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Innovative Activities of Public Sector Enterprises in the Context of Poland's Economic Growth in 2012–2021

Abstract

Objectives: The principal aim of the paper is to analyse and assess the impact of the innovative activities of public sector enterprises on the change in GDP per capita in Poland. The object of the research turned out to be public sector enterprises, but the analysis was extended to include NUTS2 units. Therefore, 16 Polish Provinces were examined in this respect. The research period covered the years 2012–2021.

Research Design & Methodology: In the theoretical part, a critical analysis of the literature on the subject was used, while in the empirical part, statistical analysis was provided. The empirical analysis included the characterisation of the selected features, an analysis of basic descriptive statistics, and an analysis of the obtained results. The collected data was prepared using descriptive statistics – mean values, median, minimum and maximum values, first and third quartiles, and distance from the average value, as well as changes in relation to the base year. Several predictors were identified and determined in an arbitrary manner, allowing research to be conducted and conclusions to be drawn. Pearson correlation analysis was also used, the results of which made it possible to determine the strength of the relationship between the examined measures in the field of innovative activities of public sector enterprises and Poland's economic growth.

Findings: The main conclusions at the national level include, firstly, that in the analysed period in the Polish economy, on average 26% of public sector enterprises were innovative industrial entities.Secondly, the most frequently introduced type of innovation in the surveyed sector were new or improved processes; the average percentage of enterprises generating this type of activity was 24%. Thirdly, on average, 19.4% of public sector enterprises incurred expenditure on innovation activities, but in 2021, this percentage increased by slightly over 3 percentage points.However, at the regional level, the following regularities can be formulated. Firstly, both in terms of the highest average percentage of innovative industrial enterprises and the highest average expenditure on innovative activities, the Silesian Province was the leader, followed closely by the Masovian Province. A completely different situation concerned the regions for which the percentages of these predictors turned out to be the lowest, i.e. the Lubusz Province and the Warmian-Masurian Province. Secondly, the average share of net revenues from the sale of innovative products in total net revenues from sales in three Provinces, i.e. Pomeranian, Sub-Carpathian, and Łódź, turned out to be higher than the average share for Poland.

Implications/Recommendations: The practical implication of the study may be the identification of several predictors of innovative activity of the public sector that influences Poland's economic growth (measured by the growth dynamics of GDP per capita); the obtained results provide some scope for applying a targeted policy aimed at developing the innovativeness of public sector enterprises in Poland on the one hand, and at improving the attractiveness and competitiveness of the economy on the international arena on the other.

Contribution/Value Added: The practical implication of the study may be the identification of several predictors of innovative activity of the public sector that influences Poland's economic growth (measured by the growth dynamics of GDP per capita); the obtained results provide some scope for applying a targeted policy aimed at developing the innovativeness of public sector enterprises in Poland on the one hand, and at improving the attractiveness and competitiveness of the economy on the international arena on the other.

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Introduction

The complex interconnections between innovation activities and economic growth have long been the subject of multidisciplinary research, the consequences of which extend to various sectors. Within this connection, the role of innovative activities of the public sector appears as a key factor that shapes not only the employment landscape, but also economic efficiency. In Poland, a country characterised by dynamic economic growth, examining the evolution of innovative activities of the public sector in the context of economic growth, measured by the change in Gross Domestic Product (GDP) per capita, is of profound scientific and practical importance. The paper discusses the theoretical and empirical bases of various connections in which the development of innovative activities of the examined sector may affect the dynamics of GDP per capita both in Poland and in NUTS2 regions. The aim of these considerations is to analyse and assess the impact of the innovative activities of public sector enterprises on the change in GDP per capita in Poland.

The research problem:

1. An analysis of the impact of the determinants of innovation in public sector enterprises on Poland's economic growth

The research questions:

1. Can there be found any relationship between the percentage of innovative enterprises in the public sector and GDP per capita?
2. Is there a relationship between the percentage of public sector enterprises incurring expenditure on innovative activities and GDP per capita?
3. Does the percentage of net revenues of enterprises from the sale of innovative products affect the dynamics of GDP growth, and to what extent?

The research hypotheses:

1. There is a relationship between the percentage of innovative enterprises in the public sector and economic growth measured by GDP per capita.
2. There is a relationship between the percentage of public sector enterprises incurring expenditure on innovative activities and GDP per capita.
3. The percentage of net revenues of enterprises from the sale of innovative products moderately shapes the value of GDP per capita, contributing to economic growth.

In the theoretical part, a critical analysis of the literature on the subject was used, while in the empirical part, statistical analysis was provided. The necessary statistical data was taken from the Local Data Bank (GUS, BDL, 2023). The empirical analysis included the characterisation of the selected features, an analysis of basic descriptive statistics, and an analysis of the obtained results. The collected data was prepared using descriptive statistics – mean values, median, minimum and maximum values, first and third quartiles, and distance from the average value, as well as changes in relation to the base year. Several predictors were identified and determined in an arbitrary manner, allowing research to be conducted and conclusions to be drawn. Pearson correlation analysis was also used, the results of which made it possible to determine the strength of the relationship between the examined measures in the field of innovative activities of public sector enterprises and Poland's economic growth.The latter was divided into two parts. The first one discussed the conclusions at the national level, while the second one presented its results obtained at the regional level.

The practical implication of the study may be the identification of several predictors of innovative activity of the public sector that influences Poland's economic growth (measured by

the growth dynamics of GDP per capita); the obtained results provide some scope for applying a targeted policy aimed at developing the innovativeness of public sector enterprises in Poland on the one hand, and at improving the attractiveness and competitiveness of the economy on the international arena on the other.

The innovative activity of the public sector enterprises – theoretical analysis

Innovations are widely recognised as a source of economic growth and competitiveness. Macroeconomists focus primarily on the innovativeness of national economies and the innovativeness of regions. However, entrepreneurs and managers are looking for new solutions relating to products and production processes that allow achieving and maintaining a lasting competitive advantage (Weresa, 2014, p. 11). Due to the high complexity of innovation processes taking place in enterprises and the variety of their forms, it is worth presenting several definitions and basic types of innovations (Table 1).

In the 1930s, the concept of innovation was one of the first to be formulated by J. Schumpeter (1934); The scholar defined it as the activity of entrepreneurs based on "[…]creating new combinations of existing production factors in conditions where the result of this process cannot be easily predicted" (Marciniec, 2009, pp. 3–4). However, the definition of innovation according to the OECD and the European Commission describes innovation as the use in economic practice of new or significantly improved products (goods or services), processes, marketing and organisational methods, changes in work organisation, and relations with the environment (OECD, 2005, p. 46). Most definitions of innovation emphasise the novelty of the proposed solution. S. Kuznets, for example, considers the originality and uniqueness of a new solution as a criterion for innovative activity. Following Kuznets (1959), innovations constitute, therefore, a new application of knowledge to the production process (or these that initiate the use of inventions). Nevertheless, according to most researchers, innovation does not have to be a breakthrough discovery on a global scale.

