

# RESEARCH AND DEVELOPMENT EXPENDITURES IN THE SECTOR OF POLISH ENTERPRISES AS AN INSTRUMENT OF RESEARCH AND DEVELOPMENT POLICY

## NAKŁADY NA BADANIA I ROZWÓJ W SEKTORZE POLSKICH PRZEDSIĘBIORSTW JAKO INSTRUMENT POLITYKI BADAWCZO-ROZWOJOWEJ

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### ABSTRACT

One of the important and open issues in modern businesses is the financing of research and development (R&D) activities, treated as an instrument of research and development policy. Maintaining the competitiveness of business entities requires the systemic creation and implementation of innovations, which requires expenditure on R&D activities. The aim of this paper is to identify the level, dynamics and structure of expenditures on R&D activities in Poland and in Polish businesses. The time range of the study covers the years 2015–2019 (or 2017–2019 in the analysis of expenditures in the enterprise sector), the scope concerns the financial aspects of R&D activity on a national scale and in the sector of Polish enterprises, and the sources of the data for analysis are publications of Poland's Central Statistical Office (Statistics Poland). The study applied the following methods: a critical and cognitive analysis of literature in identifying the research problem, a descriptive and comparative method in presenting the problem, a statistical method in calculating percentage shares, and a projection method in proposing model solutions. Overall, the analysis found a relatively low level and dynamics of expenditures incurred on R&D in Poland and in the enterprise sector. Therefore, R&D policy among Polish enterprises can be described as conservative and ad hoc in nature.

**Key words:** research and development activity, innovation, customer, enterprise, knowledge, management

## ABSTRAKT

Jednym z ważnych i otwartych problemów współczesnych przedsiębiorstw jest finansowanie działalności badawczo-rozwojowej, traktowane jako instrument polityki badawczo-rozwojowej (B+R). Zachowanie konkurencyjności podmiotów gospodarczych wymaga systemowego tworzenia i wdrażania innowacji, co wiąże się z koniecznością ponoszenia nakładów na działalność B+R. Celem niniejszego opracowania jest zidentyfikowanie poziomu, dynamiki i struktury nakładów na działalność B+R w Polsce oraz w polskich przedsiębiorstwach. Zakres czasowy badania obejmuje lata 2015–2019 (2017–2019 w przypadku analizy nakładów w sektorze przedsiębiorstw), zakres przedmiotowy dotyczy finansowych aspektów działalności B+R w skali kraju i w sektorze polskich przedsiębiorstw, a źródłem danych do analizy są publikacje Głównego Urzędu Statystycznego. W opracowaniu zastosowano następujące metody badawcze: analizę krytyczno-poznawczą piśmiennictwa — do identyfikacji problemu badawczego, metodę opisową i porównawczą — do prezentacji problemu, metodę statystyczną — do obliczeń udziałów procentowych oraz metodę projekcyjną — do zaproponowania rozwiązań modelowych. Przeprowadzona analiza materiałów źródłowych wskazuje na względnie niski poziom i dynamikę nakładów ponoszonych na B+R w Polsce i w sektorze przedsiębiorstw. Można więc mówić o zachowawczym i doraźnym charakterze polityki B+R wśród polskich przedsiębiorstw.

