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Do barriers to innovation impact changes in innovation activities of firms during business cycle? The effect of the Polish green island

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Keywords: *industrial processing enterprises; innovation strategy; barriers to innovation; eco-innovations; business fluctuations*

Abstract
Research background: There is no doubt that innovation is an important source of economic growth. In the assessment of the innovative activity of Polish industrial processing enterprises, two opposing views can be found. The first indicates the exogenous shock resulting from the global financial crisis and the associated innovation crisis and the subsequent period of innovative pessimism. The second shows the Polish economy as the European Green Island due to strong and uninterrupted economic growth over the past 27 years, controlled inflation, and reduction of unemployment as well as increase of the citizens' well-being. In these conditions, an interesting research gap appeared, which is worth filling, at the centre of which there are factors determining the innovative activity of enterprises, and in particular the role and importance of innovation barriers in various phases of the business cycle.
Purpose of the article: The aim of the research is to determine the impact of innovation barriers and degrees of their importance on the innovation activity of Polish industrial processing enterprises during the business cycle. The time frame of the analysis covers three phases of the cycle: the prosperity period of 2004–2006, the global financial crisis of 2008–2010 and the recovery from 2012–2014.
Methods: Pearson's χ^2 independence test and correspondence analysis were used for data analysis. The research results are presented in a graphical form of biplots that describe the co-

occurrence of three types of variables: (1) types of enterprises and ownership sectors, (2) effects or objectives of innovative activity, and (3) innovation barriers and reasons for the lack of innovation. The basis of calculations were three databases covering the mentioned periods.
Findings & Value added: High resistance of innovative activity of Polish industrial processing enterprises to economic fluctuations has been demonstrated. Innovation barriers and degrees of their importance had little impact on the operations of enterprises in the first of the analysed periods, when prosperity was booming. The impact of the global financial crisis on innovation activities proved to be counterintuitive, as enterprises have continuously achieved their goals and the importance of innovation barriers has diminished even more. In the third period, innovation barriers no longer had any significance for the innovation activities of enterprises. The phenomenon of a gradual decline in the importance of innovation barriers, regardless of the phases of the business cycle, was called the Polish Green Island Effect. The relationship found is a peculiarity which is probably unprecedented in recent world economic history.

Introduction

The motivation to write the article was to explain the relationships between the innovative activities of Polish industrial processing enterprises and barriers hindering these activities during various phases of the business cycle. This issue is particularly important from the point of view of economic growth and development. The study covered three time intervals: period of prosperity occurring in 2004–2006, the global financial crisis of 2008–2010 and the period of recovery in 2012–2014.

The main purpose of the research is to determine the impact of innovation barriers and the degrees of their importance on the innovative activities of Polish industrial processing enterprises in the three periods mentioned above. An additional goal is to measure the achievements of enterprises in the field of innovative activity in various phases of the business cycle.

The research covered interdependencies between multiple variables that could have various states. In total, three groups of variables were distinguished: (1) describing types (size) of enterprises and ownership sectors, (2) barriers to innovation and reasons for the lack of innovation, and (3) goals (effects) of innovative activity. The first group of variables are grouping variables that mediate the impact of innovation barriers on the innovation activity of enterprises.

The study used two statistical methods: Pearson's χ^2independence test and correspondence analysis. The first method consisted in determining the relationship between variables belonging to groups (2) and (3), the second enabled an accurate analysis of co-occurrence between variables belonging to all groups and their states. The results of correspondence analysis are presented in charts called biplots. Statistical data analysis was performed using Statistica 13.3 software.

The obtained results explain some of the important issues regarding the latest economic history of Poland. There are two opposing views on the foundations of the country's economic development during and just after the global financial crisis. According to the first view, the years 2008–2010 are referred to as the innovation crisis, while the years 2010–2012 are defined as the period of innovative pessimism. This typology is based on unfavourable changes in two economic parameters: the indicator of innovative resource used by enterprises and the indicator of commercialization of innovation. Most often, these occurrences were explained by psychological factors. The second view indicates that the global financial crisis has not excessively disturbed the country's economic growth. It only caused a temporary drop in the economic growth rate from 5% in 2008 to 1.7% in 2009. It should be noted that the average growth rate in the European Union in 2009 fell below zero and amounted to -4.2%. These data prompted the Polish government to prepare an economic map of Europe, on which individual countries were attributed the growth rates they achieved in 2009. Countries with a positive growth rate were marked in green, while the other countries were marked in red, as a result of which Poland was called the European Green Island of economic growth. This approach was controversial from the beginning and was often called government propaganda. The discoveries presented in this article, demonstrate that most enterprises achieved the assumed goals of innovative activity and that the importance of innovation barriers decreased, which proved that the effect of the Polish Green Island is a real phenomenon, and not one of the possible interpretations of reality.

The rest of the article consists of the following sections: literature review, research methodology, results, discussion, conclusions, and references. The literature review section assesses research on the influence of innovation barriers on the innovation activity of enterprises and identifies an interesting research gap. The methodological part discusses the methods used and explains the basic concepts. The next part presents the results of the research divided into three periods. The discussion section contains a summary of the discoveries made and their comparison with the current state of knowledge. The conclusions section explains how the findings relate to Polish economic reality. The article ends with a list of used literature.

Literature review

Identification of factors determining the innovative activity of enterprises is one of the basic directions of research on growth and economic development. This task is extremely complex, because it is conditioned not only by the singular internal properties of enterprises, but also by the aspects regarding the socio-economic environment (Wziątek-Kubiak *et al*., 2013). As to the internal factors, great importance is attributed to the type of enterprise (small, medium, large), industry sector, R&D staff and financing of R&D from own sources (Jakimowicz & Rzeczkowski, 2019; Lorentzen & Jakobsen, 2016). The size of the region in which the enterprise operates and its quality are among the characteristics of the environment facilitating innovations (Balcerzak & Pietrzak, 2016; Balcerzak, 2020). The quality of the region should be understood as the efficiency of the regional cooperation network of enterprises in the field of innovation.

In Polish conditions, higher quality of the regions contributes to increasing of the innovative activity of enterprises, prompts sustainable economic growth and the reduction of development disparities between individual voivodeships (Gorączkowska, 2015; Pietrzak *et al*., 2017; Afonasova *et al*., 2019; Rogalska, 2018). During the last period, the importance of cooperation between enterprises within individual industry branches has also increased. This phenomenon applies in particular to high technology industries (Świadek *et al*., 2019).

The reasons for the lack of innovation and barriers to innovation, as well as the factors determining the level of innovative activity and the degree of achievement of innovation objectives, can be endogenous or exogenous. Many of them are listed in the tables in the annex at the end of the article. An example of a barrier of the first type is the lack of funding of innovation from internal sources of the company, while the barrier of the second type may be too much competition on the market.

The perception of factors impeding innovative activity may depend on the type of activity more and more often. Research shows that the barriers to innovation in the field of eco-innovation are usually more numerous and intensive than those that companies focusing on technological innovation have to face. Undertaking eco-innovation is an extremely complex process, requiring advanced technical knowledge, which results in the fact that sometimes a company operates at the technological frontier, and thus in the conditions of insufficient experience. In addition, eco-innovation requires a greater amount of information and knowledge than conducting other innovation activities. This suggests the need to distinguish eco-innovation from technological innovation. In addition, the propensity to eco-

innovation is strongly determined by the type of enterprise understood as its size. Large companies have a greater tendency to introduce eco-innovation as they are better equipped in financial and human resources (Pinget *et al*., 2015).

The exogenous barriers to innovation include all those that are determined by socio-economic and institutional factors. Also in this context, the division into eco-innovations and technological innovations is important. Eco-innovations are based to a much greater extent on external sources of knowledge than other types of innovation. Hence, elements such as belonging to a cluster, R&D cooperation, and environmental monitoring are particularly important in the strategy of an enterprise that is undertaking eco-innovations. When some eco-friendly innovative products are introduced to the market, consumer perception barriers such as usage barrier, value barrier, risk barrier, and tradition barriers may be of great importance (Chen *et al*., 2018).

The impact of innovation barriers on the innovative activity of enterprises and their goals is confirmed by numerous studies (Lewandowska, 2014; Madeira *et al*., 2017; Segarra-Blasco *et al*., 2008; Talegeta, 2014). There is also strong empirical evidence confirming the relationship between the type (size) of an enterprise and its perception of innovation barriers and degrees of their importance. Usually, barriers to innovation are most noticeable for small enterprises, which also assign them the greatest importance. For this reason, one may encounter the view that the sheer size of an enterprise can be a barrier to innovation. The likelihood of overcoming innovation barriers increases with the size of the company (Arza & López, 2018; Coad *et al*., 2016; Iammarino *et al*., 2009; Segarra-Blasco *et al*., 2008; Pachouri & Sharma, 2016; Pinget *et al*., 2015; Talegeta, 2014). It can be concluded that the type of enterprise is an important intermediary variable in the cause-and-effect relationship between barriers to innovation and achieving the goals of innovative activity.

Additionally, it can be said that there is a close relation between culture and entrepreneurship, and also culture and innovation. In this regard, Audretsch (2019), in his recent study, provides a framework for why entrepreneurship and culture matter for economic performance and growth, but also why culture influences the efficacy of policies to enhance entrepreneurial activity. Furthermore, Succurro and Costanzo (2019) focus on firm-level heterogeneity in patent propensity by studying the relationship between ownership structure and patenting activity in Italian manufacturing firms. Their empirical findings show that ownership concentration increases the probability of successful patent applications, but at decreasing returns to scale.

A review of the literature allowed for the identification of a research gap consisting in determining how in the various phases of the business cycle the impact of the reasons for the lack of innovation and innovation barriers on the innovative activity of Polish industrial processing enterprises changes. This issue has not been properly researched yet, which is why this article is one of the first attempts to comprehensively explain the links between innovation activity, obstacles to the implementation of innovation and economic fluctuations. An additional new element is that the research covers three periods, which incorporated different economic trends in Poland: prosperity, global financial crisis, and recovery.

Research methodology

The following statistical methods were used in the research: Pearson's χ^2 independence test and correspondence analysis. The first method is used to study the relationship between two nominal variables (categorical variables). Empirical data should be collected in contingency tables. The test consists in comparing the observed values of the variables with their expected values, which were calculated assuming no relationship between the variables. The value of the test is assessed using the χ^2 statistics. If the difference between the observed values of the variables and their expected values is statistically significant, then the existence of a linking relationship is assumed.