Innovative activity is the entirety of scientific, technical, organisational, financial, and commercial activities that actually lead or are intended to lead to the implementation of innovations. Some of these activities are innovative in themselves, while others are not new but are necessary to implement innovation. Innovative activities also include research and development (R&D) activities that are not directly related to the creation of a specific innovation (OECD & Eurostat, 2005, p. 49).

Polish topical literature is rich in various works dealing with different innovative activities. Wolnyet et al. (2016), Kuś (2020), or Kosała et al. (2021), for example, offer the following lists of authors dealing with this issue: M. Kosała, K. Zieliński, I. Czaja, Z. Michalik, M. Urbaniec, B. Rogoda, A. Kuś, R. Wolny, A. Dąbrowska, M. Jaciow, L. Kuczewska, S. Tajer, K. Wasilik, U. Kłosiewicz-Górecka, R. Nowacki, and many others.

According to A. Krzepicka and J. Tarapata (2012, p. 168) innovative activity is understood as the conscious and purposeful introduction of a variety of changes that cause positive economic, technical, social, and ecological effects, being also observed in the sphere of management. It requires the company's inclination and ability to develop and adopt new and improved products, provided services, or technologies to be used. Another definition of innovative activity is proposed by L. Białoń (2008, p. 16), who explains that this activity refers to the development and introduction of new (or the modernisation of existing) products and services; it can also refer to

the application of technological processes, organisational systems, entry into new markets, and orvarious changes in production factors, or methods obtaining them.

Table 1. Types of innovations according to selected authors

Author/s/	Types of innovation
Oslo Manual	• product – changes in the offer of products and services. They involve introducing a completely new offer or improving already manufactured products to best meet customer needs; • process – changes in the way products and services are created and distributed. They concern the implementation of new and improvement of existing production methods and supply chains; • marketing – changes regarding, e.g. new communication strategies, prices, promotions, target groups and distribution models; • organisational – changes in the field of new methods and principles of operation, or these of human resources management system. The main goal of these innovations is to improve work efficiency and employee satisfaction.
R. A. Webber	• routine – minor changes to the product, primarily aimed at maintaining its attractiveness; • forced – carried out when problems occur to get the company out of the crisis; • resulting from opportunities when prosperous companies can afford to invest in changing their offer or supplementing it with new products.
D. Smith	• product – innovative products are visible and have a physical form, e.g. a smartphone; • service – innovative services are usually invisible things, such as the health care system or education, where consumers use the services but do not actually purchase a specific item; • process – innovation in the form of new equipment, new methods or systems.
R. M. Henderson & K. B. Clark	• incremental – improve products existing on the market by modifying their components, but these components are not radically changed and the system remains unchanged; • radical – establishes a new dominant design and therefore the core part of the design concept is embodied in components that are combined into a new architecture; • modular – they use the architecture and configuration combined with the existing system of the adopted product, but introduce new components to create a different design concept; • architectural – components remain unchanged but the system configuration changes as soon as new connections are established.
J. Tidd & Bessant	• product – mean changes in products (products or services) that a given organisation offers on the market; • process – changes in the way products are manufactured and delivered to the market; • positioning – any changes in the context in which products or services are introduced; • paradigm – changes in basic mental models (imaginations) that formulate and define what a given organisation does.

Source: Own elaboration after: OECD & Eurostat, 2005; Godyń, 2023; Webber, 1996; Smith, 2009, p. 25; Henderson & Clark, 1990, pp. 9–30; Christensen, 1997, p. 35; Tidd & Bessant, 2013, pp. 24–29.

Innovative activity can take various forms. Following the data given by the Central Statistical Office (2015, p. 3); OECD & Eurostat (2005, pp. 96–102), and/or Zastempowski (2016, pp. 60–61), such possible types of innovative activity of enterprises may include:
- the acquisition of technologically-advanced machines and devices, means of transport, tools, instruments, movable property, and equipment in order to produce new or significantly improved products or processes;
- the acquisition of knowledge from external sources (patents, unpatented inventions, know-how, and other types of knowledge from subsequent enterprises or organisations) for the implementation of product and process innovations;
- the acquisition of software related to the introduction of product and process innovations;
- R&D work acquired externally;

- internal R&D work performed in the enterprise;
- staff training directly related to the introduction of new or significantly improved products and processes;
- activities related to the design, improvement, and change of the form or appearance of new or significantly improved products;
- marketing related to the introduction of new or significantly improved products;
- other preparations for the introduction of new or significantly improved products or processes.

It is also worth noting here that – in a less precise way – public sector enterprises (PSE) are also referred to as state-owned enterprises. Isolating and defining these entities is problematic (Christiansen, 2011) due to the fact that there is a whole spectrum of enterprises with mixed state-private ownership. M. Bałtowski and P. Kozarzewski (2016, p. 7) emphasise that the constitutive feature of public sector enterprises actually means their corporate control by the state, which can be exercised not only through ownership tools. In such a case, the state has the actual ability to influence any decision regarding this type of entities, what may include: appointing company bodies, dividing profits, or building a development strategy, to name but few.

A review of Polish and international literature on the subject clearly shows that the category of a state-owned enterprise (SOE) seems to be one of the most imprecisely defined items in economic sciences. In the topical English-language literature, in addition to the commonly used term *state owned enterprises*, one can also find terms such as: state controlled enterprises, public sector enterprises, state companies, public corporations, public enterprises, government-controlled companies, government companies, etc. The OECD defines public enterprises as economic entities in which the state, directly and indirectly, has 100% or majority ownership shares (OECD, 2010).

Authors such as D. Shapiro, S. Globerman, A. Cuervo-Cazurra, A. Inkpen, A. Musacchio, K. Ramaswamy include the term *state-owned enterprise* only in entities controlled by the state, without majority ownership shares (cf. Shapiro & Globerman, 2009; Cuervo-Cazurra et al., 2014). However, for example, A. Musacchio and S.G. Lazzarini (2014) use the terms *majority SOEs* (when state ownership is full or majority) or *minority SOEs* (when state ownership is minority).

