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Article

Analysis of factors giving the opportunity for implementation of innovations on the example of manufacturing enterprises in the Silesian province

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Abstract: The paper analyzes the actions that improve innovativeness in production enterprises in the Silesian province. Innovation is one of the elements that allows to achieve a competitive advantage. It turns out justified to research various factors that are important in improving innovativeness. The research includes selected production enterprises in the Silesian province, adopting the descriptive statistics measures and statistic tests: random sample test, chi-square independence test and the non-parametric Kruskal-Wallis test based on a survey questionnaire. As part of the most important factors determining the possibilities of innovation by manufacturing companies were detected contacts with other enterprises, R&D centers and counseling institutions, competitive position of the company and creating appropriate incentive systems.

Keywords: innovation; innovative activities; analysis of factors; production enterprises.

1. Introduction

At the beginning of this study the basic knowledge of innovation, competitiveness and specificity of functioning of production enterprises was assumed.

The research objective was to conduct an analysis in terms of innovative actions undertaken by production enterprises in the Silesian province. These were small, medium and large enterprises. The group of respondents was composed of owners of managers of the production enterprises as well as their employees. The subject of the research activities included production enterprises in the Silesian province. The research area covered the Silesian province. The research period was 2011-2016. A total of 310 production enterprises were surveyed in that time. The main reason for limitation of the surveyed population was the cost and the time-consuming nature of the project. Statistical Offices, Town Halls or Country Office did not have any data on the actual status of active enterprises. The reasons for lack of this information were:

- no consistency in the provision of information by entrepreneurs, for example in relation to cessation of activities,
- changing formats of reporting on economic operators,
- intended fraudulent behaviors of entrepreneurs, e.g. operating on the grey market [1-3].

Data from the Central Statistical Office were regarded as the most reliable source of information in the Silesian province. The population data were generated from *www.gov.pl*, which were updated on the basis of data from the Central Statistical Office in Katowice. Therefore, the population of

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production enterprises was composed of the enterprises classified by the Central Statistical Office in section C of the Classification of Economic Activities, namely "Industrial processing", including:

- Division 10 - manufacture of food products,
- Division 11 - manufacture of beverages,
- Division 12 - manufacture of tobacco products,
- Division 13 - manufacture of textiles,
- Division 14 - manufacture of wearing apparel,
- Division 15 - Manufacture of leather and related products,
- Division 16 - manufacture of wood and of products of wood and cork, except furniture;
  manufacture of articles of straw and plaiting materials,
- Division 17 - manufacture of paper and paper products,
- Division 20 - manufacture of chemicals and chemical products,
- Division 21 - manufacture of basic pharmaceutical products, medicines and pharmaceutical preparations,
- Division 22 - manufacture of rubber and plastic products,
- Division 23 - manufacture of other non-metallic mineral products,
- Division 24 - manufacture of basic metals,
- Division 25 - manufacture of fabricated metal products, except machinery and equipment,
- Division 26 - manufacture of computers, electronic and optical products,
- Division 27 - manufacture of electrical equipment,
- Division 28 - Manufacture of machinery and equipment n.e.c,
- Division 29 - manufacture of motor vehicles, trailers and semi-trailers, except for motorcycles,
- Division 30 - manufacture of other transport equipment,
- Division 31 - manufacture of furniture,
- Division 32 - other manufacturing.

As of 03 April 2017, there were 36 731 manufacturing enterprises registered in the Silesian province. The status of the surveyed manufacturing enterprises was active during the analysis [4–7].

2. Materials and Methods

10% of enterprises meeting the time and spatial criteria were selected for the preliminary research. A random number generator was applied to determine which enterprises from the list are included in the sample. A request for participation in the survey was sent to the selected enterprises. A positive reply was received from 310 enterprises. Regarding the size of the sample (research of both the enterprises and employees of the selected enterprises), high costs, time-consuming nature of the research, the sample was not broadened. For the survey of employee motivation, 2 employees were selected for each of the micro enterprises, 5 for small enterprises, 10 for medium-sized enterprises and 20 for large enterprises, with a total sample of 911 employees [8, 9].

The surveying process was carried out during meetings in the production enterprises' premises, through telephone and electronic interviews (receiving the filled-in survey questionnaire by electronic means). One of the employed motivating elements intended to obtain a greater number of responses was the organization of free OHS trainings and other courses available to choose from

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for employee teams in the surveyed production enterprises [10]. The research was carried out between 01.10.2016 and 03.10.2017, additionally confirming the validity of data in April 2018 (verification of the economic activity status in the analyzed enterprises), complementing and obtaining additional data from the interviews conducted with employees of the production enterprises.

The survey questionnaires included questions allowing to obtain information about:

- the age of the enterprise, its size and range of activities,
- types of innovations introduced by the enterprises and barrier to implementation,
- evaluation of the innovation levels when compared to the competition, according to the respondents,
- having an innovation unit responsible for implementation of innovations,
- factors that motivate the employees to implement innovation,
- employing the measures that help in implementing the innovations.

The main hypothesis was put forward.

Main hypothesis: *Creating appropriate incentive systems improved the opportunity for implementation of innovations in production enterprises.*

In order to verify the main hypothesis, detailed hypotheses were put forward:

- The type of implemented innovations depended on the size of the company, the range of its activity and its age.
- The employment size does not determine the type of implemented innovation.
- The range of company's activity determines the implementation of innovation [11].
- Having an innovation unit does not depend on the size of the company.
- The range of the company's activities significantly determined the fact of having an innovation unit [12].
- The type of implemented innovations depended on whether a company had an innovation unit.
- The reason for not implementing any innovations is lack of development capital [13].
- The barriers to growth faced by the surveyed enterprises depended on the size of the enterprises.
- The range of company's operations posed a significant determinant for the barriers to growth [14, 15].

Statistical analysis methods were used to develop the research results: descriptive statistics measures and statistical tests: random sample test, chi-square independence test and non-parametric Kruskal-Wallis test. The random sample test, also called the series test, verifies the zero hypothesis:

H_0: the sample is random

towards the alternative hypothesis:

H_1: the sample is not random.