The following two types of null hypotheses are tested:

1. the type and ownership sector of the enterprise have no impact on the effects (goals) of its innovative activities,
2. the type and ownership sector of the enterprise have no impact on the reasons for the lack of innovation and innovation barriers.

For each of these null hypotheses, an alternative hypothesis is formulated about the occurrence of dependence between the studied variables, whose adoption — as a consequence of rejecting the null hypothesis — occurs when *p*-value is lower than the significance level. Since the research was based on three empirical databases, which refer to the years 2004–2006, 2008–2010 and 2012–2014, the null hypotheses formulated in the above manner are tested separately for each of these periods.

Correspondence analysis is a descriptive and exploratory technique for examining two-way and multi-way tables that contain measures describing the relationships between rows and columns. It involves recreating the distance between points corresponding to the rows and columns of such tables in a space with fewer dimensions, usually in two-dimensions or three-

dimensions. The method of calculations provides as complete information as possible about the diversity of rows and columns (Greenacre, 1984; Borg & Groenen, 2010). The obtained results are presented graphically in charts called biplots, where the metric χ^2, which is the weighted Euclidean distance, is used to analyse the points representing the variables (Greenacre, 2010). Unlike traditional hypothesis testing, which involves verifying a priori hypotheses about the relationships between variables, exploratory data analysis enables the identification of systematic relations between variables when there is no a priori expectation about the nature of these relationships.

In order to comprehensively investigate the relations between empirical data, a cybernetic approach based on feedback loops has become necessary. The research included various types of feedbacks. The most important of them include:

1. interdependencies between ownership sectors and types of enterprises,
2. the mutual interactions between,
   a) ownership sectors and types of enterprises,
   b) effects or goals of innovative activity,
3. the mutual interactions between,
   a) ownership sectors and types of enterprises,
   b) barriers to innovation,
4. interdependencies between effects or goals of innovative activity and barriers to innovation.

The necessity to include feedback in research had an impact on the selection of statistical methods. The independence test allows to determine significant relationships between variables, while the correspondence analysis provides information on the structure of relationships between rows and columns of the contingency table. Research on enterprise innovation mostly focuses on unidirectional information flows between economic objects. In contrast, inclusion of feedback signifies focusing on bidirectional and multidirectional interactions. For this purpose, correspondence analysis is the most proper, and enables the research of the co-occurrence of phenomena (Bourdieu, 1996; Greenacre, 2007; Nenadić & Greenacre, 2007).

The size of the enterprise is one of the most important internal features affecting the innovative activity of the company (Jakimowicz & Rzeczkowski, 2019; Lorentzen & Jakobsen, 2016). It is usually determined on the basis of the neoclassical Cobb-Douglas production function according to which production volume is dependent on labour and capital expenditures (Cobb & Douglas, 1928). A similar solution was adopted in the European Union, where the size of the enterprise is influenced by factors such as the number of employees and the volume of the annual turnover or the total of

annual balance sheet (Commission Regulation (EU) No. 651/2014). From this point of view, four types of enterprises are distinguished — micro, small, medium and large. The typology of enterprises in accordance with EU standards is presented in Table 1.

All three analysed databases do not contain micro-enterprises, which is consistent with the assumption that the innovation activity of an enterprise depends on its size. It is fairly unlikely that a micro-enterprise would be involved in innovative activity on a larger scale due to low production factors resources. Symbols FR_1, FR_2 and FR_3 denote the codes of the types of enterprises tested. The ownership sector is another important factor influencing the innovative activity of enterprises. Three ownership sectors were distinguished, which were coded as follows: public (S1), private (S2) and mixed (S3). Table 2 presents the number of enterprises in all three databases with a breakdown into their types and ownership sectors. The largest database from the period 2008–2010 contains 20,655 enterprises. The remaining two data bases are half smaller.

In this study, enterprise types and ownership sectors are grouping variables which are used to assign each individual case from three analysed data bases into a particular group. This applies to the goals of innovative activity of enterprises and barriers to innovation.

Results

Analysis in the period of 2004–2006

The first point of the study is to determine the relationships between variables describing types and ownership sectors of enterprises and variables characterizing the effects of innovative activities and barriers to innovation. Secondly, correspondence analysis is used in order to refine the dependency to create the final result in the form of biplots showing the co-occurrence of phenomena.

According to Table 2, types of enterprise and ownership sectors are described by two variables having three states, so we have nine states in total. Table 3 presents nine variables describing the effects of innovative activity of enterprises, each of which can assume four states, while in Table 4 we have eleven variables related to innovation barriers and each of them can also be in four states. The effects of innovative activity and barriers to innovation may affect the innovative activity of enterprises to a high, medium, low level or be insignificant. This means that there are twenty-two variables in total that can be in eighty-nine states.

The Pearson's χ^2 independence test will be used to verify the relationship between enterprise types and ownership sectors, and the effects of their innovative activity. This task requires the formulation of the following research hypotheses:

H_0: *the type and ownership sector of the enterprise have no impact on the effects of innovative activity*;

H_1: *the type and ownership sector of the enterprise have an impact on the effects of innovative activity*.

The results of the verification of the null hypothesis are presented in Table 5. We see that at the significance level $\alpha = 0.05$ we have the inequality $p < \alpha$, therefore the null hypothesis should be rejected. In conclusion, it should be stated that the effects of an enterprise's innovative activity depend on its type and ownership sector.

Table 4 presents eleven variables describing innovation barriers. The χ^2 independence test will be used again to verify the relationships between the types and ownership sectors of enterprises and barriers to innovation. The following research hypotheses are tested:

H_0: *the type and ownership sector of the enterprise have no impact on innovation barriers*;

H_1: *the type and ownership sector of the enterprise have an impact on innovation barriers*.

The results of the verification of the null hypothesis H_0 are presented in Table 6. At the significance level $\alpha = 0.05$ we again have the inequality $p < \alpha$, which means that the null hypothesis H_0 should be rejected in favour of the alternative hypothesis H_1. It can be stated therefore, that barriers to innovation depend on the type and sector of enterprise ownership.

According to the results obtained, the types and ownership sectors of enterprises have a decisive impact on the effects of innovative activity, the strength of their impact and also determine the types and degrees of importance of innovation barriers. Innovation barriers can reduce or delay the effects of innovative activities. To detail these relationships, the correspondence analysis was used, which led to the construction of the three-dimensional biplot shown in Figure 1 and its three two-dimensional cross-sections (Figures 2–4). 3D biplot provides a general overview of the links between eighty-nine states of twenty-two variables, followed by a 2D bip-

lots for a more accurate visualisation. The construction of the 3D chart was necessary because the value of inertia for two dimensions, 1 and 2, was only 69.92%, so the limit equal to 75% of the total value of χ^2 statistic sufficient to obtain an adequate representation of the initial data by two-dimensional space was not reached. Under these conditions, three dimensions allow to reproduce almost complete information contained in the initial two-way table. Row and column profile standardization was used in the study, which allows for simultaneous analysis of points representing the row profiles (types of enterprises including ownership sectors) and column profiles (effects of innovation activities) and the supplementary points (barriers to innovation).

Variables and their states presented in Figures 1–4 were coded as shown in Tables 1 and 2, as well as Tables 3 and 4. For example, the symbol S2FR_1 represents a small enterprise from the private sector, the symbol AKI_7_2 represents the effect of innovative activity consisting in the reduction of material and energy consumption per unit of product, affecting the enterprise to a medium degree, while the symbol BR5_3 represents the barrier to innovation in the form of lack of information regarding technology, which hinders the innovation activity of the enterprise to a low degree.

In total, eighty-nine points representing states of individual variables are marked in Figures 1–4. Points representing types of enterprises along with the sectors of ownership have been marked with blue circles, points representing the states of variables regarding the effects of innovative activities are red squares, and points representing the states of variables describing the innovation barriers are green rhombi.

During this period of time, there was a good economic situation, as all four charts — one three-dimensional and three two-dimensional cross-sections — indicate the development of almost all forms of innovative activity. Points representing enterprises operating in various ownership sectors are located relatively close to the points representing the effects of innovative activities. The closer the distance between these points, the greater the likelihood of co-occurrence of the corresponding phenomena. χ^2 metric is used to evaluate the distance, which is understood as the weighted Euclidean distance. Innovation barriers practically do not apply to Polish industrial processing enterprises, as they are located in an isolated area of space on each biplot, and at the same time are located at a considerable distance from the points corresponding to enterprise types and ownership sectors. According to Table 6, the χ^2 independence test rejected the null hypothesis in favour of the alternative hypothesis about the relationship between these variables, but analysis of correspondence shows that these relationships are not particularly significant. Thus, from an economic

point of view, the impact of innovation barriers on the innovative activity of enterprises is not very strong.

The analysis of biplots presented in Figures 1–4 reveals one more interesting phenomenon, namely, it indicates some difficulties in achieving the effects of innovative activity in small and medium-sized enterprises from the public sector, S1FR_1 and S1FR_2. At the same time, these enterprises, like all others, are not significantly sensitive to innovation barriers.

Analysis in the period of 2008–2010

As in the previous case, the starting point of the study is to determine the relationships between variables describing types and ownership sectors of enterprises and variables characterizing the objectives of innovative activity and barriers to innovation. For this purpose, the χ^2 independence test will be used. The variables defining the objectives of innovation activities and innovation barriers are presented in tables 7 and 8 respectively.

The analysis should start with establishing the relationship between types and ownership sectors of enterprises and the objectives of innovative activity. The following hypotheses will be tested:

H_0: *the type and ownership sector of the enterprise have no impact on the objectives of innovative activity*;

H_1: *the type and ownership sector of the enterprise have an impact on the objectives of innovative activity*.

The results of the verification of the null hypothesis are presented in Table 9. The null hypothesis should be rejected in favour of the alternative hypothesis. In conclusion, it should be stated that the goals of the company's innovative activity depend on its type and ownership sector.

At the next stage, the relationship between types and ownership sectors of enterprise and barriers to innovation should be determined. The χ^2 independence test will be used for this purpose. The following research hypotheses should be subjected to statistical verification:

H_0: *the type and ownership sector of the enterprise have no impact on innovation barriers*;

H_1: *the type and ownership sector of the enterprise have an impact on innovation barriers*.

The results of the verification of the null hypothesis H_0 are presented in Table 10. The inequality $p < \alpha$ is preserved which means that the null hypthesis should be rejected in favour of the alternative hypothesis. Consequently, innovation barriers depend on the type and sector of enterprise ownership.