The innovative activity of public sector enterprises – statistical analysis

Innovative enterprises

It was decided that the empirical part of the study should begin with the examination of the percentage of innovative enterprises in the public sector. Innovative industrial enterprises are industrial enterprises that have introduced at least one product or business process innovation (a new or improved product or a new or improved business process) to the market during the period under review. Statistical data and calculations of basic descriptive statistics are presented in Table 2.

Analysing the data in Table 2, it can be seen that in the years 2012–2021, the percentage of innovative industrial enterprises in the Polish public sector was characterised by a variable trend. This can be best observed by analysing the last three periods examined. Namely, 2019 was the least favourable in this respect, as a minimum value of 22.1% was recorded. However, only two years later, the maximum value for the examined period was obtained, i.e. 34.4%. Consequently, comparing the base year (2012) with the current period (2021), an increase of almost 11 percentage points can be noted. In the Polish economy in 2012–2021, on average, 26.32% of innovative industrial enterprises operated in the public sector.

Table 2. Innovative industrial enterprises in Poland and NUTS 2 regions in 2012–2021 [%]

| Name | All together Public sector | | | | | | | | | | Changes compared to 2012 | Distance from the 2021 average size |
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | [p.p.] | [p.p.] |
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[p.p.]	[p.p.]
Poland	23.49	23.84	24.79	25.30	28.13	26.17	26.8	22.1	28.2	34.4	10.91	–
Lower Silesian	22.41	24.60	25.38	24.60	30.58	26.83	26.6	17.6	25.8	28.7	6.29	–5.7
Kuyavian-Pomeranian	27.50	24.69	24.05	22.62	28.38	29.33	27.9	24.4	32.9	31.0	3.50	–3.4
Lublin	20.00	31.17	22.97	32.39	34.29	31.94	30.8	20.0	26.7	39.7	19.70	5.3
Lubusz	15.56	8.89	8.33	6.12	13.04	14.89	29.2	26.1	25.0	28.6	13.04	–5.8
Łódź	14.10	18.52	19.72	19.12	24.19	27.87	24.6	18.6	21.7	32.2	18.10	–2.2
Little Poland	31.73	20.00	24.27	25.77	25.00	22.45	26.5	25.5	30.8	41.3	9.57	6.9
Masovian	25.32	28.21	26.85	28.86	31.01	32.33	33.8	26.4	31.8	38.6	13.28	4.2
Opole	22.22	18.18	24.53	26.42	38.00	26.42	18.9	17.0	26.4	25.0	2.78	–9.4
Sub-Carpathian	28.57	26.09	26.83	24.39	24.36	22.22	22.2	17.7	24.4	34.1	5.53	–0.3
Podlasie	14.29	16.67	9.76	13.95	26.19	27.91	30.2	26.8	32.6	35.6	21.31	1.2
Pomeranian	18.60	19.78	29.89	26.37	25.30	19.28	23.3	15.6	27.1	41.1	22.50	6.7
Silesian	35.80	36.25	41.96	39.58	40.00	35.88	37.3	35.3	36.1	49.3	13.50	14.9
HolyCross	31.71	23.91	25.58	30.23	30.95	27.27	23.3	23.3	31.1	26.8	–4.91	–7.6
Warmian-Masurian	18.18	18.87	17.48	20.95	16.00	17.17	14.0	18.2	21.7	21.1	2.92	–13.3
Greater Poland	20.27	18.67	21.53	22.08	26.06	23.65	26.9	19.6	28.2	34.2	13.93	–0.2
West Pomeranian	14.29	22.86	21.79	20.83	25.68	24.66	23.2	20.9	23.2	19.4	5.11	–15.0

Table 2 – continuation

	Positional measures of statistical description					
	Average	MIN	Q₁	Me	Q₃	MAX
Poland	26.32	22.10	24.08	25.74	27.80	34.40
Lower Silesian	25.31	17.60	24.60	25.59	26.77	30.58
Kuyavian-Pomeranian	27.28	22.62	24.47	27.70	29.09	32.90
Lublin	29.00	20.00	23.90	30.99	32.28	39.70
Lubusz	17.57	6.12	9.93	15.23	25.83	29.20
Łódź	22.06	14.10	18.73	20.71	24.50	32.20
Little Poland	27.33	20.00	24.45	25.64	29.73	41.30
Masovian	30.32	25.32	27.19	29.94	32.20	38.60
Opole	24.31	17.00	19.73	24.77	26.42	38.00
Sub-Carpathian	25.09	17.70	22.76	24.40	26.65	34.10
Podlasie	23.40	9.760	14.89	26.50	29.63	35.60
Pomeranian	24.63	15.60	19.41	24.30	26.92	41.10
Silesian	38.75	35.30	35.94	36.78	39.90	49.30
HolyCross	27.42	23.30	24.33	27.04	30.77	31.71
Varmian-Masurian	18.37	14.00	17.25	18.19	20.43	21.70
Greater Poland	24.12	18.67	20.59	22.87	26.69	34.20
Weßt Pomeranian	21.68	14.29	20.85	22.33	23.20	25.68

Source: Own elaboration and calculations after: GUS, BDL, 2023.

Moving on to the regional (provincial) system, it should be observed that on average in the years 2012–2021, the majority of innovative industrial enterprises were located in the Silesian Province (38.75%). The second place belonged to the Masovian Province (30.32%), while the last place on the podium belonged to the Lublin Province (29%). A completely different situation occurred in the regions where the lowest average percentages were recorded. This group includes the following NUTS 2 regions – Lubusz (17.57%), the Warmian-Masurian Province (18.37%), and the West Pomeranian Province (21.68%).

An interesting aspect may be the question whether the regional classification will look completely different when only the last year examined is taken into account? Comparing the results of individual provinces to the average percentage of Poland in 2021, one can get the right impression that once again it was the Silesian Province that reigned supreme in terms of the percentage of innovative industrial enterprises. This province gained an advantage of almost 15 percentage points over Poland in general. The remaining provinces that achieved a positive distance from the average value recorded several times worse results. For example, the second place belonged to the Lesser Poland Province(less than 7%), followed by the Pomeranian Province, the Lublin Province, and the Masovian Province. In 2021, in the Podlasie Province, the percentage of operating innovative industrial entities was also higher than the average percentage describing the entire Polish economy; this difference, however, was not clear, as it amounted to just over 1 percentage point.

In terms of the number of innovative enterprises in the public sector, 2021 was the year in which ten Polish provinces got worse results than the average value of 34.4%. Three of all regions definitely had the most to make up for compared to the Polish average. These were: the West Pomeranian Province (-15 percentage points), the Warmian-Masurian Province (-13.3%), and the Opole Province (-9.4%). The Greater Poland Province (-0.2 p.p.) and the Sub-CarpathianProvince (-0.3 p.p.) lost the least compared to the average value.