**Słowa kluczowe:** działalność badawczo-rozwojowa, innowacja, klient, przedsiębiorstwo, wiedza, zarządzanie

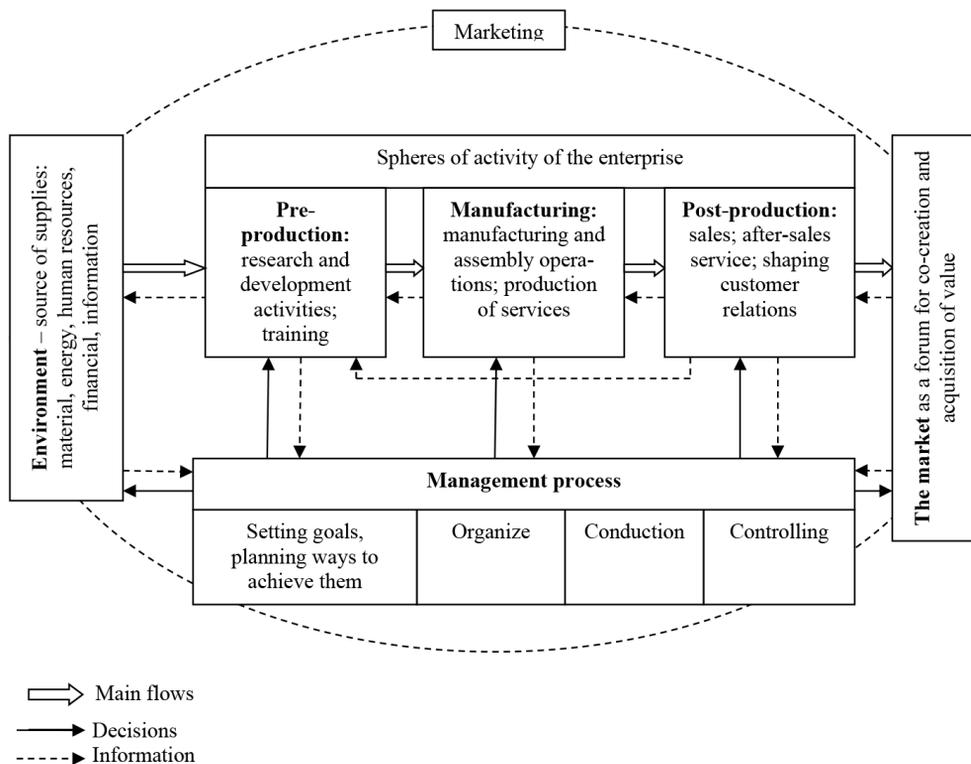
JEL: O23; O31; O32; O35; M31

## Introduction

The strategic goal of every enterprise, both industrial and service, is to systematically introduce new products and services to the market or improve already manufactured products. Achieving such a goal may lead to the more rapid meeting of changing customer needs compared to competitors and the shaping of new needs in a competitive way, conducive to acquiring the economic value necessary for the further functioning and development of business entities (Ri, Wang & Zhan 2018, p. 38; Dieter & Schmitt, 2018, p. 64). One of the basic conditions for achieving this goal is the ability of management to acquire, deploy, update and use the resources necessary for the efficient design of new products that would arouse the interest of buyers (Areri, Kipchumba & Kamau, 2020, p. 48). We can talk about material, energy, financial, human resources (employees),

information, knowledge, and so on. Rational use of such resources requires their proper organization in a static and dynamic sense, and efficient resource management, resulting in the design of new products or services arising in the pre-production sphere (see Figure 1).

**Figure 1. Model of managing the spheres of activity of the enterprise**



New or improved designs for products/services are transferred to the production sphere, where they become materialized in manufacturing (operational) processes. The resulting products (innovations), through the post-production sphere, reach the market to provide customers with the expected value. In return, the company acquires economic value, information and knowledge from its customers (Peng, Lawrence & Koo, 2009, pp. 146–147). Management according to such a model is focused on the systemic link between research and development (R&D) activities and marketing research (Szopik-Depczyńska, 2018).

As can be seen from the model above, the management process covers all spheres that make up the company's activity (Arandah, 2021, p. 47). One of these is the pre-production sphere, which fulfills the very important function of creating knowledge and processing it into specific projects for products or services (innovations) satisfying the current and future needs of real and potential customers (Emilyokwemba, 2018, pp. 16, 20; Kelemu, 2019, p. 35). Therefore, the systematic acquisition of information and knowledge from customers, combined with information and internal knowledge, can facilitate the creation of successful projects on the one hand, and on the other shape an environment conducive to interaction between customers and the company, resulting in the co-creation of the expected value in accordance with the principle: new knowledge enables the creation of new value (Baruk, 2017, pp. 20–28; Jasiński, 2020, p. 5).