The hypothesis verification procedure is as follows:

1. the determination of *Me* median from the sample,
2. assign each element of the sample with x_i, according to the order of sampling the test items, the symbol *a*, if $x_i < Me$, or the symbol *b*, if $x_i > Me$, the result $x_i = Me$ can be ignored,

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3. determination of the total number of k series, where a series is any sub-string of a series of a and b element, having the property that all consecutive elements of the sub-string are of the same type,
4. assuming that the zero hypothesis is true, the number of k series has a known and tabulated distribution,
5. the rejection area is two-sided. From the distribution tables for the series numbers for the presumed significance α, $n_1$and n_2 (abundance a and b) we take such critical values k_1 and k_2, so relationships $P(k \leq k_1) = \frac{\alpha}{2}$ and $P(k \leq k_2) = 1 - \frac{\alpha}{2}$ can occur,
6. provided $k \leq k_1$ or $k \geq k_2$ the hypothesis of randomness of the sample is rejected, whereas

when $k_1 < k < k_2$ there's no basis for rejecting the hypothesis of randomness of the sample.

Where the sample is large, i.e.$n_1 > 20$ or $n_2 > 20$the above tables cannot be used because, with the increase in the number of n_1 and n_2 the distribution of the number of series k tends to a normal distribution, so that the value of the Z statistic has the following form:

$$Z = \frac{k - \frac{2n_1 n_2}{n_1 + n_2} + 1}{\sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}} \quad (1)$$

From the normal distribution tables $N(0,1)$ a critical value is determined $u_\alpha$to have the following relationship for a predetermined materiality level α: $P(|Z| \geq u_\alpha)$. If the value of the sample U statistics is such that $|Z| \geq u_\alpha$, we reject *the* H_0hypothesis, whereas when $|Z| < u_\alpha$, there are no grounds to reject the H_0 hypothesis.

The *chi-square* independence test verifies the zero hypothesis:

H_0: two variables are independent.

towards the alternative hypothesis:

H_1: variables are dependent.

A verifying statistics is:

$$\chi^2 = \sum_{i=1}^{l} \sum_{j=1}^{k} \frac{(n_{ij} - \hat{n}_{ij})^2}{\hat{n}_{ij}} \quad (2)$$

where:

- n_{ij} - actual values

- $\hat{n}_{ij}$ - theoretical values calculated according to the formula $\hat{n}_{ij} = \frac{n_i n_j}{n}$

The test statistic, assuming that the zero hypothesis is true, has the following distribution χ^2 with $(k-1)(l-1)$ degrees of freedom, where k indicates the number of columns (number of variants of the first attribute) of the analyzed cross table and l indicates the number of rows (number of variants of the second attribute). The critical area of this test is the right-hand area $[\chi^2_\alpha; \infty]$where χ^2_α is the critical value read from the distribution tables χ^2 for the predetermined significance level α.

The Kruskal-Wallis test is used to compare average values between groups. It is a non-parametric alternative for the single-factor variance analysis, ANOVA. ANOVA single-factor variance analysis can be used in the case of random samples, compliant with a normal distribution with groups similar in terms of numbers. The Kruskal-Wallis test does not demand meeting the

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requirements for the ANOVA variance analysis. These requirements are often difficult to be met, especially in a situation where lack of funds does not allow to broaden the sample, or when the surveyed population is small. The only requirements for the Kruskal-Wallis test are [10, 16]:

- the dependent variable should be measured on at least an ordinal scale (it can also be measured on a quantitative scale)
- the observations in the analyzed groups should be independent of each other, which means that a person remaining in one group should also be available in another comparable group.

The research results are presented in the paper in a graphic and table format.

3. Results

The survey covered owners and managers of 310 production enterprises operating in the Silesian province. These enterprises were randomly selected from a population of all production enterprises, resulting in a sample of varied enterprises, in terms of both the profile of activity and its age. The obtained sample was random and was confirmed by the results of the series test $Z = -1{,}538; p = 0{,}124$. There were no grounds to reject the hypothesis of a random character of the sample.

The surveyed production enterprises had existed on the market for 20.8 years on average. The youngest company was 1 year old, and the oldest one was 141 years old. The standard deviation of the surveyed enterprises' age was 18.16 years, meaning that the coefficient of variation was at the level of 87%. This means a vary large diversity of the surveyed enterprises. A typical company had existed on the market for 2.6 - 39.9 years, thus typical enterprises were almost 94% of the sample. Only 3 enterprises were younger than those typical. There were 16 older enterprises, and they accounted for almost 5% of the surveyed group. The surveyed group was characterized by a right asymmetry, meaning that there were more young enterprises (figure 1).

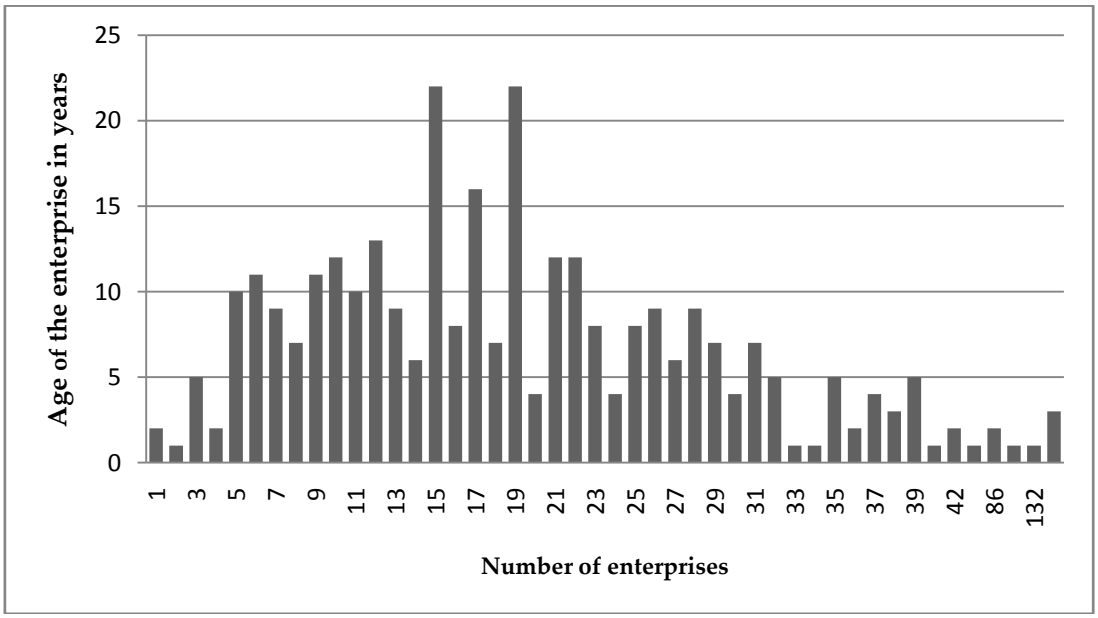

Figure 1. The age of the surveyed production enterprises. Source: own study based on data from questionnaires.