The results presented above prove that innovation barriers impede enterprises from achieving the goals related to innovation activities. A detailed analysis of these relationships requires the use of correspondence analysis, as it enables simultaneous analysis of individual variables and their states. The coding of enterprise and sector types is in accordance with tables 1 and 2. Tables 7 and 8 apply accordingly to innovation activity and innovation barriers.

It should be noted that the PNT–02 questionnaire used to study innovation in the industry sector during the years 2008–2010 has undergone some changes in comparison to the PNT–02 questionnaire used in the 2004–2006 period. Variables describing the effects of innovation activity were used in the previous period, however, in the period 2008–2010 variables used were describing the objectives of innovative activity. Moreover, a new target appeared in the form of replacement of obsolete products or processes, which in Table 7 was marked as AKI_2. The effect in the form of regulations, norms or standards compliance has been removed (symbol AKI_9 in Table 3) and the effect involving the reduction of environmental damage and improvement of occupational health and safety has been split into two separate goals. Therefore, it should be remembered that despite the same designations, the variables in Table 7 differ from those in Table 3. However, the barriers to innovations have not changed, as the way they are coded coincides in tables 8 and 4, except that in the period 2008–2010 the degree of their importance, not the degree of their influence is considered.

Figure 5 presents a three-dimensional biplot determining the co-occurrence of variables representing types and ownership sectors of enterprises, goals of innovative activity and barriers to innovation. In total there are twenty-three variables that occur in ninety-three states. Figures 6–8 show three two-dimensional biplots that are cross-sections of the biplot from Figure 5. 2D biplots contain the same information as the 3D biplot, but they visually refine the information shown on the 3D biplot.

During this period, the global financial crisis became apparent and the enterprises surveyed gradually began to feel the impact. The least resistant to exogenous changes proved to be small and medium-sized enterprises from the public sector (S1FR_1, S1FR_2), that gradually limited their innovative activity. This phenomenon is already partially visible on the 3D biplot from Figure 5, and fully confirmed on the 2D biplots from Figures

6–8, where points S1FR_1, S1FR_2 are relatively isolated. They are largely distant from points representing the goals of innovative activity. Figure 6 shows that with two dimensions we can reproduce as much as 79.18% of inertia, therefore the biplot presented in this form is a good representation of the initial data. The credibility of statistical inference is particularly high in this case. A similar relationship did not occur so clearly in 2004–2006. In the analysed period, the remaining types of enterprises belonging to specific ownership sectors achieved the goals (effects) of innovative activity at a similar level as before.

At the same time, the lack of significance of innovation barriers for almost all surveyed enterprises is a surprise. These points were in an isolated and relatively small area of space. Green rhombi denoting innovation barriers are located at a relatively large distance both from the blue circles denoting the types and ownership sectors of enterprises, including small and medium-sized enterprises from the public sector (S1FR_1 and S1FR_2), as well as from the red squares denoting the objectives of innovative activity. The noticeable increase in these distances is another significant change in comparison to the previous period (2004–2006). The χ^2 independence test still indicates the dependence of innovation barriers on types and ownership sectors of enterprises, but it can be seen that it is clearly weaker during the global financial crisis than before. Thus, the impact of innovation barriers on the effects or goals of innovative activity of enterprises is weakening. Another new phenomenon compared to the previous period is the concentration of all variable states representing barriers to innovation in a much smaller area, which indicates that differences in degrees of their importance cease to be significant for enterprises.

Analysis in the period of 2012–2014

For comparative purposes, it is necessary to perform a similar verification as in the previous two periods of relationships between types and ownership sectors of enterprises and the objectives of innovation activity and innovation barriers. The χ^2 independence test and correspondence analysis are also used. The goals of innovative activity are characterized in Table 11, while the reasons for the lack of innovation and innovation barriers are presented in Table 12. Both tables are included in Annex.

In order to determine the relationship between types and ownership sectors of enterprises and the goals of innovative activity, the following hypotheses were statistically verified:

H_0: *the type and ownership sector of the enterprise have no impact on the goals of innovative activity*;

H_1: *the type and ownership sector of enterprise have an impact on the goals of innovative activity*.

Table 13 shows the results of verification of the null hypothesis. Calculations show that the null hypothesis should be rejected in favour of the alternative hypothesis. Thus, the goals of the company's innovative activity depend on its type and ownership sector.

Another issue is the determination of the relationship between the type and ownership sector of the enterprise and the reasons for the lack of innovation and barriers to innovation. The following hypotheses were tested:

H_0: *the enterprise type and ownership sector have no impact on the reasons for the lack of innovation and barriers to innovation;*

H_1: *the type and ownership sector of the enterprise have an impact on the reasons for the lack of innovation and barriers to innovation.*

The results of the verification of the null hypothesis H_0 are presented in table 14. The inequality $p > \alpha$ indicates that there are no reasons for rejecting the null hypothesis. This leads to a rather sensational conclusion that the reasons for the lack of innovation and the innovation barrier do not depend on the type and sector of enterprise ownership.

Considering the above conclusions, it seems that in the examined period the reasons for the lack of innovation and barriers to innovation listed in Table 12 did not apply to Polish industrial processing enterprises, which means that these reasons and barriers did not affect the objectives of innovation activity listed in Table 11. In order to establish more detailed relationships between variables, correspondence analysis was used.

The 3D biplot from Figure 9 presents the co-occurrence of points representing types and ownership sectors of enterprises, goals of innovative activity and the reasons for the lack of innovation and the barriers to innovation. The next three biplots, shown in Figures 10–12, are the two-dimensional cross-sections of the 3D biplot that enable the refinement of the research. 3D biplot presents a general picture of the co-occurrence of the studied phenomena, and the reason for its preparation is the fact that three dimensions explain as much as 87.72% of the total value of the χ^2 statistics. It includes the co-occurrence between two variables in the form of types and sectors of enterprises, which in total can be in nine states, and

fifteen one-state variables characterizing the objectives of innovative activity and eleven four-state variables describing the reasons for the lack of innovation and the barriers to innovation. In total, we have twenty-eight variables, which can be in sixty-eight states represented by points on the chart. The variable coding is identical to the coding used in previous biplots.

In general, the biplots presented in Figures 9–12 show that in the third period the distances of points representing types and ownership sectors of enterprises and points describing the objectives of innovative activity from points corresponding to the reasons for lack of innovation, barriers to innovation and their degrees of significance are much greater than in 2004–2006 and 2008–2010. At the same time, it can be seen that the reasons for the lack of innovation, barriers to innovation and their degrees of importance (green rhombi) are concentrated in a relatively small region of space. Therefore, these variables and their states have practically no impact on the goals of innovative activity. In addition, the points representing the goals of innovative activity (red squares) are usually located at a short distance from the points corresponding to the types of enterprises and ownership sectors (blue circles), which indicates the achievement of these goals by most enterprises.

The analysis of the biplots from Figures 9–12 allows for one more interesting phenomenon to be noticed, which has already appeared partly in previous periods. Figure 9 shows that all types of public sector enterprises are relatively isolated points: S1FR_1, S1FR_2 and S1FR_3. Small enterprises S1FR_1 have some problems with achieving the goals of innovative activity, but the reasons for the lack of innovation and the barriers to innovation as well as their degrees of importance do not hinder their activities at all. This is confirmed by 2D biplots shown in Figures 11 and 12. Medium enterprises S1FR_2 also have some difficulties in achieving the objectives of innovation activity, but the reasons for the lack of innovation and barriers to innovation affect them much more than small enterprises from the public sector. On all 2D biplots (Figures 10–12) the S1FR_2 point is located between and at a fairly large distance from the points representing the goals of innovative activity as well as the reasons for the lack of innovation and barriers to innovation. The position of enterprises S1FR_3 is much better compared to the two previous types, because the point representing them lies near the points corresponding to the objectives of innovative activity (Figures 10–12). In addition, for this type of enterprises, the reasons for the lack of innovation and the barriers to innovation are not significant (long distances from green points). It should be noted, however, that in terms of achieving the objectives of innovative activity, S1FR_3 enterpris-

es, the best in the public sector, are in a slightly worse position than all other types of enterprises from other ownership sectors. In summary, small and medium-sized enterprises from the public sector have the biggest problems with innovations. This is probably due to political considerations in the selection of managerial staff for these enterprises.

When comparing the dynamics of innovative activity of enterprises in the years 2012–2014 with the previous two periods, certain differences in statistical reporting should be taken into account, namely the construction of the PNT–02 questionnaire, based on which the data was collected. As for the goals (effects) of innovative activity, there has been a clear shift of emphasis on eco-innovation, which is the result of the growing importance of pro-ecological economic policy in the European Union. Therefore, there are some differences between the variables describing the innovation activity. However, it cannot be said that they prevent comparative studies of the three periods because the essence of innovation activities has remained unchanged. Variables still describe the same phenomenon. While defining the effects (goals) of innovative activity, a need to abandon degrees of influence or significance was also noted, due to their low consequence for enterprises, which results from the economic development of the country. In the case of innovation barriers, the changes are only formal and the whole substance remains unchanged.

Discussion

The article examines the impact of innovation barriers on the implementation of the objectives (effects) of innovative activity by Polish industrial processing enterprises. The analysis covered three periods of 2004–2006, 2008–2010 and 2012–2014. Pearson's χ^2 independence test was used to assess the research hypotheses, and a detailed analysis of the relationships between multiple variables was performed with use of correspondence analysis. Both methods provide results that complement each other. In each case, statistical significance criteria were met. The use of correspondence analysis enabled the preparation of 3D biplot and three two-dimensional cross-sections of the 3D biplot for each period, which allowed for a very detailed analysis of the co-occurrence of phenomena. The reliability of the inference based on the mentioned biplots is particularly high because they provide a very good representation of the initial data from contingency tables. In the first period 77.77% , in the second — 85.833%, and in the third — 87.72% of the total value of the χ^2 statistics was reproduced. In addition, there is one 2D biplot in each of the tested periods, which fulfils

the condition of good representation of initial data even in two-dimensional space, as it allows for reproducing almost 75% of inertia; for the second period it is as much as 79.18%, which results from Figure 6.