Subsequently, it was decided that the percentage of innovative industrial enterprises in the Polish public sector should be looked at according to the types of innovations introduced; the data is presented in Figure 1.

In Poland, in the years 2012–2021, innovative industrial enterprises in the public sector were most likely to introduce new or improved processes; the average percentage of enterprises generating this type of activity was 24%. The second most commonly observed issues were new or improved products; in this case, the average was 8.75% of enterprises introducing this type of innovations. The third, the least common type of innovation included new or improved products for the market, with an average of 3.48%.

Process innovations dominated among the surveyed enterprises. For example, in 2021, the maximum value was obtained, which meant that less than every third entity in the public sector introduced this type of innovation. The minimum value described the initial year and then public sector enterprises introducing this type of innovations accounted for 20.08%. A value similar to the one found in the base year was obtained in 2019; then this percentage was 0.82 percentage points higher more.

In the years 2012–2021, the percentage of enterprises from the analysed sector introducing product innovations fluctuated in the range of ≤7.48; 9.9≥. This means, for example, that in the best year for product innovations, i.e. 2018, approximately every tenth public sector enterprise introduced new or improved products. In the case of new or improved products for the market, a very clear and annoying pattern should be observed; namely,it could be seen that from year to year this type

of innovative activity loses importance. This is evidenced by the continuous downward trend from the base year to 2020. Although a slight increase of 0.1 percentage points was recorded in 2021, this still can be considered insignificant.
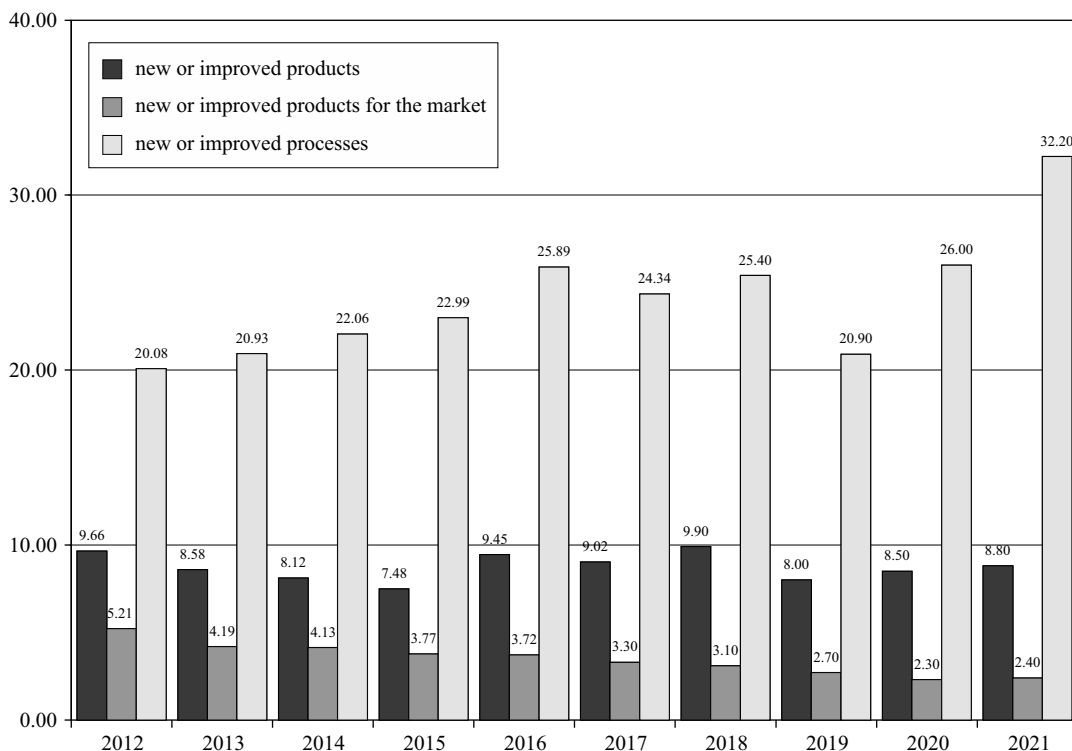

Figure 1. Innovative industrial enterprises in the public sector by types of innovations introduced in Poland in 2012–2021 [in %]

Source: Own elaboration after: GUS, BDL, 2023.

Enterprises incurring expenditure on innovative activities

The following part of the considerations was devoted to verifying the percentage of industrial enterprises from the public sector that incurred expenditure on innovative activities. Table 3 collects the necessary data and calculates basic statistical measures.

Analysing the data in Table 3, it can be seen that the percentage of industrial enterprises from the public sector that incurred expenditure on innovative activities in the years 2012–2021 changed. Initially, from 2012, there was an upward trend for the next few years, but in 2017–2020, there was a downward trend. However, this trend was stopped, because in the following year (2021), a record increase was observed and it was in the last of the analysed periods that the maximum value was achieved. This means that 22.5% of industrial enterprises in the public sector allocated expenditure on innovative activities. Comparing the base year with the current period, we can talk about an increase of 2.83 percentage points, while comparing 2021 with 2020, we can talk about a much higher increase in this percentage, and the difference was as much as 7 percentage points.

Table 3. Industrial enterprises that incurred expenditure on innovative activities in Poland and NUTS 2 regions in 2012–2021 [%]