The key elements of the co-creation process are as follows (Prahalad & Ramaswamy, 2005, pp. 31–39):

- 1) Dialog leading to loyal cooperation between customers and the company and its maintenance. Dialog inspires the sharing of information and knowledge, and shapes a new quality of mutual understanding and trust between enterprises and customers, as well as facilitating the introduction of the personal views of customers on the essence of value into the process of co-creation of value. Consequently, it leads to customer satisfaction, which is a key indicator of the level of customer service (Shete, 2021, p. 34);
- 2) Access to data, information, experiences, and services creates new opportunities for cooperation in new or existing markets, gives grounds to change the existing belief that only ownership allows customers to use value (offering customers access to new forms of services);
- 3) Risk assessment to ensure that customers have full access to information on the risks and benefits of engaging in the value co-creation process, facilitating trade-offs between risks and benefits. If customers are to be co-creators of value, they should be provided with more information about the potential dangers that may arise in the products and services they design, which requires greater customer responsibility for these risks;
- 4) Transparency resulting from the increasing availability of information about the products, indicators and operating systems of enterprises.

Transparency of activities and market transactions promotes the growth of customer involvement in the co-creation of value, enables the establishment of a dialog with customers leading to the initiation or deepening of cooperation and leads to the formation of strong trust between customers and enterprises.

The role of managers of enterprises focused on co-creating value as part of R&D activities is to rationally shape the aforementioned components of value co-creation and give them the character of system solutions (Kolomiiets, Krzyżanowska & Mazurek, 2018, p. 31). This is a difficult task, requiring mental changes, new management knowledge, social innovation, the ability to shape rational policies (research and development, innovative, production, marketing, social), strategic thinking, the abandonment of traditional thinking from the perspective of the enterprise in favor of strategic, innovative thinking from the perspective of customers and new incentive instruments, etc. (Prahalad & Ramaswamy, 2005, pp. 45–48; Janasz & Koziół, 2007, p. 81). The introduction of the concept of co-creation of value at the research and development (R&D) stage requires management to innovate in management, which helps to alleviate the tensions between the company and customers, manifested at the points of interaction (Heij, Volberda, Van den Bosch & Hollen, 2020, p. 278; Barbieri & Alvares, 2016, pp. 122–124).

The development of R&D activities in enterprises requires specific financial outlays, which are an instrument of R&D and innovation policy. Meanwhile, the lack or shortage of financial resources is one of the basic barriers to the dynamic development of R&D and innovation activities in enterprises, which translates into limiting or omitting this issue in decision-making processes (Matejun, 2015, p. 40; Jasiński, 2005, p. 39; Poznańska, 2017, p. 199; IDEA Institute, 2021, p. 112).

This article is organized based on the following concept: the implementation of each function in the enterprise requires incurring certain expenditures. One of such functions is the function of R&D activity. It is a source of knowledge materialized in innovation. Decisions on the amount of expenditure on R&D are made by the company's management. These decisions result from a specific R&D policy, which is why the level, dynamics and structure of actual expenditures incurred reflect the quality of R&D policy.

The following measures were used to analyse the level, dynamics and structure of R&D expenditures: 1) the amount of gross domestic expenditure on R&D (GERD); 2) the share of gross domestic expenditure on R&D in gross domestic product (GDP); 3) the number of entities conducting R&D activities; 4) the number of research employees per 1,000 employees; 5) the sum of internal expenditure on R&D activities in total, by executive sectors, by number of employees in enterprises, by ownership sector and by type of R&D activity.

**Research problem:** The essence of the research problem is therefore contained in the following questions: 1) what is the level of financing of R&D activities in Poland and in Polish enterprises? 2) what are the dynamics of R&D expenditures? 3) what is the structure of these expenditures in terms of the type of research, the size of enterprises and the ownership sector?