The same phenomenon is examined in each of the periods, i.e. the impact of innovation barriers on the innovative activity of enterprises. As previously emphasized, differences in databases are more formal than substantive, which enables the comparison of changes occurring in all analysed periods. Therefore, it is possible to formulate the following conclusions:

1. In each of the three periods, points representing types and ownership sectors of enterprises (blue circles) are located near points representing the effects (goals) of innovative activity and degrees of their impact (significance) for enterprises (red squares). Both of these types of points form common clusters. The above means that in the studied periods, most enterprises did not have major problems with achieving the goals of innovative activity.
2. Small and medium-sized enterprises from the public sector, marked with symbols S1FR_1 and S1FR_2, are much worse at achieving the goals of innovative activity compared to other enterprises. Points corresponding to these enterprises are located at relatively large distances from points representing the goals of innovative activity and their degrees of importance. This regularity is visible in all periods, except that it deepened in the years 2008–2010 and this trend persisted in the period 2012–2014. Moreover, the innovation activity of these enterprises is unlikely to be hindered by innovation barriers. Initially, the deterioration of the situation of these enterprises could have a source in the global financial crisis, and the persistence of this state in subsequent years may be the result of applying political criteria for the selection of managerial staff.
3. In each of the examined periods, points representing barriers to innovation and their degrees of importance for enterprises (green rhombi) form separate clusters located at relatively large distances from points representing the types and sectors of ownership of enterprises and points indicating the objectives of their innovative activity. So we have two separate clusters of points. Interestingly, the average distance between these clusters increased slightly in the years 2008–2010, i.e. during the global financial crisis, compared to the period 2004–2006. This means that the crisis has not stopped the innovation activity of enterprises, and at the same time a reduction of the undesirable effects of barriers to innovation has been observed. In addition, the significance of these barriers decreased so significantly in the period 2012–2014 that they became irrelevant to all enterprises. Both clusters have increased their distance even more.

4. In the last examined period, the innovation strategy of enterprises has changed, as the focus has shifted from traditional technological innovations to eco-innovations. The type of eco-innovation undertaken is strongly dependent on the type of enterprise and ownership sector.

Professional literature assesses the changes in the Polish economy in the studied periods in an ambivalent way. On the one hand, innovation crisis and innovative pessimism as the effects of the global financial crisis are mentioned, while on the other hand, Polish economy is presented as a Green Island of economic growth on the background of the crisis-stricken European Union. These extreme points of view create a certain thematic framework in which the results of this article can be evaluated.

In the recent economic history of Poland, the period 2008–2010 is treated as the years of the innovation crisis, during which the frequency of the use of innovative resources by industrial processing enterprises decreased and the indicators of innovation commercialization deteriorated. In turn, the period 2010–2012 was characterized by growing discrepancies between the indicator of resource use and the indicator of commercialization of innovation. Both showed a decreasing tendency, but the first decreased faster than the second. A conclusion was drawn from this about the psychological basis of the phenomenon and these years were called the period of innovative pessimism (Wziątek-Kubiak & Pęczkowski, 2019). The analysis carried out in this article does not confirm the existence of either an innovative crisis or a period of innovative pessimism. Although qualitative research is presented in this article, it clearly shows the relatively good implementation of innovative goals by enterprises and the decreasing importance of innovation barriers.

According to the second point of view, Polish economy did not feel much the effects of the global financial crisis and during its duration it showed a slightly lower, but positive, rate of economic growth. In 2010, the then economic authorities presented a map of Europe with Poland distinguished as the Green Island of economic growth on the red background of other countries in crisis, with negative growth rates (Tomescu-Dubrow *et al*., 2018, pp. 202–216; Tomescu-Dubrow *et al*., 2019, pp. 17–18). In the most difficult year for the Polish economy in 2009, the growth rate decreased to 1.7% (after a later revision it was changed to 1.3%), with the average in the European Union at the level of -4.2%. For comparison, the economic growth rate of Poland in 2008 was 5%. In 2010, this rate was 3.9% with the EU average of 2.1%. The increase in unemployment in Poland was also moderate. In the second half of 2008, unemployment amounted to 7.1% and increased gradually to 9.7% in January 2011 (Kaczyński, 2012). However, it turned out that at the turn of 2012 and 2013 the

Polish economy was affected by a technical recession. In the fourth quarter of 2012, GDP decreased by 0.3% compared to the previous quarter, and in the first quarter of 2013 it fell further by 0.1%. However, immediately afterwards Poland regained the title of Green Island. According to the latest data, the growth rate of the Polish economy in 2018 reached 5.1%, and estimates for 2019 are close to this value. The resistance of the Polish economy to the crisis resulted from many factors, but mainly from stable internal consumption (Cienski, 2012). The quantitative data presented here coincide with the results of the qualitative research presented in this article. Stable implementation of the goals of innovative activity by enterprises in the three analysed periods and a gradual decrease in the importance of innovation barriers despite the occurrence of various phases of the business cycle means that Polish Green Island effect is plausible. Due to the above, innovation barriers and their degrees of importance on all biplots are marked in green.

Conclusions

The research carried out in this article indicates high resistance of the innovative activity of Polish industrial processing enterprises to cyclical fluctuations. This result is to some extent inconsistent with the current research, so it can contribute to its expansion (Świadek, 2015). The points corresponding to the types and sectors of ownership of enterprises (blue circles) form a joint cluster with points representing the goals or effects of innovative activity (red squares) on biplots made for all analysed periods, i.e. 2004–2006, 2008–2010 and 2012–2014. Points representing the reasons for the lack of innovation and barriers to innovation (green rhombi) form a separate cluster. Since the beginning of the 2004–2006 period, the distance between these two clusters has been gradually increasing, which proves the decreasing impact of innovation barriers and the degree of their importance to enterprises. This inference is made possible due to the fact that the scales are the same for each of the biplots, which are based on χ^2 metrics, which is the weighted Euclidean distance. The results collected here coincide with the views on the Polish economy as a European Green Island of economic growth.

The latest data presented at the Economic Forum in Krynica in 2019 indicate that since 1992 the Polish economy has been recording uninterrupted economic growth exceeding on average 4% per year. Over the past 27 years, only Australia has also achieved such a result among OECD countries. In the years 1990–2018, GNP tripled, and the Polish economy is cur-

rently the 7th largest economy in the European Union and 23rd in the world. Strong and uninterrupted economic growth, economic openness to the world, controlled inflation, reduction of unemployment and increase of wellbeing of the people should be mentioned among the achievements of the Polish economy in the last thirty years. These achievements would not have been possible without large-scale innovation activities undertaken by enterprises. The research results presented in this article explain at least partly the reasons for Poland's economic successes and indicate that the title of Green Island is not a propaganda trick of one of the governments, but a lasting economic achievement.

As far as the Polish and Australian economies are concerned, it seems that the factors of economic growth may be of a similar nature. This would indicate the need for appropriate comparative analyses. This issue could be a fascinating subject for future research.

The obtained research results also point to another interesting phenomenon, which is probably still in the initial phase, namely the specialization of individual types of enterprises from various ownership sectors in specific types of eco-innovation. In this context, the possibility of explaining earlier discrepancies in the assessment of the innovative activity of Polish industrial processing enterprises arises. In order to clarify these differences, it would be necessary to divide innovations into traditional innovations and eco-innovations. The stagnation signalled by some authors would mainly concern traditional innovations, while undertaking eco-innovations would indicate the emergence of a new innovation strategy among enterprises. This trend is particularly pronounced in the years 2012–2014 (Jakimowicz & Rzeczkowski, 2019). Thus, the importance of pro-ecological economic policy is growing, which in the future may have an even greater impact on the innovation activity of enterprises.

Biplots presented in Figures 1–12 provide insights about many other relationships between types and ownership sectors of enterprises, goals of innovation activities and barriers to innovation. The presented approach to the issue, covering multiple variables, is comprehensive and unique in the literature on the subject. The analysis presented here provides many more results than described in the article. Due to the wide range of issues raised and their complex nature, only basic relationships are discussed here. The presented biplots provide much more information about the relationships between variables, which are not examined due to lack of space. The reader interested in the subject, even without access to the three extensive databases that were the source of data for the research, can independently discover and interpret different interrelations that are particularly interesting to him, by analysing the biplots in detail.

The results presented in the article lead to another research question about the reasons for Poland's economic success. Although it goes beyond the scope of this article, it may show possible directions of future research. In this case, one should refer to the concept of innovative capital (Kijek, 2012) and define the problem of low sensitivity of this capital to economic fluctuations. Among the possible explanations, one should definitely consider economic policy and its adequacy to the given economic situation. However, it seems that assuming the optimal economic policy may not be enough to fully explain the lack of impact of innovation barriers on the innovation activity of enterprises. In the three studied periods, different types of economic policy were implemented, depending on the political option represented by successive governments. There must, therefore, be some other explanation, some economic factor that is hardly sensitive to political influence. The source of Polish enterprises' success is undoubtedly the entrepreneurship of citizens and a relatively new element on the consumption side, which is prosumption (Jakimowicz & Rzeczkowski, 2016). A prosumer is a new type of business entity that is not only a consumer but is also actively participating in the design and creation of new products and services (Toffler & Toffler, 2006). Therefore, the source of innovative success of Polish enterprises could be mutual fuelling of entrepreneurship and prosumption. However, confirmation of this hypothesis requires further research.

Record results prove that the Polish economy has a strong and at the same time flexible production structure, which is probably due to the multilevel relationships between various economic entities. Until now, these issues have not received much attention, probably due to the limited data or lack of relevant data. In addition, in such an economy, learning processes and diffusion of innovation must run extremely smoothly, probably innovative capital is growing at a very fast pace, therefore more attention should be devoted to knowledge acquisition processes, information flow channels and methods of learning of business entities. Since stable internal consumption is one of the sources of success, it might also be worth obtaining information about prosumption. Therefore, another practical implication would be an improved adaptation of the PNT-02 statistical questionnaires, used to acquire information about industrial innovations, to rapidly changing economic conditions.

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Annex

Table 1. Typology of enterprises in the light of European Union standards and the method of coding

Types of enterprise/Code	Number of employees (NE, in persons)	Annual turnover (AT, in EUR million)	Annual balance sheet total (ABS, in EUR million)
Micro	NE < 10	AT ≤ 2	ABS ≤ 2
Small (FR_1)	10 ≤ NE < 50	2 < AT ≤ 10	2 < ABS ≤ 10
Medium (FR_2)	50 ≤ NE < 250	10 < AT ≤ 50	10 < ABS ≤ 43
Large (FR_3)	NE ≥ 250	AT > 50	ABS > 43

Source: own elaboration based on Commission Regulation (EU) No. 651/2014, Annex I, Article 2 (26.6.2014, p. L 187/70).

Table 2. The number of enterprises depending on types and sectors of ownership in the three analysed databases

Type/Ownership Sector (Code)	Database								
	2004–2006			2008–2010			2012–2014		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Public (S1)	90	234	120	52	119	73	20	54	39
Private (S2)	2,222	4,725	1,110	10,187	4,327	1,012	2,052	1,677	906
Mixed (S3)	739	690	219	3,560	1,039	286	1,522	3,467	507
Subtotal	3,051	5,649	1,449	13,799	5,485	1,371	3,594	5,198	1,452
Total		10,149			20,655			10,244	

Source: Statistics Poland (GUS), Statistical Office in Szczecin.