The vast majority of surveyed enterprises, i.e. as much as 72.58%, were micro enterprises employing up to 9 employees. Every fifth enterprise (21.94%) was a small enterprise with 10 to 49 employees. Less than 5% of enterprises were medium enterprises employing from 50 to 249 employees. Large companies account for only 0.65% of the surveyed manufacturing enterprises (figure 2).

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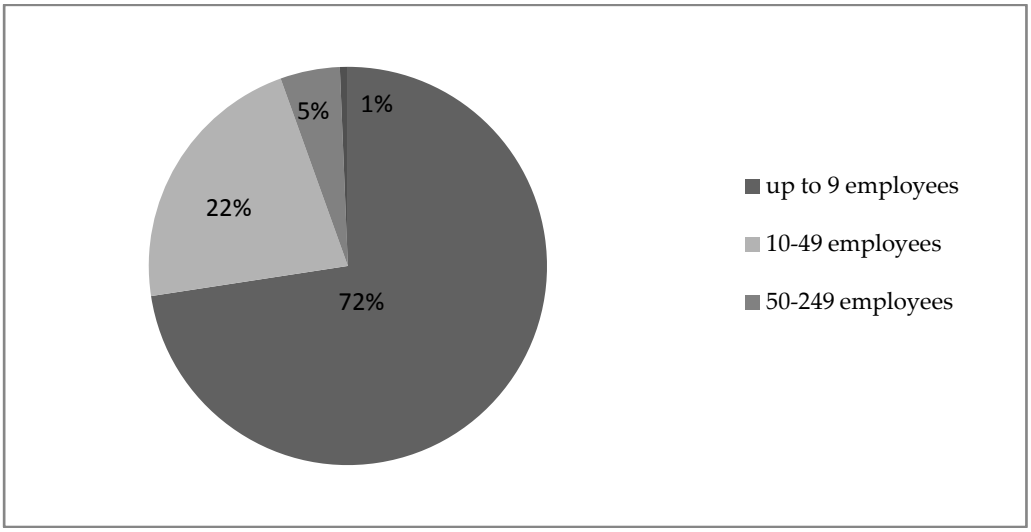

Figure 2. Structure of the surveyed production enterprises by employment size. Source: own study based on data from questionnaires.

Having the data on the enterprises age and employment size, the hypothesis that the average age of companies depends on the enterprise size has been verified. Results of the Kruskal-Wallis test $H(3) = 3{,}757; p = 0{,}289$ carried out did not allow to confirm this hypothesis. No differences were found between the average ages of particular groups of enterprises by size of employment. The average age of micro, small and large enterprises was 17 years (figure 3). The average age of the medium-sized enterprises was 20 years. The difference was not statistically significant [9,15].

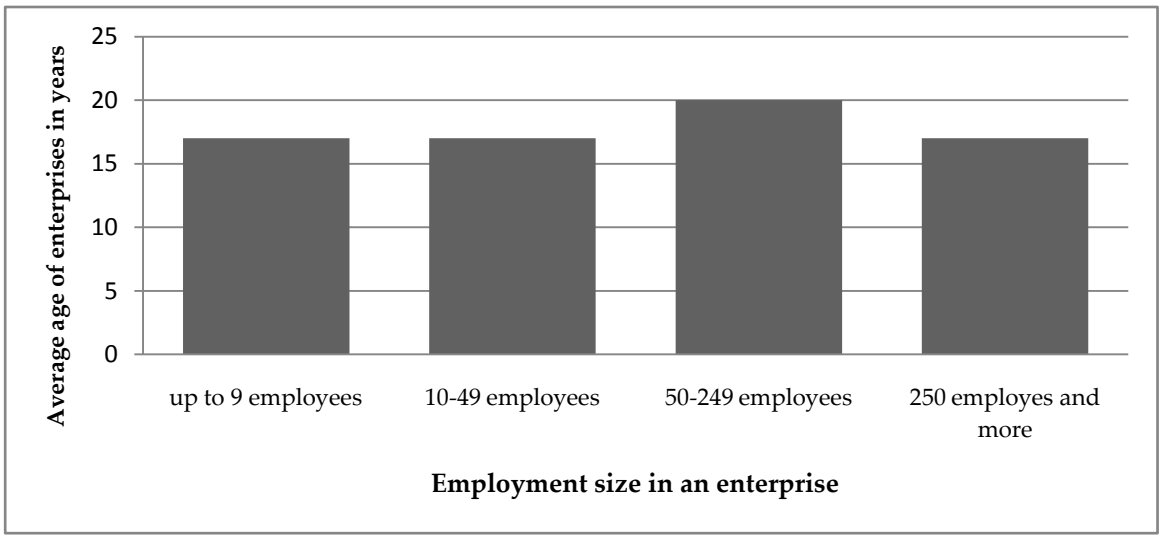

Figure 3. Average age of enterprises by employment size. Source: own study based on data from questionnaires.

The majority of surveyed enterprises (69%) covered the area of the whole country with their scope of activity. Every fifth enterprise (20%) operated on the international market. The smallest group was constituted by enterprises of local range (11%).

The enterprise age may determine the range of enterprises operations. Longer-established companies may have greater range of the operation. Results of the Kruskal-Wallis test $H(2) = 0{,}934; p = 0{,}627$ carried out did not allow to confirm this assumption. There were no statistically

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significant differences in the length of existence of enterprises by the range of their operations. The average age of the enterprises operating on a regional and international market was 16 years, and the enterprises operating on the national market 0 17 years.