Name	Enterprises Public sector										Changes compared to 2012	Distance from the 2021 average size
	2012 [%]	2013 [%]	2014 [%]	2015 [%]	2016 [%]	2017 [%]	2018 [%]	2019 [%]	2020 [%]	2021 [%]	p.p.	p.p.
Poland	19.67	19.78	20.59	20.34	21.80	19.72	17.6	16.1	15.5	22.5	2.83	–
Lower Silesian	18.97	16.67	16.15	17.46	22.31	20.33	15.6	9.2	12.5	17.8	–1.17	–4.7
Kuyavian-Pomeranian	21.25	22.22	24.05	19.05	24.32	24.00	17.7	18.0	20.3	28.2	6.95	5.7
Lublin	18.57	23.38	17.57	18.31	18.57	12.50	18.0	13.3	0.0	14.7	–3.87	–7.8
Lubusz	13.33	8.89	8.33	6.12	10.87	8.51	10.4	8.7	14.6	22.4	9.07	–0.1
Łódź	11.54	14.81	12.68	8.82	17.74	19.67	19.3	15.3	15.0	22.0	10.46	–0.5
Little Poland	21.15	14.29	22.33	20.62	15.63	17.35	16.7	21.3	15.4	20.2	–0.95	–2.3
Maasovian	21.43	24.36	23.49	28.19	31.01	28.57	27.8	21.4	22.7	31.1	9.67	8.6
Opole	20.37	20.00	28.30	24.53	28.00	18.87	17.0	17.0	15.1	14.6	–5.77	–7.9
Sub-Carpathian	23.81	23.91	24.39	15.85	21.79	22.22	14.8	13.9	0.0	29.4	5.59	6.9
Podlasie	9.52	14.29	9.76	11.63	19.05	11.63	11.6	4.9	9.3	24.4	14.88	1.9
Pomeranian	15.12	16.48	22.99	19.78	20.48	18.07	18.9	16.7	16.5	27.8	12.68	5.3
Silesian	38.27	32.50	35.66	37.50	37.04	29.77	27.0	32.8	24.8	32.9	–5.37	10.4
Holy Cross	19.51	19.57	23.26	23.26	21.43	18.18	20.9	16.3	0.0	19.5	–0.01	–3.0
Warmian-Masurian	12.12	15.09	13.59	14.29	10.00	12.12	7.0	8.1	12.4	12.6	0.48	–9.9
Greater Poland	16.22	15.33	15.28	18.83	19.72	18.92	14.5	15.5	12.8	18.1	1.88	–4.4
West Pomeranian	9.09	20.00	17.95	16.67	13.51	12.33	15.9	11.9	8.7	12.5	3.41	–10.0

Table 3 – continuation

| | Positional measures of statistical description | | | | | |
	Average	MIN	Q_1	Me	Q_3	MAX
Poland	19.4	15.50	18.12	19.75	20,53	22.50
Lower Silesian	16.7	9.20	15.74	17.07	18.68	22.31
Kuyavian-Pomeranian	21.9	17.70	19.36	21.74	24.04	28.20
Lublin	15.5	0.00	13.65	17.79	18.51	23.38
Lubusz	11.2	6.12	8.56	9.65	12.72	22.40
Łódź	15.7	8.82	13.21	15.15	18.91	22.00
Little Poland	18.5	14.29	15.90	18.78	21.02	22.33
Maasovian	26.0	21.40	22.90	26.08	28.48	31.10
Opole	20.4	14.60	17.00	19.44	23.49	28.30
Sub-Carpathian	19.0	0.00	15.06	22.01	23.89	29.40
Podlasie	12.6	4.90	9.58	11.62	13.63	24.40
Pomeranian	19.3	15.12	16.55	18.49	20.31	27.80
Silesian	32.8	24.80	30.45	32.85	36.70	38.27
HolyCross	18.2	0.00	18.51	19.54	21.30	23.26
Warmian-Masurian	11.7	7.00	10.53	12.26	13.34	15.09
Greater Poland	16.5	12.8	15.29	15.86	18.65	19.72
West Pomeranian	13.9	8.7	12.01	13.01	16.48	20.00

Legend: 0 – no information, the need to maintain statistical confidentiality, or it was impossible to complete the item.

Source: Own elaboration and calculations after GUS, BDL, 2023.

The median for the percentage of industrial enterprises in the public sector allocating expenditure on innovative activities in the period under study in Poland was 19.75%, which means that 50% of the examined observations were characterised by a percentage of enterprises allocating more than this amount for this purpose, and the remaining 50% – below.

Analysing the average percentage of public sector enterprises providing funds for innovative activities, by territorial division, it should be noted that the Silesian Province took the lead again. It was in this region that in the years 2011–2021, on average, less than every third industrial enterprise from the examined sector allocated expenditure on innovative activities(more precisely, it was 32.8% of all enterprises). The Masovian Province came second in the ranking, but was already 6.8 percentage points behind the leading region; the third place was taken by the Kuyavian-Pomeranian Province, with a loss of 10.9 percentage points to the leader. The lowest percentage of enterprises allocating expenditure on innovative activities belonged to the Lubusz Province (11.2%) and the Warmian-MasurianProvince (11.7%), which were 21.6 and 21.1 percentage points, respectively, behind the Silesian Province.

It can be observed that when examining the regional values from 2021 in relation to the average one describing whole Poland, only six provinces managed to record higher results. As was the case with the previous measure, here too, the group of provinces with higher results than the Polish average included: Silesia, Masovia, Pomerania, Podlasie; in this case, they were also joined by the Sub-Carpathian and Kuyavian-Pomeranian Provinces. The leading province was again the Silesian Province. The province that lost the least to the Polish average was the Lubusz Province (only 0.1 p.p.), followed by the Łódź Province with a loss of 0.5 p.p. By far the smallest percentage of enterprises allocating expenditure on innovative activities occurred in the West Pomeranian Province and the Warmian-Masurian Province (the distance from the average value ~ 10 percentage points).

Once again, the Silesian Province deserves special attention, as it achieved the maximum value in the analysed period in the base year (at that time it was 38.27% of public sector enterprises providing funds for innovative activities). The minimum value for this province concerned 2020, in which a percentage of 24.8% was obtained. At the same time, the Podlasie Province, with the minimum value for the entire set (4.9%), was placed on the opposite continuum. For this NUTS 2 region, the worst period was definitely 2019, when only every twentieth entity from the analysed sector allocated expenditure on activities related to innovation.

2.3. Revenues of industrial enterprises from the sale of innovative products

The last part of the research was devoted to analysing net revenues from the sale of innovative products of the analysed sector to enterprises. The necessary data describing this measure, together with the calculations of positional measures of statistical description, are presented in tabular form(Table. 4).

When examining the share of net revenues from the sale of innovative products in total net revenues from sales in the years 2012–2021 in the Polish public sector, it should be noted that the average share was 6.47%. When it comes to an extended analysis of this measure, one can certainly notice a relatively large spread of values from the average value, which indicates a large range of values. For example, the range in this case was 14.78, which can be interpreted as a significant dispersion of the values of statistical features in the analysed population. This means that in the base year, the share of net revenues from the sale of innovative products in total net

Table 4. Net revenues from the sale of products of innovative industrial enterprises in Poland and NUTS 2 regions in 2012–2021 [%]