Table 3. Variables describing the effects of innovative activity of enterprises in 2004–2006, the degrees of their influence on enterprises and the method of coding

Effect Type	Effects of innovative activity Scale: 1 – high; 2 – medium; 3 – low; 4 – irrelevant	Codes	Degree of influence
Product effects	Increase of the product assortment	AKI_1	1, 2, 3, 4
	Entering into new markets or increasing the existing market share	AKI_2	1, 2, 3, 4
	Product quality increase	AKI_3	1, 2, 3, 4
Process effects	Improvement in production flexibility	AKI_4	1, 2, 3, 4
	Increase of production capacity	AKI_5	1, 2, 3, 4
	Reduction of labour costs per unit of product	AKI_6	1, 2, 3, 4
	Reduction of consumption of materials and energy per unit of product	AKI_7	1, 2, 3, 4
Other effects	Reduction of harmfulness to the environment and improvement of work safety	AKI_8	1, 2, 3, 4
	Compliance with regulations, norms or standards	AKI_9	1, 2, 3, 4

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovation for 2004–2006, Statistics Poland (GUS).

Table 4. Variables describing innovation barriers in the years 2004–2006, degrees of their influence on enterprises and coding

Type of barrier	Factors impeding innovative activity Scale: 1 – high; 2 – medium; 3 – low; 4 – irrelevant;	Codes	Degree of influence
Economic factors	Lack of financial resources in your company or in your group of enterprises	BR1	1, 2, 3, 4
	Lack of financial resources from external sources	BR2	1, 2, 3, 4
	Too high costs of innovation	BR3	1, 2, 3, 4
Knowledge factors	Lack of qualified staff	BR4	1, 2, 3, 4
	No information about technology	BR5	1, 2, 3, 4
	No information on markets	BR6	1, 2, 3, 4
	Difficulties in finding partners for cooperation in the field of innovative activity	BR7	1, 2, 3, 4
Market factors	Market split by dominant enterprises	BR8	1, 2, 3, 4
	Uncertain demand for innovative (new) products	BR9	1, 2, 3, 4
Other factors	No need to run innovative activity due to the introduction of innovations in previous years	BR10	1, 2, 3, 4
	No demand for innovation	BR11	1, 2, 3, 4

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovation for 2004–2006, Statistics Poland (GUS).

Table 5. List of assumptions and calculations necessary to verify the hypothesis about the relationship between the type and sector of enterprise ownership and the effects of its innovative activities (2004–2006)

χ^2 **test of independence**	
χ^2 **statistics value**	426.05
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.0000$
Decision	H_0 hypothesis should be rejected in favour of H_1

Table 6. List of assumptions and calculations necessary to verify the hypothesis about the relationship between the type and sector of enterprise ownership and innovation barriers (2004–2006)

χ^2 **test of independence**	
χ^2 **statistics value**	1,519.68
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.0000$
Decision	H_0 hypothesis should be rejected in favour of H_1

Table 7. Variables describing the goals of innovative activity in the years 2008–2010, their degrees of importance for enterprises and the method of coding

Goals of innovative activity **Scale: 1 – high; 2 – medium; 3 – low; 4 – irrelevant**	**Codes**	**Degree of importance**
Increase of the product or service assortment	AKI_1	1, 2, 3, 4
Replacement of obsolete products or processes	AKI_2	1, 2, 3, 4
Entering into new markets or increasing the existing market share	AKI_3	1, 2, 3, 4
Improvement of the quality of products or services	AKI_4	1, 2, 3, 4
Improvement in production flexibility	AKI_5	1, 2, 3, 4
Increase of production capacity	AKI_6	1, 2, 3, 4
Reduction of labour costs per unit of product	AKI_7	1, 2, 3, 4
Reduction of consumption of materials and energy per unit of product	AKI_8	1, 2, 3, 4
Reduction of harmfulness to the environment	AKI_9	1, 2, 3, 4
Improvement of work safety	AKI_10	1, 2, 3, 4

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovations for the years 2008–2010, Statistics Poland (GUS).

Table 8. Variables describing barriers to innovation in the years 2008–2010, degrees of their importance for enterprises and coding method

Barrier type	Factors impeding innovative activity Scale: 1 – high; 2 – medium; 3 – low; 4 – irrelevant;	Codes	Degree of importance
Economic factors	Lack of financial resources in your enterprise or in your group of enterprises	BR1	1, 2, 3, 4
	Lack of financial resources from external sources	BR2	1, 2, 3, 4
	Too high costs of innovation	BR3	1, 2, 3, 4
Knowledge factors	Lack of qualified personnel	BR4	1, 2, 3, 4
	No information about technology	BR5	1, 2, 3, 4
	No information on markets	BR6	1, 2, 3, 4
	Difficulties in finding partners for cooperation in the field of innovative activity	BR7	1, 2, 3, 4
Market factors	Market split by dominant enterprises	BR8	1, 2, 3, 4
	Uncertain demand for innovative (new) products	BR9	1, 2, 3, 4
Other factors	No need to run innovative activity due to the introduction of innovations in previous years	BR10	1, 2, 3, 4
	No demand for innovation	BR11	1, 2, 3, 4

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovations for the years 2008–2010, Statistics Poland (GUS).

Table 9. List of assumptions and calculations necessary to verify the hypothesis about the relationship between the type and sector of enterprise ownership and the goals of its innovative activities (2008–2010)

χ^2 **test of independence**	
χ^2 **statistics value**	668.581
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.0000$
Decision	H_0 hypothesis should be rejected in favour of H_1

Table 10. List of assumptions and calculations necessary to verify the hypothesis about the relationship between the type and sector of enterprise ownership and innovation barriers (2008–2010)

χ^2 **test of independence**	
χ^2 **statistics value**	3,174.84
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.0000$
Decision	H_0 hypothesis should be rejected in favour of H_1

Table 11. Variables describing the goals of innovative activity in the years 2012–2014, their types and coding method

Goal types	Goals of innovative activity	Codes
Products	New or significantly improved manufactured goods	AKI_1
	New or significantly improved services	AKI_2
Processes	New or significantly improved methods of producing goods and services	AKI_3
	New logistic processes	AKI_4
	New management processes	AKI_5
Environmental benefits obtained during the production of products or services	Reduction of material consumption or water consumption per unit of product	AKI_6
	Reduction of energy intensity or carbon dioxide emissions	AKI_7
	Reduction of soil, water, air or noise pollutions	AKI_8
	Use of materials that are less polluting or less dangerous to the environment	AKI_9
	Reduction of the fossil fuels, higher use of energy obtained from renewable sources	AKI_10
	Re-use (recycling) of waste, water or materials for personal use or sale	AKI_11
Environmental benefits obtained during the period of use of the purchased product or use of the service by end users	Reducing energy consumption or carbon dioxide emissions	AKI_12
	Reduction of air, water, soil or noise pollutions	AKI_13
	Facilitating the re-use (recycling) of the product after use	AKI_14
	Extending the life of products thanks to increased durability and strength	AKI_15

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovation for 2012–2014, Statistics Poland (GUS).

Table 12. Variables describing the reasons for the lack of innovation and barriers to innovation in the years 2012–2014, their degrees of importance for enterprises and the method of coding

Reasons for a lack of innovation	Factors impeding innovative activity Scale: 1 – high; 2 – medium; 3 – low; 4 – irrelevant;	Codes	Degree of importance
No compelling reason for introducing innovation	Low demand for innovation on market	BR_1	1, 2, 3, 4
	No need to implement innovation due to earlier innovations	BR_2	1, 2, 3, 4
	No need to implement innovation due to low competition on the market	BR_3	1, 2, 3, 4
	Lack of good ideas for innovation	BR_4	1, 2, 3, 4
The implementation of innovations was considered, but the barriers proved to be too high	Lack of financing opportunities for innovation from the company's internal sources	BR_5	1, 2, 3, 4
	Lack of financing for innovation from external sources – loans or funds under private equity financing (including venture capital)	BR_6	1, 2, 3, 4
	No staff with the right skills in your company	BR_7	1, 2, 3, 4
	Difficulties in obtaining public grants or subsidies for innovation	BR_8	1, 2, 3, 4
	No partners to cooperate with	BR_9	1, 2, 3, 4
	Uncertain market demand for your ideas for innovation	BR_10	1, 2, 3, 4
	Too much competition on the market	BR_11	1, 2, 3, 4

Source: own elaboration based on questionnaire PNT-02: Report on industrial innovation for 2012–2014, Statistics Poland (GUS).

Table 13. List of assumptions and calculations necessary to verify the hypothesis regarding the relationship between the type and ownership sector of an enterprise and the goals of its innovative activity (2012–2014)

χ^2 test of independence	
χ^2 statistics value	2,361.7
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.0000$
Decision	H_0 hypothesis should be rejected in favour of H_1

Table 14. List of assumptions and calculations necessary to verify the hypothesis regarding the relationship between the type and ownership sector of an enterprise and the reasons for the lack of innovation and barriers to innovation (2012–2014)

χ^2 test of independence	
χ^2 statistics value	251.602
Critical region	right-tailed
Level of significance (α)	$\alpha = 0.05$
P-value (p)	$p = 0.9999$
Decision	Since $p > \alpha$, there are no grounds for rejecting H_0

Figure 1. 3D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the effects of innovative activity, and the barriers to innovation in period 2004–2006 (dimensions 1–2–3; 77.77% of total inertia)