The range of operations of the companies can also depend on the size of the enterprise. Larger companies may need a larger range of activities. Results of the conducted *chi-square independence test* $\chi^2(6) = 2{,}012; p = 0{,}919$ did not confirm this presumption in relation to the surveyed companies. The majority of micro, small and medium-sized enterprises were of nationwide range. All analyzed large enterprises covered the territory of the whole country with their range. Difference in enterprise structure by employment size and range of operations were not statistically significant (figure 4).

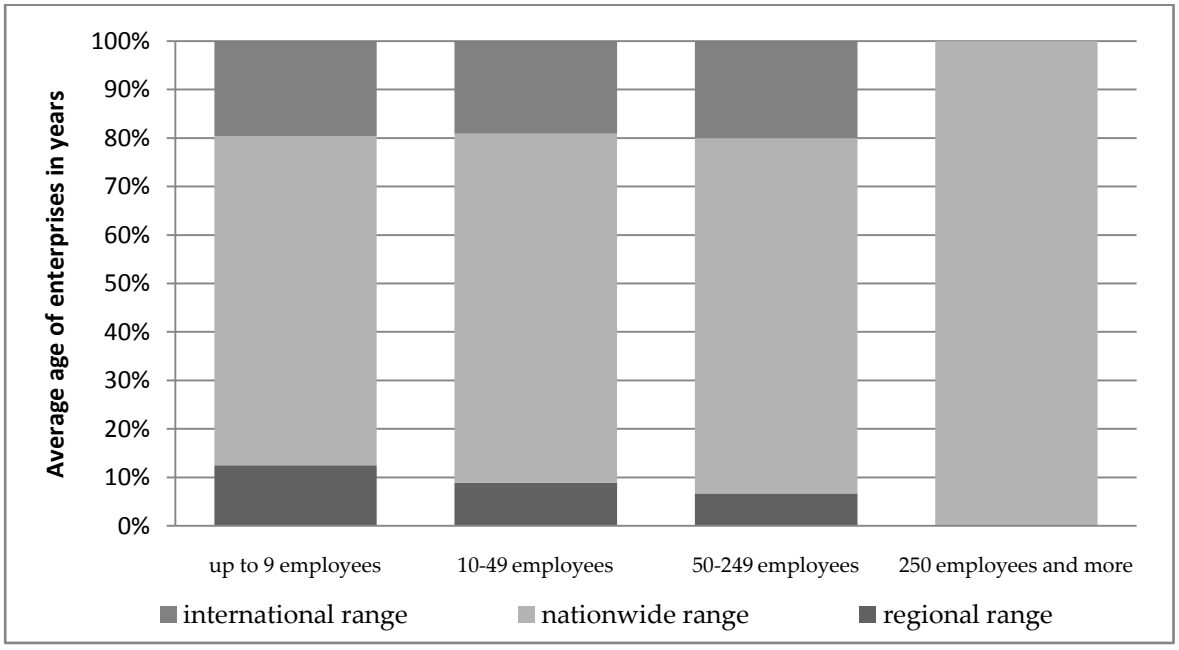

Figure 4. Structure of enterprises by employment size and range of activity. Source: own study based on data from questionnaires.

The success of an enterprise may depend on its competitive advantage resulting from the introduced innovations. Innovations may be of various character. The majority of surveyed enterprises (58%) introduced such innovations which the respondents were unable to determine the character of or could not decide whether the innovations have been implemented at all. 15% of companies introduced product innovations. Every tenth surveyed company introduced technological innovations (10%) or process innovations (10%). Marketing innovations were introduced by 7% of the surveyed production enterprises. In total, about 42% of the surveyed enterprises introduced some specific innovations (figure 5).

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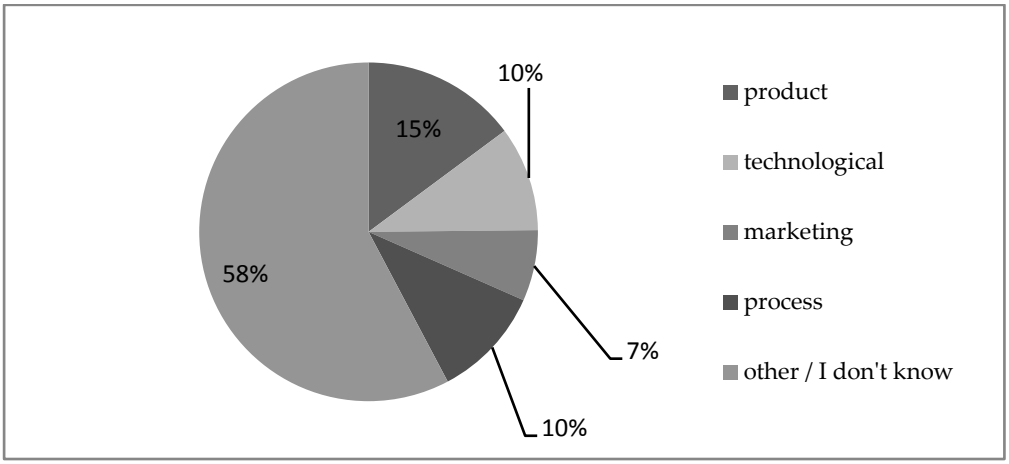

Figure 5. Structure of surveyed enterprises by the range of activity. Source: own study based on data from questionnaires.

The type of introduced innovations may depend on how long the company has been operating on the market. Results of the Kruskal-Wallis test $H(4) = 2{,}380; p = 0{,}666$ did not confirm this hypothesis. There were no statistically significant differences between the average length of existence of the surveyed enterprises by the type of innovations introduced. The enterprises that introduced the product innovations had existed on the market for 18 years on average, similarly to the enterprises that introduced the marketing innovation. The enterprises which introduced the technological innovations had existed on the market for 16 years on average. The longest-established companies on the market were those that introduced process innovations. Companies that did not introduce any innovations or introduced some innovations of other nature had existed on the market for 16 years.

