1 were selected to analyze the representation of individual types of innovations by activity. Within the manufacturing industry the petrochemical and chemical industry (as a representant of so-called process kind of industry) and automotive (as a representant of discrete kind of industry and at the same time the industry with very high employment in the Czech Republic) were selected.

Table 1 – Percentage of Enterprises in Selected Fields of Activities (Both Innovative and Non-Innovative) by Type of Process Innovation (Author's Elaboration Based on Data from CZSO, 2018)

| Field of activity | Share in the total number of enterprises in a row (both innovative and non-innovative) | | |
|--|---|--|-------------------------------|
| | Innovative production or processing method | An innovative logistics, delivery or distribution method | Innovative support activities |
| <i>CZ total</i> | 20.4% | 10.0% | 16.0% |
| <i>Manufacturing industry</i> | 25.8% | 11.8% | 17.9% |
| <i>Wholesale trade, except of motor vehicles and motorcycles</i> | 12.9% | 12.1% | 11.7% |
| <i>Transport and storage</i> | 7.1% | 4.5% | 7.8% |
| <i>Petrochemical and chemical industry</i> | 43.1% | 22.3% | 24.3% |
| <i>Automotive</i> | 26.2% | 16.5% | 22.2% |
| <i>Information and communication activities</i> | 29.7% | 7.9% | 29.1% |
| <i>Financial and insurance activities</i> | 21.8% | 7.6% | 29.4% |

From Tab. 1 is clear that the chemical and petrochemical industry achieves more than double the share of enterprises with an innovative production or processing methods (43.1%) compared to the processing industry as a whole (which follows from the very nature of the industry). Also in the intensity of innovation in logistics methods as well as in innovation support activities the petrochemical and chemical industry outperformed the automotive industry. Information and communication, financial and insurance sectors, as well as the automotive and wholesale sectors, are characterized by a fairly balanced commitment to both core and support activities.

The authors of this article were more interested in the innovations of logistics, delivery or distribution methods, as there is great potential in this area to increase process flexibility, reduce costs and reduce environmental impacts. It was found that the share of enterprises with this type of innovation in the total number of enterprises (both innovative and non-innovative) is quite small. It ranges between 4.5% and 22.3% (in manufacturing as a whole it is only 11.8%, in wholesale 12.1%, in transport and storage only 4.5% of all enterprises).

3.3 Analysis of Process Innovation Benefits

The analysis of the benefits of process innovation was focused on:

- spectrum of benefits of process innovations (elaborated from answers to the question “What were the benefits of performed process innovations?”, where respondents could mention more areas and thus the sum of the share of enterprises does not have to give 100%; Fig. 7);
- the most important benefits of process innovation (respondents stated only the area they considered most important).

The following commentary compares the results obtained from both points of view.

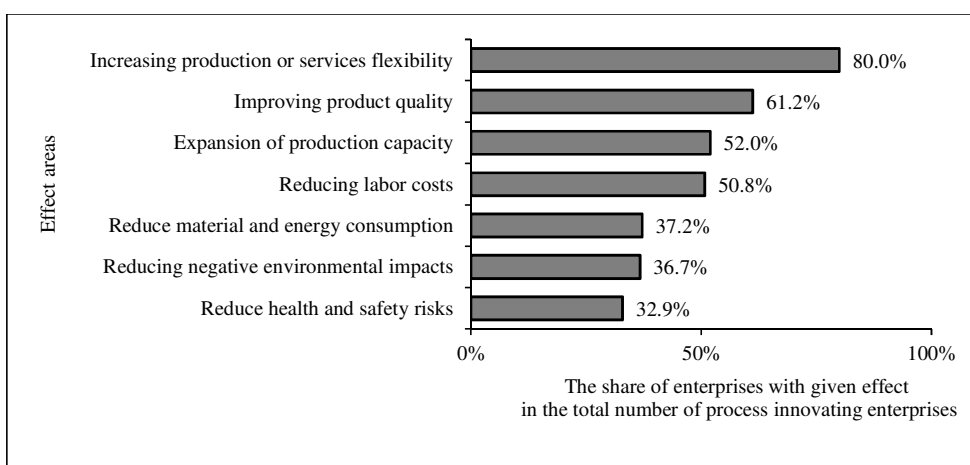


Figure 7 – Spectrum of Process Innovation Benefits (Author’s Elaboration Based on Data from CZSO, 2018)

Fig. 7 shows that process innovations often had a positive impact in several areas at the same time. High share of enterprises that have introduced process innovation have had the effects of increasing production flexibility (even 80%), increasing product quality (61.2%), increasing production capacity (52%) and reducing labor costs (50.8%). The share of companies that felt the effects of reducing material and energy consumption, reducing negative environmental impacts and reducing risks for employees is also quite significant (about a third of enterprises).