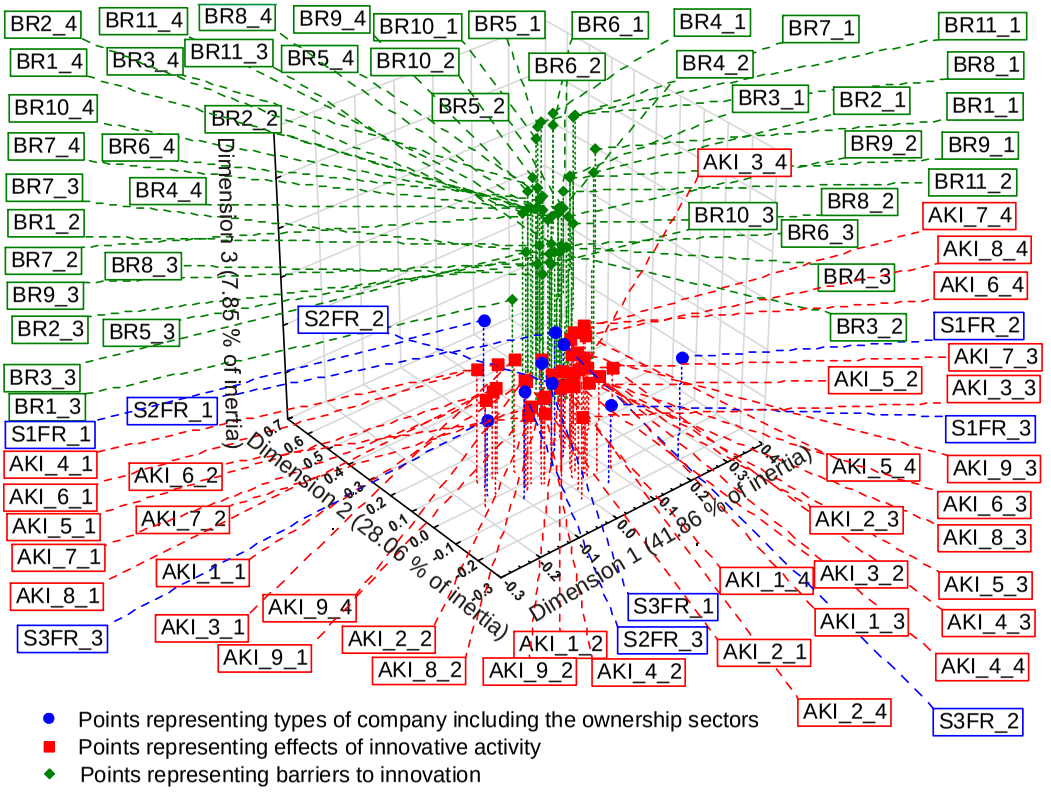

Figure 2. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the effects of innovative activity, and the barriers to innovation in period 2004–2006 (dimensions 1–2; 69.92% of total inertia)

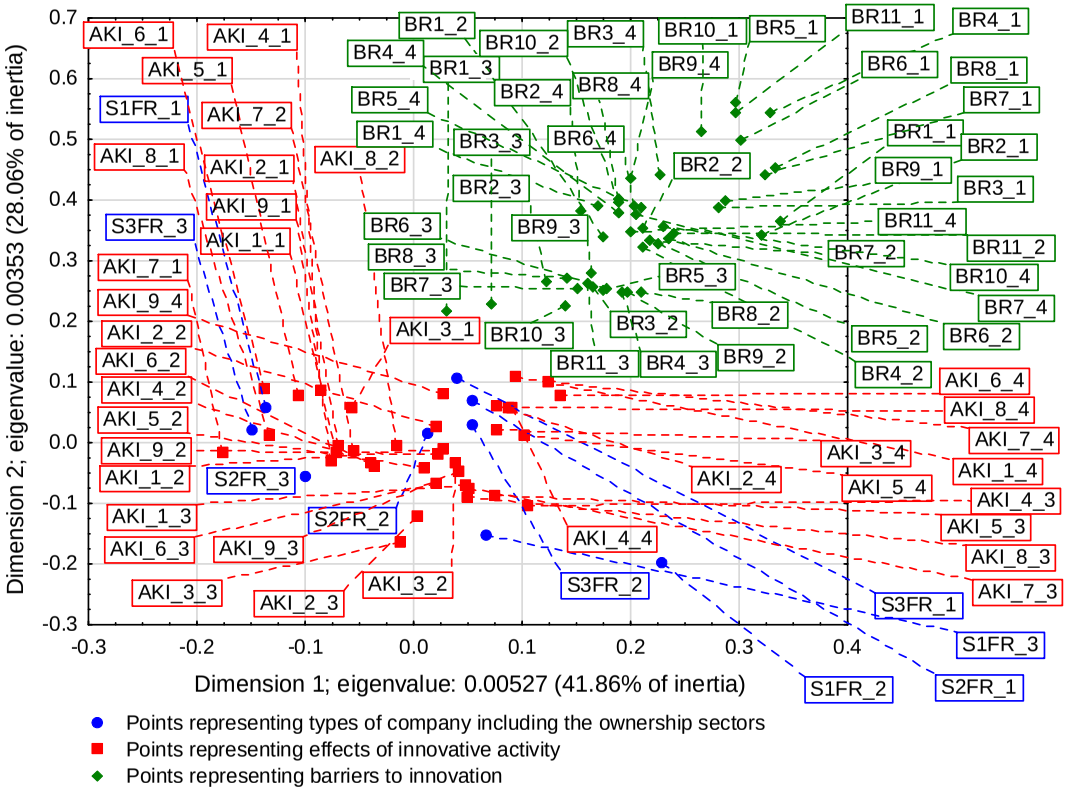

Figure 3. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the effects of innovative activity, and the barriers to innovation in period 2004–2006 (dimensions 1–3; 49.71% of total inertia)

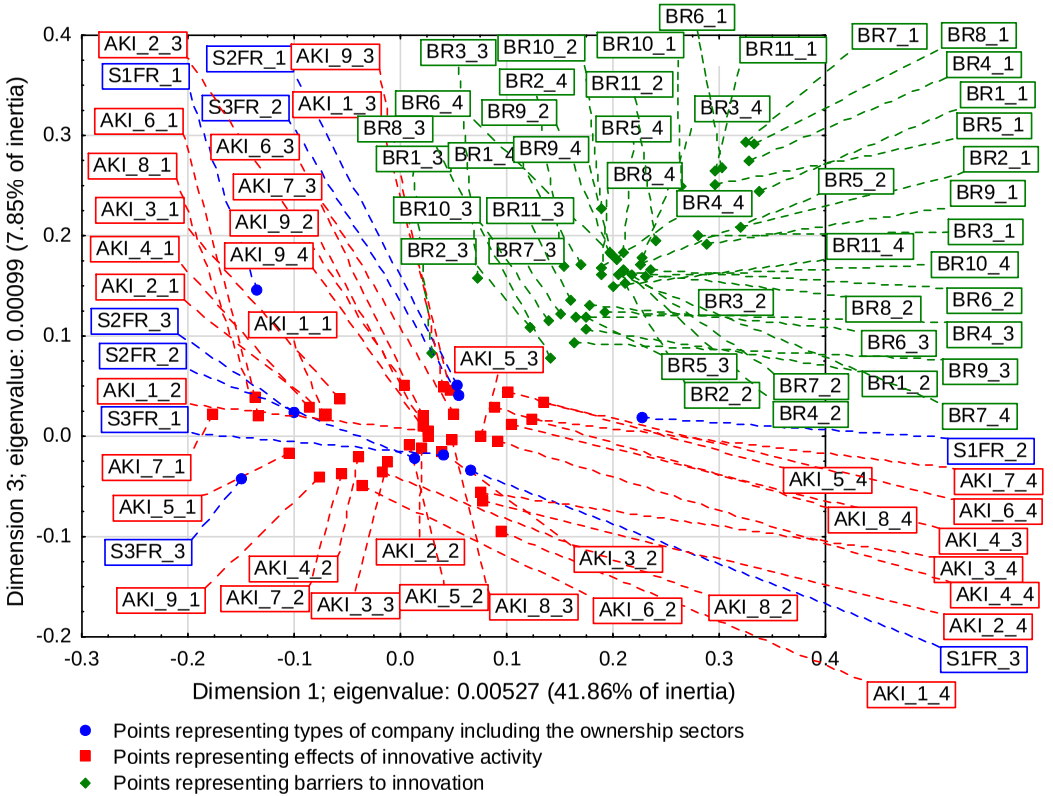

Figure 4. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the effects of innovative activity, and the barriers to innovation in period 2004–2006 (dimensions 2–3; 35.91% of total inertia)

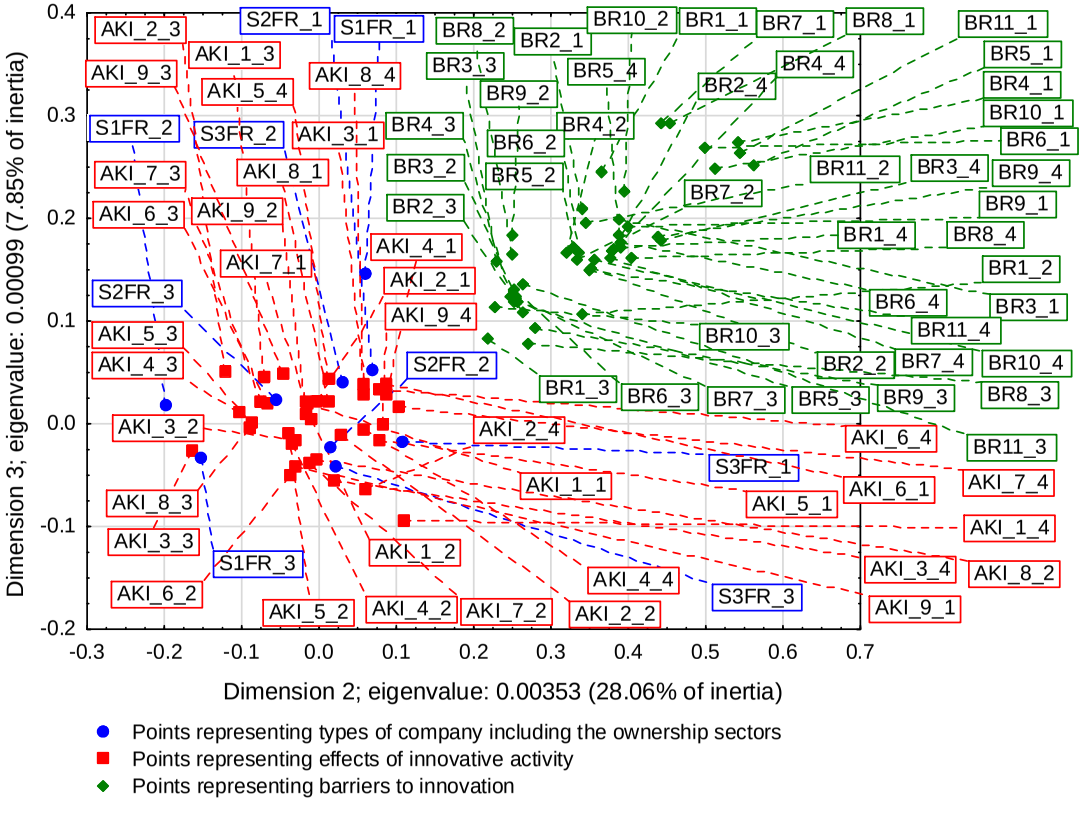

Figure 5. 3D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2008–2010 (dimensions 1–2–3; 85.833% of total inertia)