Name	Share of net revenues from the sale of innovative products in total net revenues from sales										Changes compared to 2012	Distance from the 2021 average size
	Public sector											
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	p.p.	p.p.
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]		
Poland	16.78	7.99	12.31	7.72	4.11	4.63	3.9	2.7	2.6	2.0	-14.78	–
Lower Silesian	6.17	4.06	2.86	0.70	1.16	1.83	0.8	0.6	0.5	0.3	-5.87	-1.7
Kuyavian-Pomeranian	1.19	1.92	1.98	2.50	2.68	3.97	1.0	5.6	3.2	0.0	-1.19	-2.0
Lublin	1.53	0.71	0.41	0.00	1.04	0.86	1.1	0.5	0.8	0.0	-1.53	-2.0
Lubusz	3.56	3.94	3.82	3.87	4.05	4.40	0.9	1.1	0.0	0.0	-3.56	-2.0
Łódź	7.95	11.13	12.62	9.41	4.18	6.12	7.0	7.3	0.0	0.0	-7.95	-2.0
Little Poland	0.25	0.39	0.75	1.40	2.62	4.51	15.7	16.1	0.8	0.6	0.35	-1.4
Maasovian	1.28	0.60	0.92	1.13	0.83	0.85	1.2	1.7	1.6	0.6	-0.68	-1.4
Opole	1.27	1.13	0.93	1.14	1.00	2.80	1.8	2.8	0.0	0.0	-1.27	-2.0
Sub-Carpathian	15.51	10.74	11.29	7.77	18.63	25.72	28.1	24.7	0.0	0.0	-15.51	-2.0
Podlasie	0.27	0.14	0.01	0.00	4.57	2.39	2.6	0.1	0.2	0.0	-0.27	-2.0
Pomeranian	61.38	25.24	43.50	28.38	12.81	13.33	7.9	0.5	0.0	0.0	-61.38	-2.0
Silesian	0.69	0.51	0.61	0.67	1.26	1.36	1.1	1.6	2.6	1.9	1.21	-0.1
Holy Cross	1.08	3.74	2.39	3.56	2.03	0.48	2.9	3.4	0.0	0.2	-0.88	-1.8
Warmian-Masurian	0.76	1.06	1.31	0.68	0.10	0.00	0.4	0.4	0.0	0.0	-0.76	-2.0
Greater Poland	0.16	0.54	0.15	1.06	0.27	1.13	1.6	2.7	0.5	0.3	0.14	-1.7
West Pomeranian	0.32	0.19	0.29	0.35	0.27	0.28	2.0	3.6	0.1	0.0	-0.32	-2.0

Table 4 – continuation

	Positional measures of statistical description					
	Aversge	MIN	Q_1	Me	Q_3	MAX
Poland	6.47	2.00	3.00	4.37	7.92	16.78
Lower Silesian	1.90	0.30	0.63	0.98	2.60	6.17
Kuyavian-Pomeranian	2.40	0.00	1.37	2.24	3.07	5.60
Lublin	0.70	0.00	0.43	0.76	1.00	1.53
Lubusz	2.56	0.00	0.95	3.69	3.92	4.40
Łódź	6.57	0.00	4.67	7.15	9.05	12.62
Little Poland	4.31	0.25	0.64	1.10	4.04	16.10
Maasovian	1.07	0.60	0.84	1.03	1.26	1.70
Opole	1.29	0.00	0.95	1.14	1.67	2.80
Sub-Carpathian	14.25	0.00	8.51	13.40	23.18	28.10
Podlasie	1.03	0.00	0.03	0.17	1.86	4.57
Pomeranian	19.30	0.00	2.35	13.07	27.60	61.38
Silesian	1.23	0.51	0.68	1.18	1.54	2.60
Holy Cross	1.98	0.00	0.63	2.21	3.28	3.74
Warmian-Masurian	0.47	0.00	0.03	0.40	0.74	1.31
Greatrer Poland	0.84	0.15	0.28	0.52	1.11	2.70
West Pomeranian	0.74	0.00	0.21	0.29	0.34	3.60

Legend: 0 – no information, the need to maintain statistical confidentiality, or it was impossible to complete the item.

Source: Own elaboration and calculations after GUS, BDL,2023.

revenues from sales was 16.78%, and in the last comparable year, this percentage was only 2%. The highest share was recorded in the years 2012–2015, when values in the range ≤7.72 were obtained; 16.78≥. In the following years, this share was much lower, as it was in the range of ≤4.63; 2.0≥.

The first quartile value of 3 obtained for Poland meant that 25% of observations were lower or equal to the value of the first quartile, while 75% of observations were equal to or greater than the value of Q1. Interpreting the value of the third quartile, it can be stated that 75% of observations had a percentage lower than or equal to 7.92%, and 25% of observations had a percentage equal to or higher than the Q3 value.

Moving on to the regional analysis, it should be noted that in the years 2012–2021, only three provinces managed to obtain an average value higher than that describing Poland. Namely, this concerned, first of all, the Pomeranian Province, which obtained an average percentage of 19.30%. In addition, it is also worth paying attention to the base year in which the Pomeranian Province received the maximum value in the entire regional ranking. At that time, it was 61.38%, which meant that the vast majority of enterprises received net revenues from the sale of innovative products. Apart from the Pomeranian Province, the Sub-Carpathian Province also received a higher average percentage(14.25% to be exact). It is also worth noticing that this region recorded the highest result in 2018 (it was 28.1% at that time). The adjacent years were also successful, because the percentage in question for 2017 was 25.72%(and for 2019, it was 24.7%).

The third and last province that recorded a higher percentage in the analysed period was the Łódź Province. However, in this case, the difference from the Polish average was not significant; on the contrary, it oscillated around the said indicator, exceeding it by only 0.1 percentage points. In this province, the highest share of net revenues from the sale of innovative products in total net revenues from sales occurred in 2014 and it was 12.62%. The remaining thirteen provinces received an average much lower than that described by the indicator for Poland. The worst results were achieved by four regions in which the share of net revenues from the sale of innovative products in total net revenues from sales was less than 1%. These were the following provinces: the Warmian-Masurian Province (0.47%), the Lublin Province (0.70%), the West Pomeranian Province (0.74%), and the Greater Poland Province (0.84%).

An analysis of the correlation of selected indicators of innovative activity of public sector enterprises with the dynamics of regional GDP growth

After analysing the statistical data on selected factors in the area of public sector innovation in Poland and the NUTS2 regions, it was decided that the considerations should be expanded by combining previously studied predictors with a selected macroeconomic measure describing economic growth. The main aim of the work was defined as follows: an analysis and assessment of the impact of innovative activities of the public sector enterprises on the change in GDP per capita in Poland. Therefore, in the next stage, it was necessary to recall and discuss the development of the value of Gross Domestic Product per capita in Poland and its individual regions. The necessary data in this area is included in Table 5.