Regarding the most important effects of process innovations, all areas of effects were also represented, but with considerably greater differentiation. Due to limited extent of the paper the graph of the most important effects is not included. Increasing flexibility in production or service provision 41.5% of enterprises proved to be the most important. The largest share of enterprises with this effect was in information and communication (66.2%), financial and insurance activities (65.2%), wholesale (48.3%) and manufacturing as a whole

(34% of enterprises). Improvement of product quality, resp. the expansion of production capacity was no longer so significant. The effect of expanding production capacity was the most in companies from the automotive industry (31.5% of process innovators).

Only 10.6% of process innovating enterprises reported the decrease of labor costs as the most important effect. With these savings being most abundantly reflected in wholesale (17.1% of enterprises of process innovators in this sector) and transport and storage (14.2% of enterprises).

Effects in reducing negative impacts on the environment were mentioned as the most important by companies from the fields of energy production and distribution (21%), water supply and waste water management (16.5%), as well as from transport and storage (13.5%). In other sectors the share of enterprises with this most important effect was only up to 5%.

3.4 Analysis of Cooperation in Developing Process Innovations

When asked by the CZSO questionnaire, “Who developed the innovated processes?”, companies could list more subjects from the offer, which included the following options: on their own, in cooperation with enterprises within the corporate group, in cooperation with enterprises outside the corporate group, in collaboration with universities or research institutions, adapting the process developed by another entity, commissioning development to another enterprise, including group companies, commissioning development to a higher education institution or research institution.

I was found that representation of these particular forms varied significantly. In practice, several options are combined at the same time, and therefore the sum of the shares of the companies in each form does not give 100%. It is not possible to deduce from the results how many percent of enterprises used exclusively one form and which form it was.

The results of the analysis are summarized in one graph (Fig. 8), in which the first group presents the results for the Czech Republic as a whole. Two aspects of classification are applied to show the differences between enterprises by size according to the number of employees (small, medium, large) and by prevailing ownership (domestic enterprises, foreign affiliates).

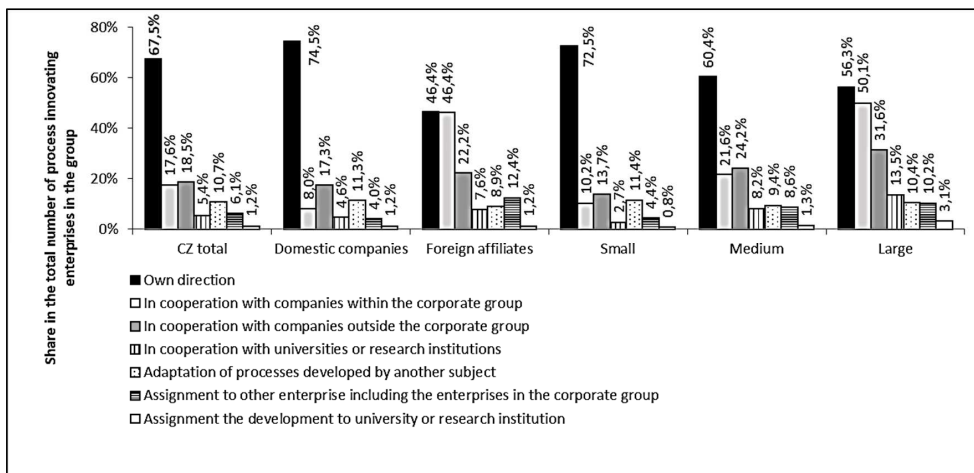


Figure 8 – Cooperation in the Development of Process Innovations According to the Size and Ownership of Enterprises (Author's Elaboration Based on Data from CZSO, 2018)

For the Czech Republic as a whole, self-directed development of process innovations prevails (this form was reported by 67.5% of the addressed enterprises that introduced process innovation). Almost 20% of enterprises (17.6%) used cooperation with other companies in the group and roughly the same share of enterprises (18.5%) used cooperation outside the corporate group. Adaptation of the process developed by another enterprise has proved to be low (10.7% of enterprises). Co-operation with research institutions or universities, or the commissioning of development directly to these organizations or other enterprises was only slightly represented (this was reported by only few percent of enterprises).