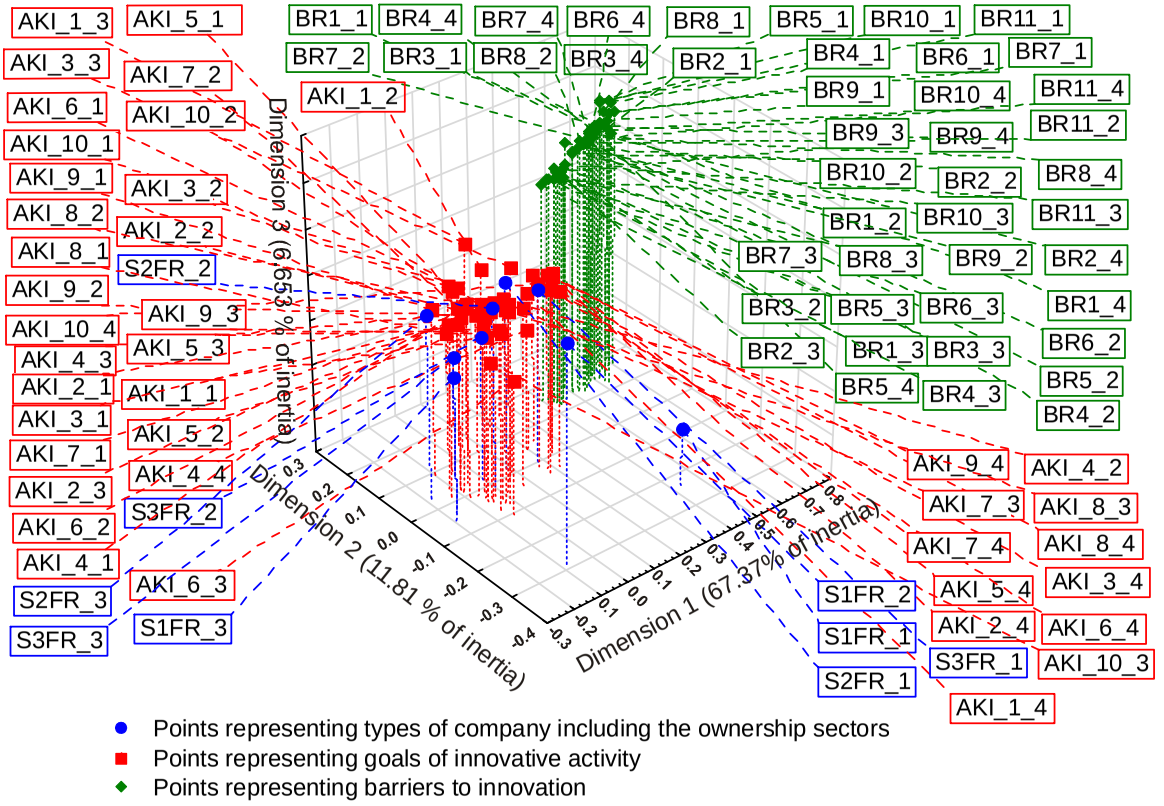

Figure 6. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2008–2010 (dimensions 1–2; 79.18% of total inertia)

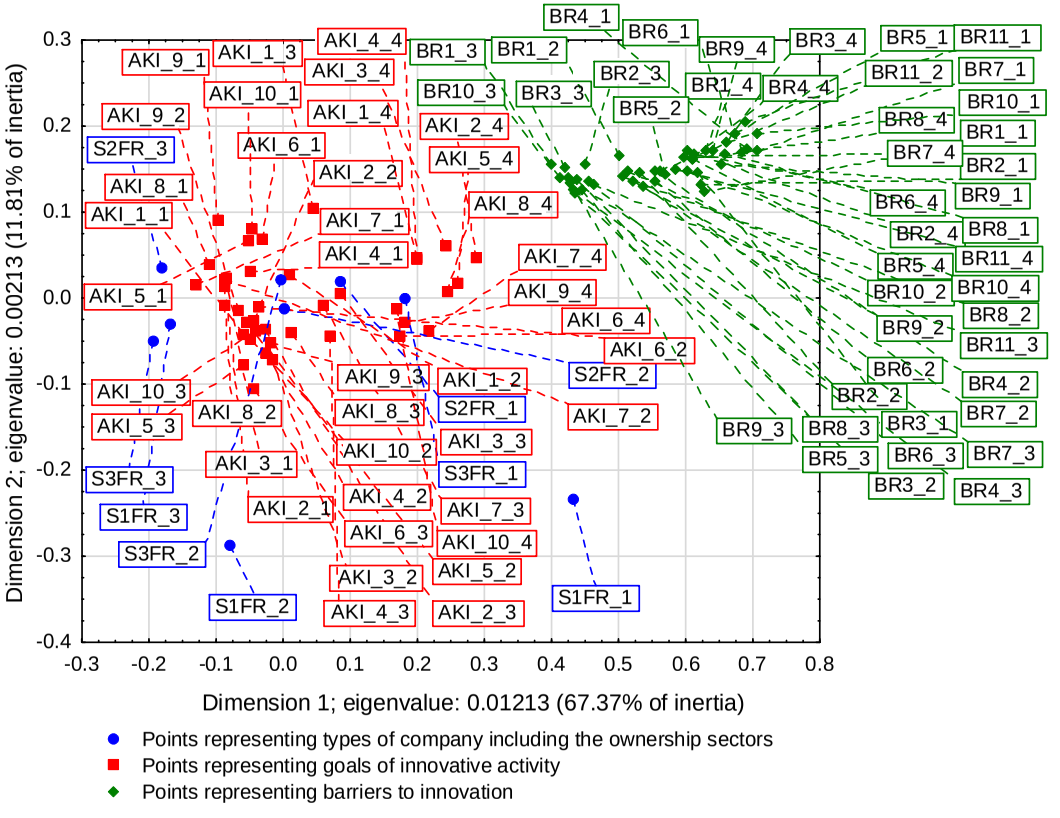

Figure 7. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2008–2010 (dimensions 1–3; 74.023% of total inertia)

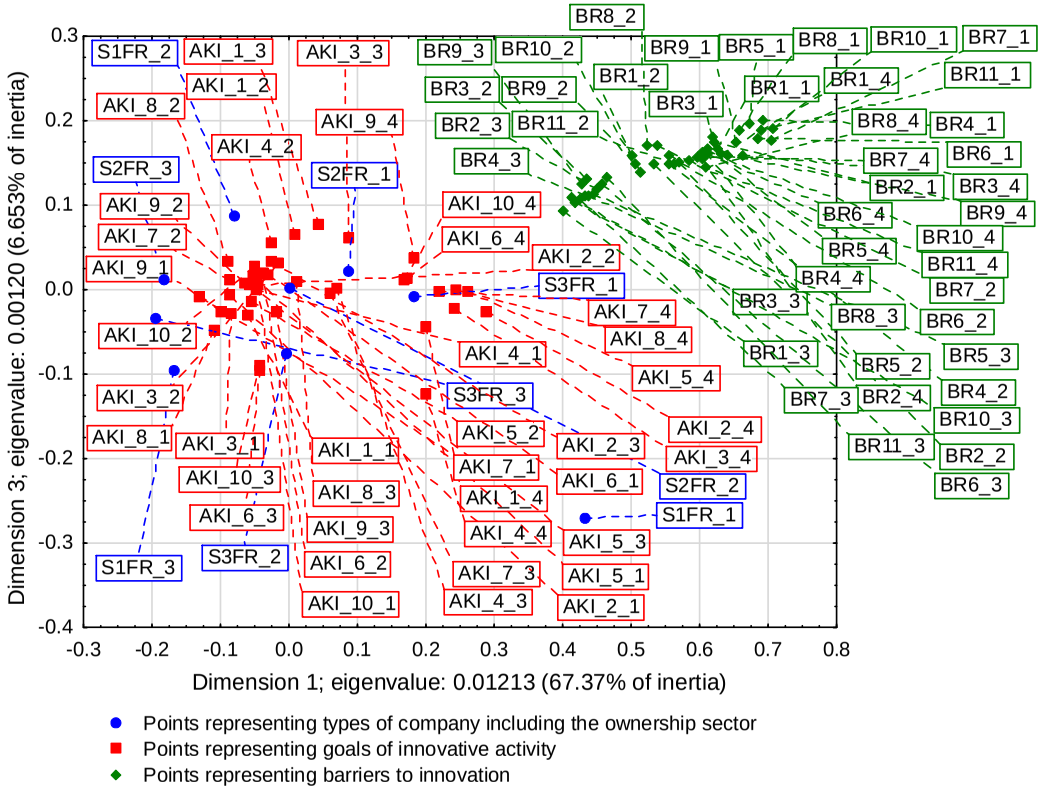

Figure 8. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2008–2010 (dimensions 2–3; 18.463% of total inertia)

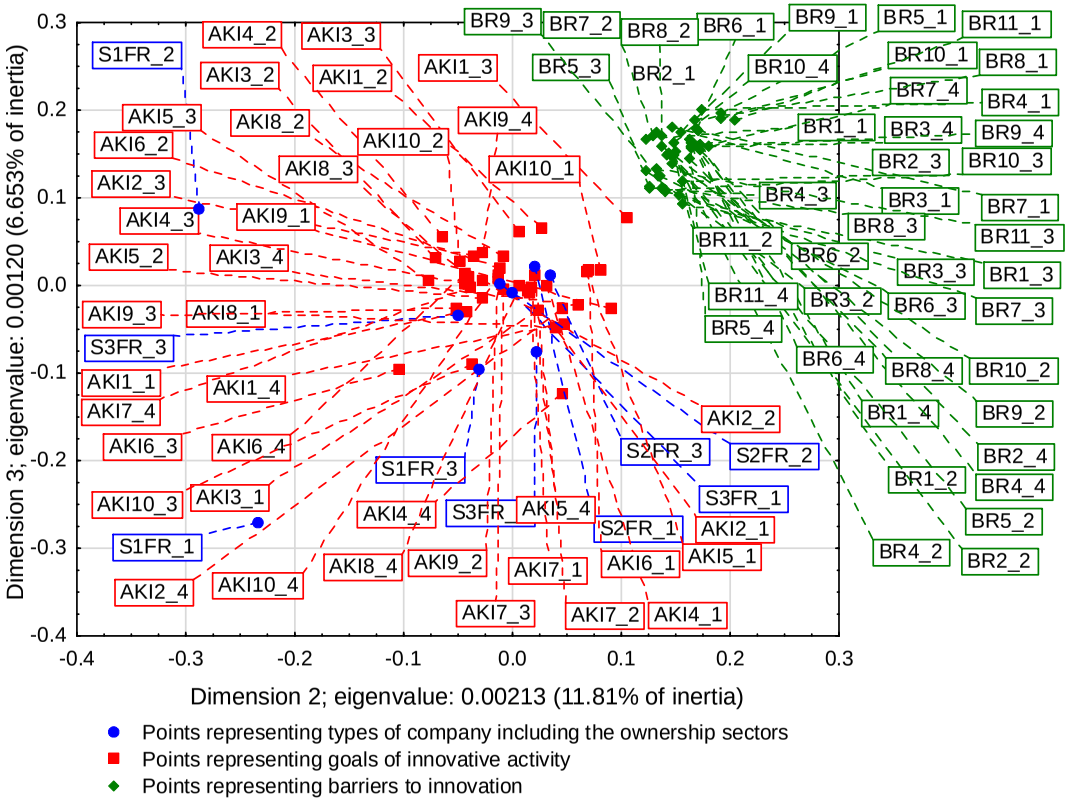

Figure 9. 3D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2012–2014 (dimensions 1–2–3; 87.72% of total inertia)