Analysing the data included in the upper part of Table 5, it can be observed that in the examined period only a few provinces managed to achieve a GDP per capita value higher than that describing the Polish economy. Assuming that Poland = 100%, then the highest positive distance from the base value concerned the Masovian P rovince (average for the examined period 159.03%), then Lower Silesian (110.85%), Greater Poland (108.09%), to be followed by the Silesian

Table 5. GDP per capita and GDP per capita dynamics in Poland and NUTS 2 regions in 2012–2021 [%]

Name	Gross domestic product per capita, Poland = 100									
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
	[%]	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
Poland	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Lower Silesian	113.2	111.5	112.0	111.5	110.8	110.5	109.3	109.3	109.6	110.8
Kuyavian-Pomeranian	81.3	82.1	81.6	81.6	81.6	81.0	81.2	79.6	82.1	82.0
Lublin	70.4	71.1	70.4	69.0	69.4	69.6	68.2	68.4	69.2	68.7
Lubusz	83.3	83.6	85.0	83.6	84.1	82.7	82.0	81.1	82.0	81.9
Łódź	94.0	93.7	94.2	93.9	93.6	93.5	93.1	94.1	97.2	95.9
Little Poland	88.3	88.4	88.8	90.0	90.5	91.2	91.9	91.2	90.0	90.8
Maasovian	158.6	159.9	158.9	158.8	158.4	159.3	160.4	161.9	158.6	155.5
Opole	80.9	80.7	81.6	81.0	79.9	79.5	79.3	79.1	79.8	81.8
Sub-Carpathian	70.0	71.1	71.0	70.9	70.6	69.8	70.5	70.5	69.4	70.1
Podlasie	72.1	73.5	73.2	71.6	71.4	72.3	71.8	72.2	74.1	73.1
Pomeranian	97.8	96.3	95.3	96.1	96.9	96.5	97.2	97.3	94.2	96.6
Silesian	105.8	103.8	103.8	103.9	103.7	103.6	103.8	102.5	100.7	103.4
Holy Cross	75.2	73.5	73.7	72.9	72.2	72.0	72.5	71.5	73.1	73.1
Warmian-Masurian	71.8	71.9	72.4	71.3	71.7	70.6	69.1	68.5	71.3	70.9
Greater Poland	105.9	107.3	107.6	108.7	109.4	109.4	108.1	108.7	108.6	107.2
West Pomeranian	84.3	84.0	84.7	85.1	84.3	84.0	83.9	83.2	84.6	84.2
Dynamics of gross domestic product per capita, previous year = 100										
Poland	103.8	101.2	104.4	105.8	103.1	107.0	107.3	107.7	102.2	113.1
Lower Silesian	103.2	99.6	104.8	105.4	102.5	106.6	106.1	107.7	103.6	114.4
Kuyavian-Pomeranian	103.1	102.2	103.7	105.9	103.1	106.2	107.6	105.5	104.4	113.0
Lublin	104.7	102.1	103.3	103.7	103.7	107.4	105.1	108.0	102.0	112.4
Lubusz	103.7	101.5	106.1	104.2	103.7	105.3	106.3	106.5	102.4	112.9
Łódź	104.8	100.9	104.9	105.5	102.9	106.8	106.9	108.8	105.1	111.5
Little Poland	103.1	101.3	104.9	107.2	103.7	107.8	108.1	106.9	102.1	114.1
Maasovian	104.5	102.0	103.7	105.8	102.9	107.6	108.0	108.7	102.3	110.9
Opole	102.7	100.8	105.6	105.0	101.7	106.6	107.0	107.4	101.4	116.1
Sub-Carpathian	103.1	102.9	104.2	105.7	102.7	105.8	108.3	107.8	99.9	114.2
Podlasie	101.7	103.2	104.0	103.5	102.8	108.3	106.6	108.3	103.8	111.7
Pomeranian	105.7	99.5	103.3	106.8	104.0	106.5	108.1	107.8	100.0	116.0
Silesian	102.5	99.2	104.4	105.9	103.0	106.9	107.5	106.4	99.0	116.1
Holy Cross	102.0	98.8	104.7	104.7	102.2	106.6	108.1	106.2	103.0	113.0
Warmian-Masurian	103.1	101.3	105.0	104.3	103.6	105.5	105.0	106.6	104.7	112.5
Greater Poland	104.4	102.5	104.6	106.9	103.8	107.0	106.1	108.2	102.9	111.6
West Pomeranian	103.9	100.7	105.3	106.3	102.2	106.6	107.1	106.7	102.8	112.6

Source: Own study based on the data found in Central Statistical Office.

Province(103.5%). However, when it comes to the region that fared the worst in the context of the entire economy, undoubtedly the Lublin Province should be mentioned (with an average result for the examined period of 69.44%). Moving to the lower part of Table 5, and specifically to the dynamics of changes in GDP per capita (assuming that the previous year = 100%), it can be seen that the most significant increase in this measure (y/y) both at the national and province level took place in 2021.

The culmination of the analysis was a Pearson correlation analysis, which allowed for the identification and quantification of the strength of the relationship between the examined measures of public sector innovation and the macroeconomic predictor, which turned out to be GDP per capita. The results of the analysis are included in Table 6. For the sake of order, it is worth emphasising that correlation has been perceived as a statistical tool that allows one to determine the degree of relationship between two variables. Correlation values range from –1 to 1, where a score close to 1 indicates a strong positive correlation, a score close to –1 indicates a strong negative correlation, and a score close to 0 indicates no relationship between the variables.

Table 6. An analysis of the strength of the relationship between selected measures for 2021

Dependency	Results of correlation
The percentage of innovative enterprises in the public sector and GDP per capita	0.340296
The percentage of public sector enterprises that incurred expenditure on innovative activities and GDP per capita	0.400143
Percentage of net revenues from the sale of products of innovative industrial enterprises in total net revenues from sales and GDP per capita	0.400421
The percentage of innovative enterprises in the public sector and the dynamics of GDP per capita	0.231853
The percentage of public sector enterprises that incurred expenditure on innovative activities and the dynamics of GDP per capita	0.15734
The percentage of net revenues from the sale of products of innovative industrial enterprises in total net revenues from sales and the dynamics of GDP per capita	0.22404

Source: Own calculation.

Analysing the correlation results included in Table 6, it can be seen that there are different levels of relationship between the examined measures and GDP per capita. In two analysed cases, a moderate positive correlation was obtained. Firstly, there is the relationship between the percentage of public sector enterprises that incur expenditure on innovative activities with GDP per capita. Secondly, the relationship describing the percentage of net revenues from sales of products of innovative industrial enterprises in total net revenues from sales of GDP per capita ought to be mentioned. In both cases, the correlation coefficient was approximately 0.40. In both situations, the increase can be noticed of GDP per capita with simultaneous increase of the percentage of public sector enterprises incurring expenditure on innovative activities increases, and similarly vice versa. Similar conclusions can be reached when taking into account the correlation coefficient for the percentage of innovative public sector enterprises and GDP per capita (0.34), as the obtained result also indicates a relatively moderate positive correlation.