The employment size may determine the type of introduced innovations. Results of the conducted *chi-square independence test* $\chi^2(12) = 15{,}066; p = 0{,}238$ however, they do not confirm this presumption for the surveyed production enterprises. The type of introduced innovations did not depend on the size of surveyed enterprises. Micro, small and medium-sized enterprises introduced the process, technological, product or marketing innovations to a similar degree (figure 6).

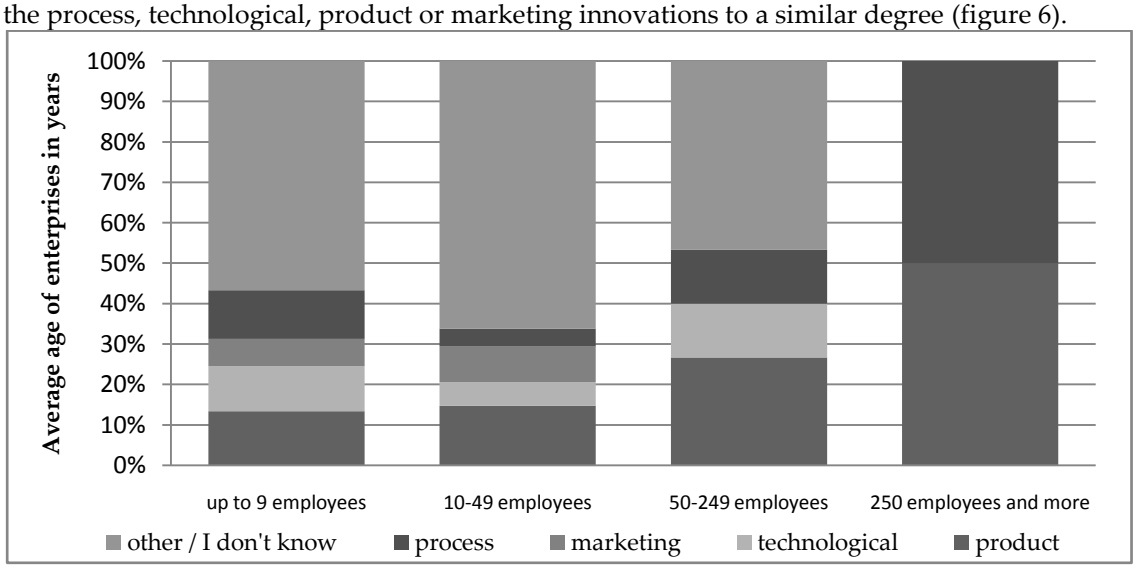

Figure 6. Structure of enterprises by employment size and type of introduced innovations. Source: own study based on data from questionnaires.

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The range of enterprise's activity may determine the introduction of innovations. This assumption made in relation to the surveyed production enterprises has not been confirmed. Results of *the Chi-square independence test* $\chi^2(8) = 5{,}979; p = 0{,}650$ clearly indicate that there is no link between the type of innovation introduced and the range of activity of the surveyed manufacturing enterprises. However, they do not confirm this presumption for the investigated companies. Regardless of the range of enterprise's activity, the largest number of companies did not introduce any innovations or introduced some innovations of an unspecified nature (figure 7).

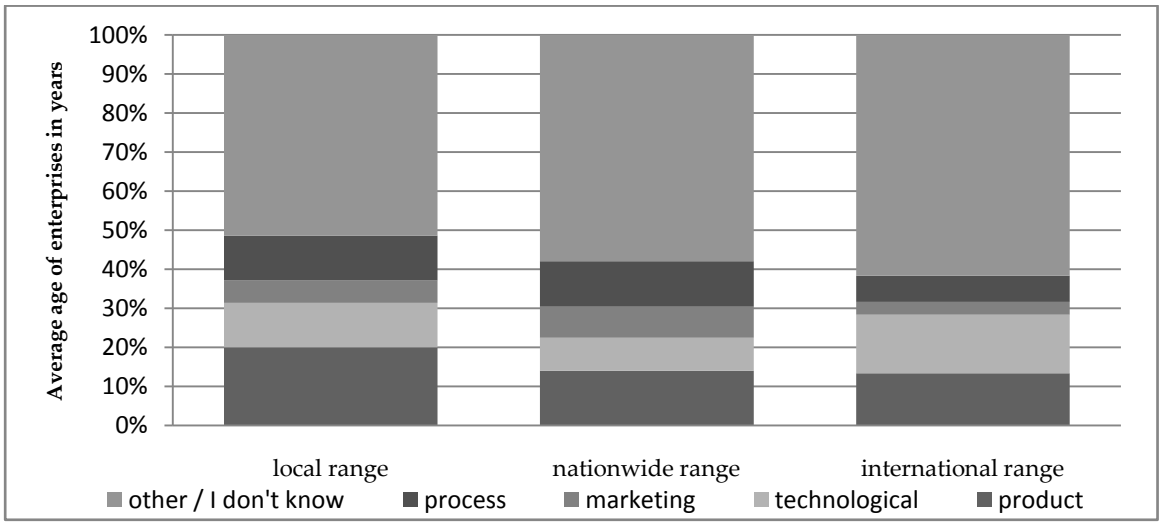

Figure 7. Structure of enterprises by range of activity and type of introduced innovations. Source: own study based on data from questionnaires.

Introduction of innovations may be supported by an innovation unit in some enterprises. Only 9% of the surveyed enterprises had such an innovation unit (figure 8).