As regards the prevalence of self-directed development of process innovations the own questionnaire survey performed in 2019 led to the similar finding that the products and processes in enterprises regardless of size and ownership are developed mainly in their R&D department (75.9%).

While innovating enterprises with predominantly domestic ownership develop innovative processes predominantly on their own (74.5% of enterprises that have introduced process innovation), for foreign affiliates it is only 46.4% of enterprises. The same percentage of companies owned by foreign entities then uses cooperation with other companies within the corporate group. A smaller share of foreign enterprises (8.9%) uses adaptation of the process developed by another enterprise than domestic enterprises (11.3%).

In the development of process innovation there are also differences between categories of enterprises by size. As the size of the enterprise decreases, the share of own-account development decreases and the use of other forms of development is more pronounced in large enterprises than in small enterprises. In

adapting a process developed by another enterprise, the difference by size of the enterprise is not significant. The proportion of this form is slightly around 10% of enterprises. Ordering the development of process innovation to universities and research institutions is applied more often by large enterprises (3.1%) than medium (1.3%) and small (0.8%). This confirms the continuation of the tendency, which Spišáková (2010) stated, for example, based on her analyses of the innovation activities of Slovak and Czech companies based on Eurostat data from 2006.

4 DISCUSSION

The facts that the share of enterprises that carried out innovations of any type in the Czech Republic in the period under review is below 50% and the share of process innovators is below 30% is not very favorable. The own questionnaire research revealed that the main obstacles to the innovation activity of companies are the lack of skilled workers (61.1%) and the lack of financial resources (48.1%). However, companies are aware of the importance of innovation, which is again illustrated by the results of own research, where companies state that innovation is part of their corporate philosophy (92.6%).

The findings that large enterprises are significantly more active in this area than small and medium-sized enterprises and that foreign-owned enterprises are more active than Czech-owned enterprises are not very surprising. Regarding the intensity of innovation activities according to the sectoral structure, it may be interesting to note that the in ICT sector and in financial and insurance sector the share of process innovating enterprises was higher than in manufacturing. Placing the transport and storage sectors (with 11.7%) and wholesale (with 20.7% of enterprises) among the least process-innovating sectors may signal that their level of processes may be a brake on the development of supply chains as a whole.

The spectrum of effects of process innovation is broad and concerns not only traditional competitiveness factors (dominated by increased production flexibility, product quality and production capacity expansion), however the process innovation has led also to a reduction in labor costs in 50.8% of process innovating enterprises, contributing to addressing the urgent problem of labor shortages. It can be considered significant that the implemented process innovations had in about a third of companies positive societal impacts in reducing material and energy consumption, reducing negative environmental impacts and reducing employees' health and safety risks.

Analyses have shown that there is little cooperation in the development of process innovations, both business-to-business cooperation and, in particular, cooperation with research institutions and universities, suggesting that the knowledge potential and scientific infrastructure are not exploited.

The results obtained represent only a partial probe from the last valid survey conducted in 2016. It is necessary to respect the fact that the intensity of innovation is related to the length of innovation cycles in individual fields. For instance, in the automotive industry, the largest wave of technology and logistics innovations has taken place before the period under review, and now, for example, advanced processes in the logistics field are expanding to other sectors. The intensity of innovation is also dependent on the phases of the business cycle and the support of innovation by the state. Therefore it will be interesting to compare the results achieved with the results of the 2018 survey once they have been published.

5 CONCLUSION

For the period after 2019, further significant process changes can be expected in connection with the expansion of digitization and automation as well as the promotion of circular economy principles.

The Government of the Czech Republic has adopted an innovation strategy (RVVI, 2019) for the years 2019-2030 aimed at promoting science, research and innovation, based on the ambition to become a European innovation leader within 12 years. The innovation strategy focuses on the final production, technological solutions and knowledge-based services generating added value. The innovation strategy includes the following pillars: R&D funding and evaluation, polytechnic education, digital state, manufacturing and services, mobility and construction environment, smart marketing, intellectual property protection, smart investment, innovation and research centers, national start-up and spin -off environment. This created an innovative concept that covers national key activities across ministries, sets framework objectives and addresses strategic tools for their implementation.

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