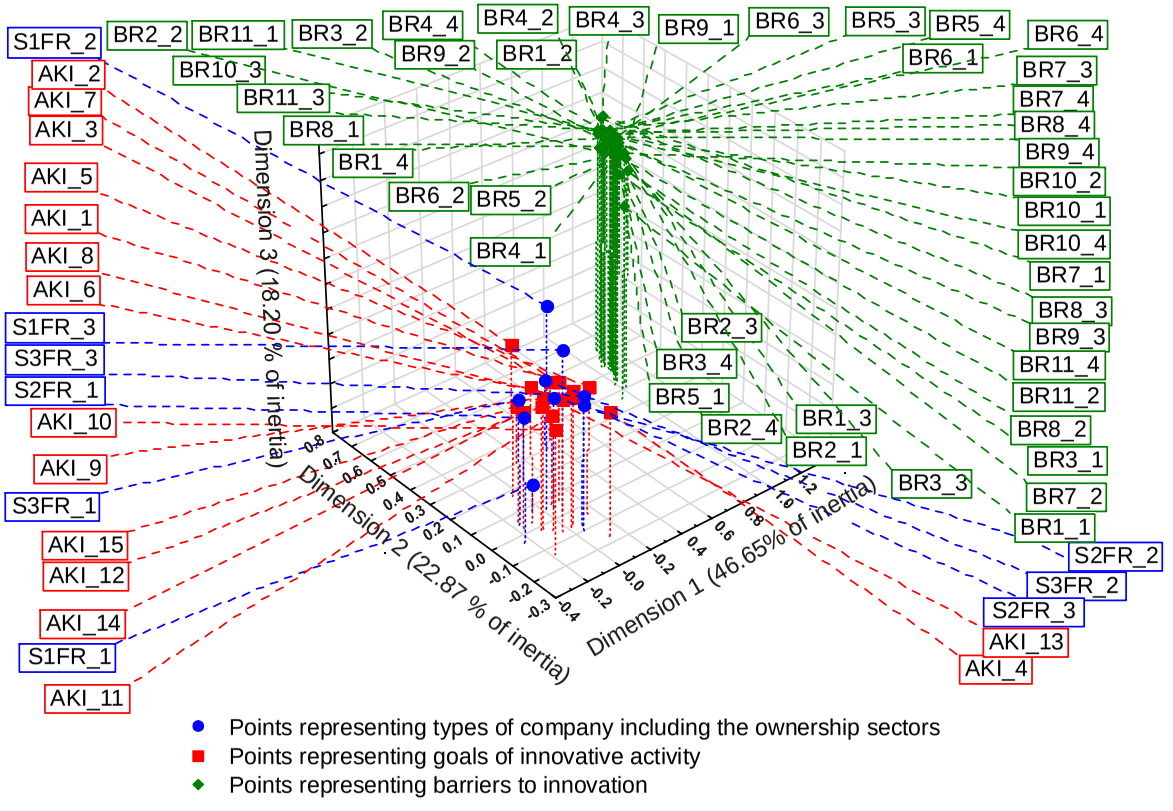

Figure 10. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2012–2014 (dimensions 1–2; 69.52% of total inertia)

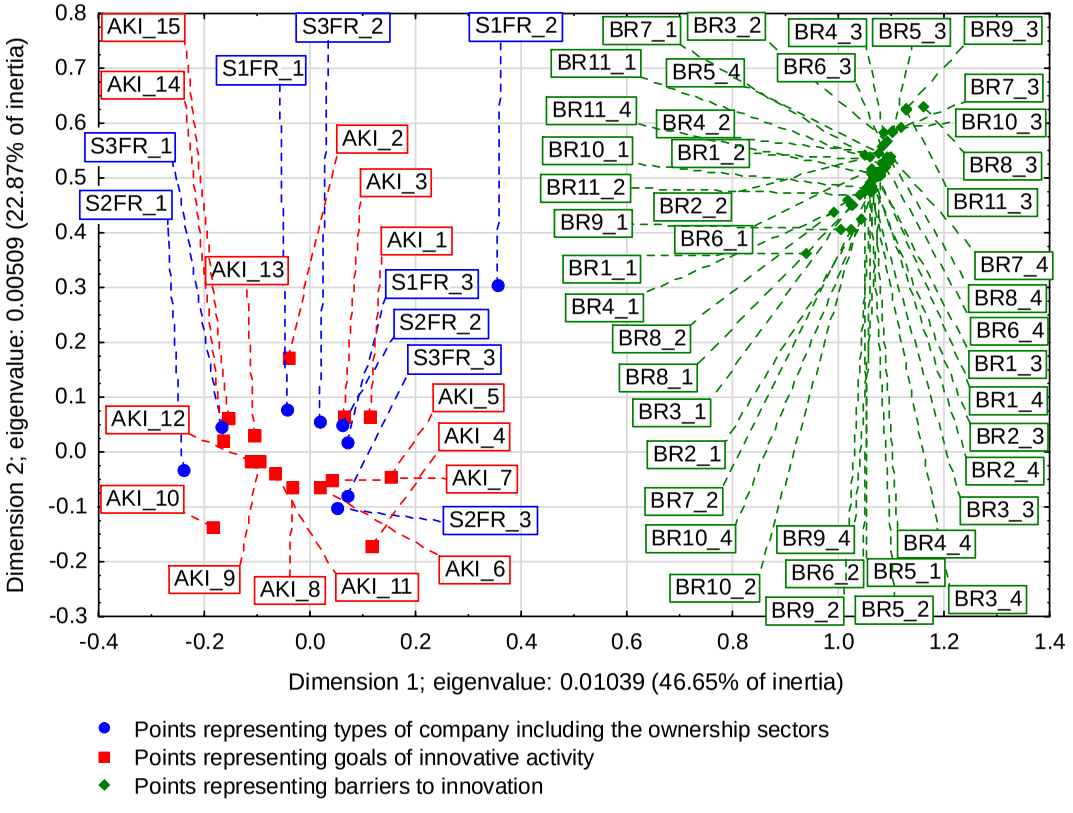

Figure 11. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2012–2014 (dimensions 1–3; 64.85% of total inertia)

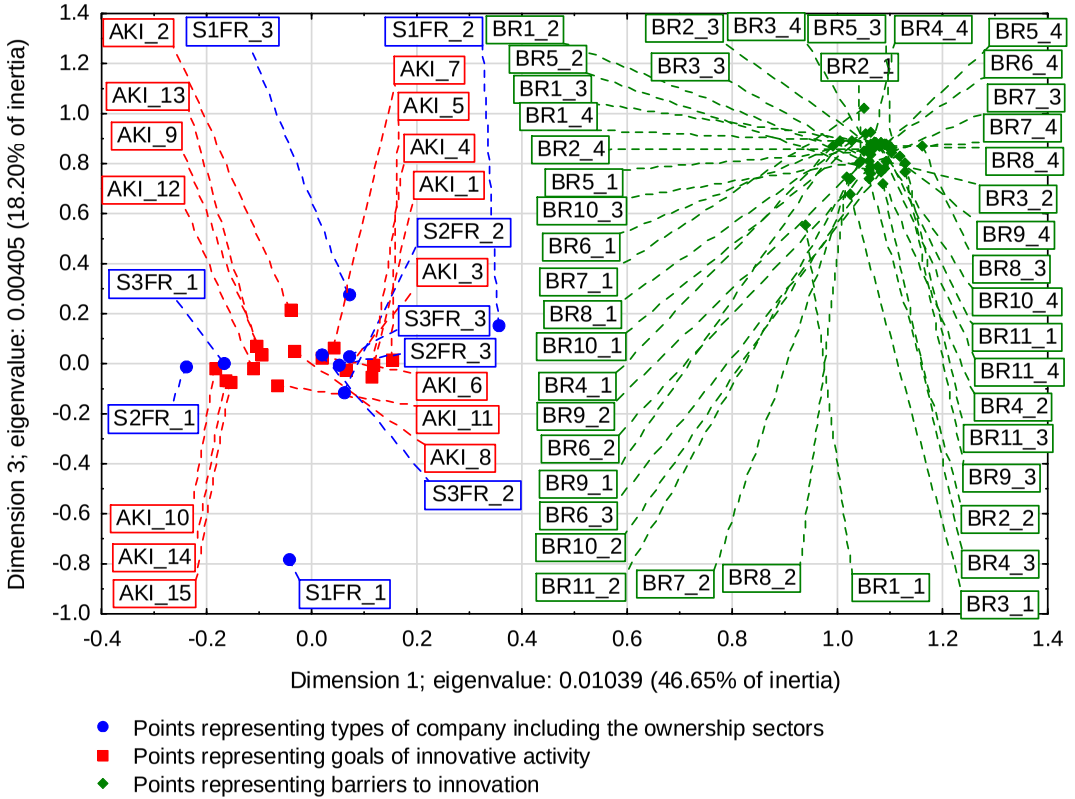

Figure 12. 2D biplot showing the co-occurrence of the types of enterprises including the ownerships sectors, the goals of innovative activity, and the barriers to innovation in period 2012–2014 (dimensions 2–3; 41.07% of total inertia)