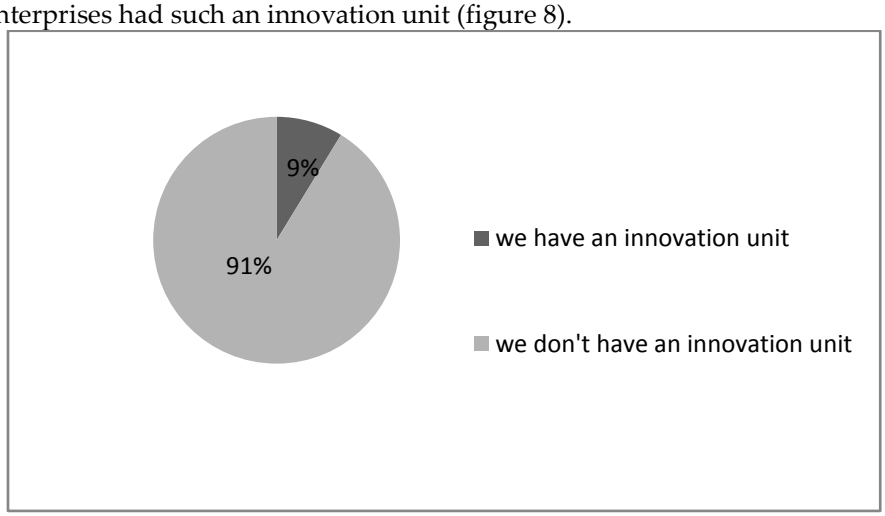

Figure 8. Structure of surveyed enterprises depending on whether they have an innovation unit or not. Source: own study based on data from questionnaires.

Having an innovation unit could depend on the age of the enterprise, its size and range of activity. The results of *the U-Mann-Whitney test* $Z = -1{,}000; p = 0{,}317$ did not show any differences between the average company's existence due to the fact that there is an innovation unit.

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Average age of an enterprise having such a unit and not having such a unit was the same, and amounted to 17 years (figure 9).

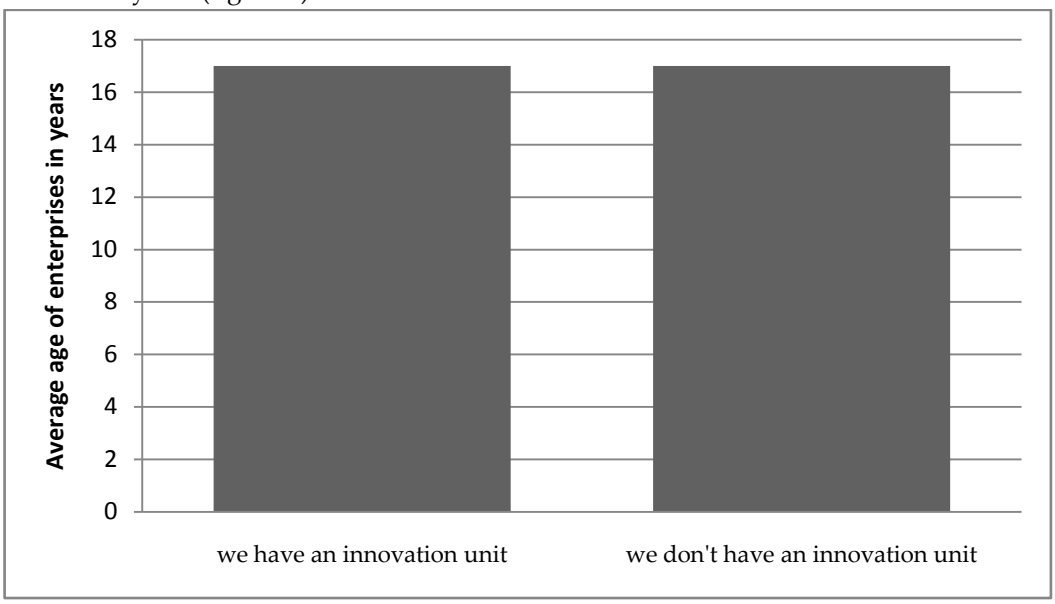

Figure 9. Average age of the enterprises depending on whether they have an innovation unit or not. Source: own study based on data from questionnaires.

The surveyed manufacturing enterprises most often did not have an innovation unit regardless of the size of the company (figure 10), which was confirmed by the results of *the chi-square independence test* $\chi^2(3) = 5{,}373; p = 0{,}146$.

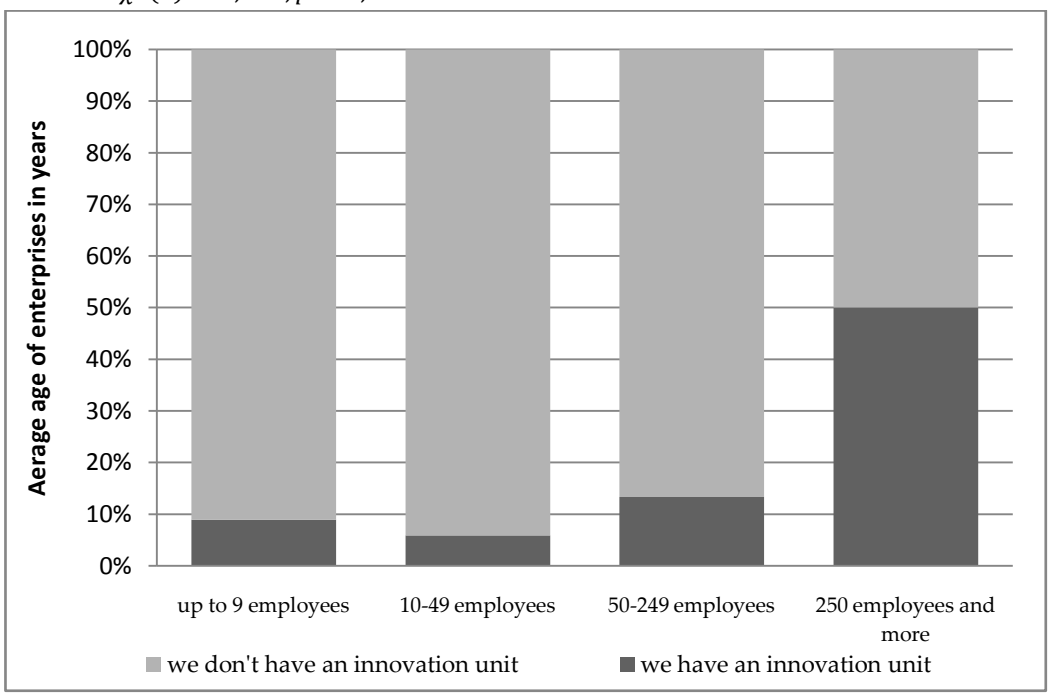

Figure 10. Structure of enterprises by employment size and type of introduced innovations. Source: own study based on data from questionnaires.