However, the correlation between the examined measures of innovation in public sector enterprises and the dynamics of changes in GDP per capita turned out to be low, with values ranging from <0.157;0.232>, which suggests the lack of significant relationships between these variables.

Research results and their discussion

The nature of the considerations is overwhelmingly empirical. The results of the analysis were presented in a tabular, graphical, and descriptive form. The main conclusions at the national level claim, firstly, that in the analysed period in the Polish economy, on average 26% of public sector enterprises were innovative industrial entities. Secondly, the most frequently introduced type of innovation in the surveyed sector were new or improved processes; the average percentage of enterprises generating this type of activity was 24%. Finally, thirdly, on average, 19.4% of public sector enterprises incurred expenditure on innovation activities, but in 2021, this percentage increased by slightly over 3 percentage points.

However, at the regional level, the following regularities could be formulated. Firstly, both in terms of the highest average percentage of innovative industrial enterprises and the highest average expenditure on innovative activities, the leading province is the Silesian one, followed closely by the Masovian Province. A completely different situation concerned the regions for which the percentages of these predictors turned out to be the lowest, i.e. the Lubusz Province and the Warmian-Masurian Province. Secondly, the average share of net revenues from the sale of innovative products in total net revenues from sales in three Provinces, i.e. Pomeranian, Sub-Carpathian, and Łódź, turned out to be higher than the average share for Poland. However, the lowest share of net revenues from the sale of innovative products in total net revenues from sales, in some Polish NUTS 2, did not exceed 1% (e.g. the Warmian-Masurian Province).

Conclusions

The considerations were divided disproportionately, i.e. into an elementary theoretical part explaining the basic aspects of the issue and a much more extensive empirical part. In the research part, the analysis was based on arbitrarily selected predictors in the field of innovative activities of the public sector, after which an analysis of changes in the GDP growth dynamics of Polish regions was carried out. The culmination of the analysis was a Pearson correlation analysis between the examined measures. Based on the obtained results, a moderate relationship was shown between the examined variables in the area of the innovation of public sector enterprises and economic growth measured by the value of GDP per capita. The nature of the considerations is overwhelmingly empirical. The results of the analysis were presented in tabular, graphical, and descriptive form.

The presented considerations, including the presentation of the results of the analysis in the field of innovative activities of public sector enterprises in Poland, allowed for the formulation of the following conclusions:

a) at the national level:
   - the average percentage of innovative industrial enterprises in the public sector in 2012–2021 was 26.32%. In the last year under review, there was an increase in innovative enterprises, ultimately to the level of 34.4%;
   - most often, enterprises from the surveyed sector introduced new or improved processes. The average percentage of enterprises generating this type of activity was 24%, second in order were new or improved products, with an average of 8.75%, and third were new or improved products for the market (3.48%);
   - on average, 19.4% of public sector enterprises incurred expenditure on innovative activities, but in 2021, this percentage was 22.5%;

- the average share of net revenues from the sale of innovative products in total net revenues from sales was 6.47%. However, this percentage in 2021 turned out to be lower by 4.47 percentage points;

b) at the regional level:

- the highest average percentage of innovative industrial enterprises in the public sector was located in the Silesian Province (38.75%), to be followed by the Masovian Province (30.32%) and the Lublin Province (29%). The regions with the lowest average percentage of this type of enterprises included the Lubusz Province (17.57%), the Warmian-Masurian Province (18.37%), and the West Pomeranian Province (21.68%);
- the highest average percentage of enterprises allocating expenditure on innovative activities was once more recorded in the Silesian Province (32.8%), the second largest being the Masovian Province (26%), followed by the Kuyavian-Pomeranian Province (21.9%). The smallest percentage of enterprises allocating expenditure on innovative activities included enterprises operating in the Lubusz Province (11.2%) and the Warmian-Masurian Province (11.7%);
- the average share of net revenues from the sale of innovative products in total net revenues from sales in three provinces was higher than the average share in Poland. These were: the Pomeranian Province (19.3%), the Sub-CarpathianProvince (14.25%), and the Łódź Province (6.57%). The lowest share of net revenues from the sale of innovative products in total net revenues from sales occurred when this percentage did not exceed 1%. This was the case for the following NUTS 2 regions – Warmian-Masurian, Lublin, West Pomeranian, and Greater Poland.

Summing up, the paper analyses several measures related to the innovative activities of public sector enterprises in Poland and NUTS 2 regions in 2012–2021. The analyses of the percentage of innovative enterprises in the public sector, as well as those incurring expenditure on innovative activities, and the percentage of net revenues from the sale of innovative products in total net revenues from sales, showed differences in their dynamics of changes.

The relatively moderate strength of the relationship between selected predictors in the field of innovative activities of public sector enterprises and GDP suggests the existence of a certain economic relationships; it has to be mentioned, however, that different correlation results indicate the complexity of these relationships. This suggests that Gross Domestic Product is, to a varying extent, related to the examined measures of innovative activity, which may result from many economic, political, and/or social factors.

Correlation analysis allows for positive verification of all three research hypotheses, and thus for drawing the following conclusions:

1. A moderate positive correlation between the number of innovative public sector enterprises and GDP per capita suggests that a decline in the percentage of these enterprises may have a negative impact on economic growth.
2. The increase in the number of enterprises incurring expenditure on innovative activities in the public sector has a moderate impact on economic growth measured by GDP per capita.
3. The percentage of net revenues of enterprises from the sale of innovative products has a moderate impact on the value of GDP per capita, indirectly contributing to economic growth.
4. The identified and quantified relationship between GDP and the examined measures indicates that the dynamics of GDP per capita is not a clear indicator of the development of innovative activities in the public sector.

In the spectrum of economic interactions, the symbiosis between the innovative activities of the public sector and GDP dynamics is complex and multi-faceted. Drawing on the insights of outstanding economists and political scientists, the paper attempts to highlight the potential that appears when investments in innovative activities of the public sector intersect with GDP per capita. Theoretical research explains the likely mechanisms by which such investments can influence economic growth. Undertaking the processes aimed at the clarification of these fundamentals has profound implications for policymakers, practitioners, and other stakeholders, in this way helping them leverage the synergies between public sector enterprise innovation and economic flourishing in a turbulent environment. The identification and demonstrated strength of the relationship between the examined dependencies may, at least partially, contribute to targeting those activities that have the greatest impact on economic growth. Further analysis of this research problem will attempt to develop main recommendations and demonstrate well-established practical implications.

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