In the case of the surveyed enterprise, a statistically significant determinant for having an innovation unit was the range of the enterprise's activity which was confirmed by the *chi-square independence test results* $\chi^2(2) = 6{,}962; p = 0{,}031$. In most cases these were the local-range enterprises that had the

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innovation unit, and such a unit was present in the international-range companies least often. The greater the range of an enterprise, the less often it had an innovation unit (figure 11).

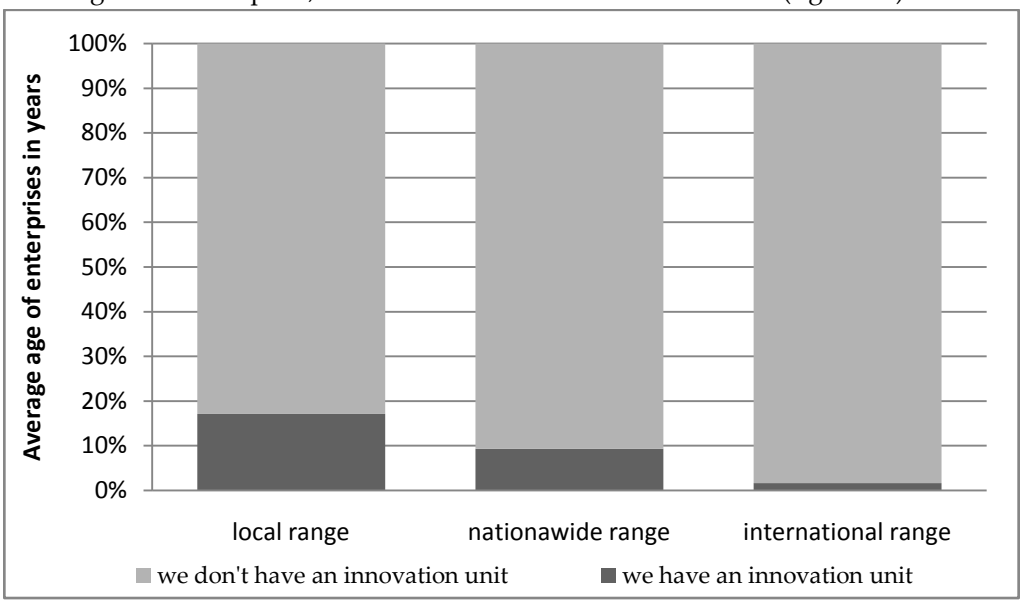

Figure 11. Structure of enterprises by employment size and type of introduced innovations. Source: own study based on data from questionnaires.

In the surveyed enterprises, having an innovation unit did not influence the type of innovations introduced, which was confirmed by *the chi-square* independence test $\chi^2(4) = 1{,}017; p = 0{,}907$. Therefore, having an innovation unit did not improve the frequency of innovations introduction among the surveyed enterprises (figure 12). The innovations were introduced regardless of works carried out in the specialized units of the surveyed enterprises.

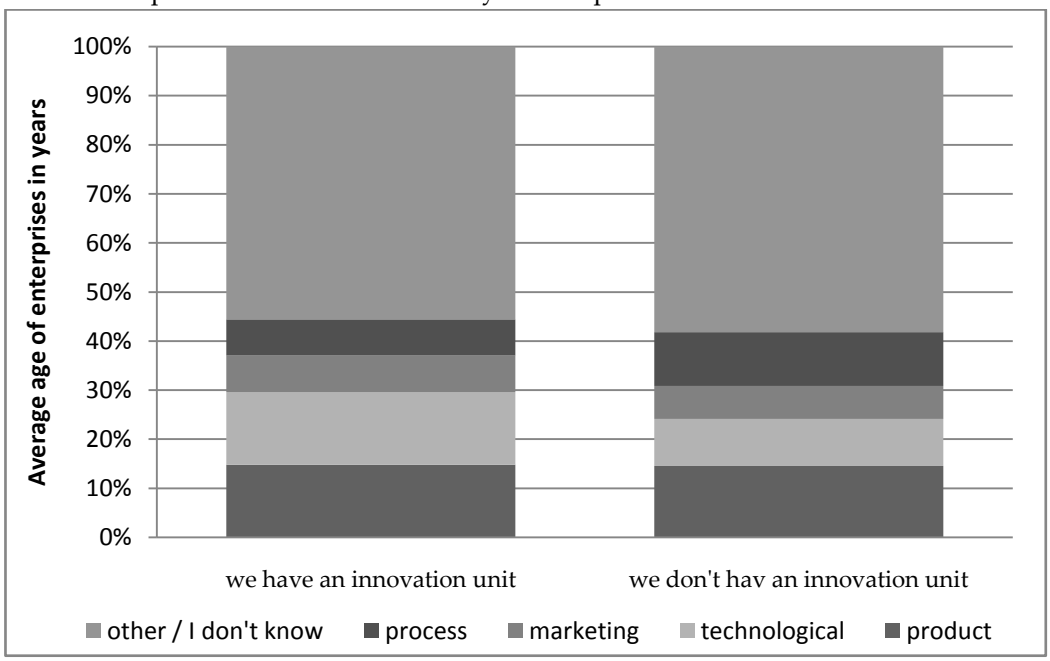

Figure 12. Structure of enterprises depending on whether they have an innovation unit or not and the type of introduced innovations. Source: own study based on data from questionnaires.

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In conclusion, it should be noted that the surveyed enterprises were diverse in terms of age, range of activities and size of employment. These features did not have a significant statistical impact on the type of innovations introduced. The innovations were also not dependent on whether an enterprises had an innovation unit or not. The age of the enterprise and its size also did not impact the fact of having an innovation unit or not. However, this was statistically significantly influenced by the range of the enterprise's operation. The lower the range, the more often an enterprise had an innovation unit. It should therefore be recognized that the determinant of introducing innovations should be sought outside factors such as the age of the enterprise, the range of the enterprise's activity, the size of the enterprise and the fact of having an innovation unit or not. Therefore, the factors that decide about the innovations may include: barriers for introduction of innovations in the enterprise, contacts with other enterprises, R&D centers and counseling institutions, competitive position of the company.

In the vast majority, the surveyed manufacturing enterprises (65%) faced a lack of capital for growth, which may be reflected in issues with introducing innovations. One in five enterprises reported a lack of skilled workers as a barrier to growth, while 15% reported outdated technology (figure 13).

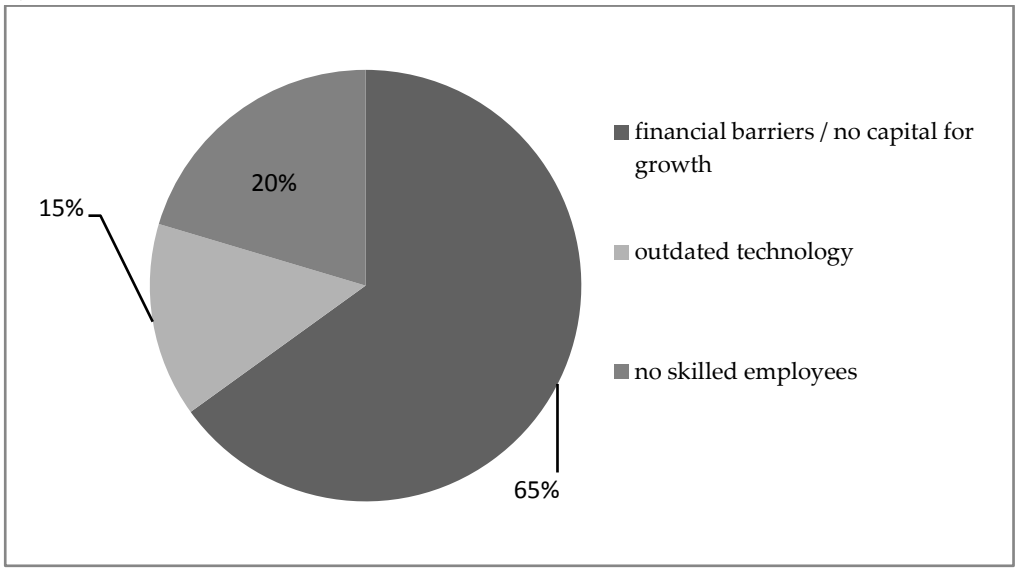

Figure 13. Structure of researched enterprises by barriers to growth. Source: own study based on data from questionnaires.

Barriers faced by the analyzed companies did not depend on the age of the enterprises, which was confirmed by the results of the Kruskal-Wallis test $H(2) = 2{,}648; p = 0{,}266$. The enterprises complaining of lack of capital for growth had operated on the market for 17 years on average. The companies that recognized an outdated technology as the barrier to growth had existed for 14 years on average, the the companies complaining about lack of skilled workers - 18 years. The differences among the listed average values were not statistically significant.

4. Discussion and Conclusions

Authors discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The research objective was achieved by performing an analysis of activities influencing innovative actions in manufacturing enterprises of the Silesian province. Small,

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medium and large enterprises were surveyed. The group of respondents was composed of owners of managers of the production enterprises as well as their employees. The subject of the research activities included production enterprises in th Silesian province. The research area covered th Silesian province. The research period was 2011-2016. A total of 310 production enterprises were surveyed in that time. The main reason for limitation of the researched population was the cost and the time-consuming nature of the project. Statistical Offices, Town Halls or Country Office did not have any data on the actual status of active enterprises. The reasons for lack of this information were: inconsistency in the provision of information by entrepreneurs, for example in relation to cessation of activities, changing reporting formats regarding the enterprise, intended fraudulent behaviors of the entrepreneurs.

The conducted research suggests that the average age of the enterprises did not depend on their size. The enterprise age may determine the range of enterprises operations. The success of an enterprise may depend on its competitive advantage resulting from the introduced innovations [17]. Innovations may be of various character [18]. The longest-established companies on the market were those that introduced process innovations.

The type of introduced innovations does not depend on the size of surveyed enterprises , which is confirmed by many other studies [19, 20]. Micro, small and medium-sized enterprises introduced the process, technological, product or marketing innovations to a similar degree. The range of enterprise's activity does not determine the introduction of innovations. Introduction of innovations may be supported by an innovation unit in some enterprises. Only 9% of the surveyed enterprises had an innovation unit. Having an innovation unit could depend on the age of the enterprise, its size and range of activity [21].

In the case of the surveyed enterprise, a statistically significant determinant for having an innovation unit was the range of the enterprise's activity which was confirmed by the *chi-square independence test results* $\chi^2(2) = 6{,}962; p = 0{,}031$. In most cases these were the local-range enterprises that had the innovation unit, and such a unit was present in the international-range companies least often. The greater the range of an enterprise, the less often it had an innovation unit.

In the surveyed enterprises, having an innovation unit did not influence the type of innovations introduced, which was confirmed by the *chi-square independence test* $\chi^2(4) = 1{,}017; p = 0{,}907$. Therefore, having an innovation unit did not improve the frequency of innovations introduction among the surveyed enterprises. The innovations were introduced regardless of works carried out in the specialized units of the surveyed enterprises in relation to age, range of activity and employment size. These features did not have a significant statistical impact on the type of innovations introduced. The innovations were also not dependent on whether an enterprises had an innovation unit or not. The age of the enterprise and its size also did not impact the fact of having an innovation unit or not [22]. However, this was statistically significantly influenced by the range of the enterprise's operation. The lower the range, the more often an enterprise had an innovation unit. It should therefore be recognized that the determinant of introducing innovations should be sought outside factors such as the age of the enterprise, the range of the enterprise's activity, the size of the enterprise and the fact of having an innovation unit or not. Therefore, the factors that decide about the innovations may include: barriers for introduction of innovations in the enterprise, contacts with other enterprises, R&D centers and counseling institutions, competitive position of the company.

In the vast majority, the surveyed manufacturing enterprises (65%) faced a lack of capital for growth [23, 24], which may be reflected in issues with introducing innovations. One in five enterprises reported a lack of skilled workers as a barrier to growth, which is also confirmed by other studies [25]. In addition, an important factor reported in the study was (15%) outdated technology. The barriers that the analyzed enterprises had to face did not depend on the age of the companies.

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