Undoubtedly, these are basic and current issues in academic considerations on the identification of enterprise policy in the field of financing R&D activities. The results may be the basis for changing this policy and directing it towards increasing the rationality of R&D management, treated as sources of knowledge for innovative activities. The importance of this research problem is particularly great in the light of the relatively low percentage of enterprises conducting R&D activities. According to research conducted in 2016 by Kantar Millward Brown, only 40% of Polish enterprises conducted R&D activities. This percentage rose to 55% in 2018 (Ayning Report, 2018, p. 16). In a similar study from October 2016, it was found that 60% of the surveyed companies in Poland did not conduct R&D activities. R&D activity was declared by only 16% of small companies, 50% of medium-sized companies and 64% of large companies (Ayning Report 2016, pp. 5, 17).

**Purpose:** The purpose of the publication is to identify the level, dynamics and structure of expenditures on R&D activities in Poland and in Polish enterprises. These parameters define the nature of the R&D policy pursued by managerial staff. At the same time, they form the basis for proposing improvements (in the form of model solutions) in this area.

**Research methods:** The following research methods were used to develop this paper: a cognitive-critical analysis of the literature to identify the research problem; the descriptive and comparative method for the

presentation of the problem; the statistical method for calculating percentages of the level, dynamics and structure of R&D expenditures; and the projection method for proposing model solutions.

**Results:** The level of measures of R&D activity analyzed indicates that the enterprise sector played a leading role in the sectoral system. The priority for this sector was development work in all the cross-sections considered. The lowest expenditures were spent on basic research. Compared to the average results in the European Union, Poland and Polish enterprises achieved lower indicators in terms of financing R&D activities. The relatively low level and diversified nature of the measures in the period under investigation indicates relatively low R&D activity among enterprises. One of the reasons for this is the random and ad hoc nature of R&D policy, which is aimed more at solving current problems.

**Practical implications:** Becoming aware of the real results in terms of R&D expenditure may serve as the basis for rationalising R&D policy and giving it a strategic dimension. The use of the proposed model solutions in this policy may lead to an increase in this rationality, and thus an increase in the integration of R&D work with innovative activities and the market. The consequence may be an improvement in the competitive position of enterprises, their economics and customer relations.

**Social implications:** Rationalization and strategic orientation of R&D management is conducive to the socialization of R&D processes, and the inclusion of the company's own employees, institutional and individual clients in this activity. Because of changes in management and R&D policy, healthy relations between the company and individuals and institutions in the environment may be formed, as well as the willingness of employees to learn and share knowledge.

**Originality:** This article makes an empirical contribution in terms of the level, dynamics and structure of R&D expenditures in Poland and in the enterprise sector. It also makes a conceptual contribution in the form of organizing knowledge on the essence of R&D activity, R&D policy and model solutions facilitating the management of the R&D sphere and its integration with production and post-production activities.

**Scope of the study:** The time range of the research covers the years 2015–2019 (or 2017–2019 in the case of the analysis of the enterprise

sector). The scope concerns the financial aspects of R&D activity on a national scale and in the Polish enterprise sector. The scope of the survey covers the country and the enterprise sector that complete the annual PNT reports on R&D activities and send them to the Central Statistical Office (GUS), where aggregate results are prepared, edited in publications entitled "Science and technology in the years of..." and "Research and development activities in Poland in the years...". It is the data contained in these studies that constitute the basic source of analysis of R&D expenditures.

## **The essence of R&D activity and R&D policy**

R&D activity has become an integral part of modern economies, treated as a source of knowledge necessary for the dynamic and systemic pursuit of innovative activities, conditioning the increase in the competitiveness of enterprises and their ability to co-create value for customers (Jasiński, A.H. 2020, p. 6; Mate & Molero, 2021, p. 2; Kelemu, 2019, p. 36). R&D activities consist of creative work carried out in a methodical manner to acquire new knowledge resources — especially knowledge about humanity, culture and society — as well as to search for new applications for knowledge hitherto gained. This activity is aimed at new discoveries based on original concepts and their interpretations or hypotheses. Its aim is to achieve results that would be freely transferable and tradeable on the market (GUS, 2018b, p. 47; OECD, 2015, p. 44). R&D activity may be characterized by: innovativeness, creativity, unpredictability, methodicality, possibility of reproduction or transfer (GUS, 2018b, p. 47; OECD, 2015, p. 45).

R&D activities include the following three sets of activities (Witness, 2021, p. 89):

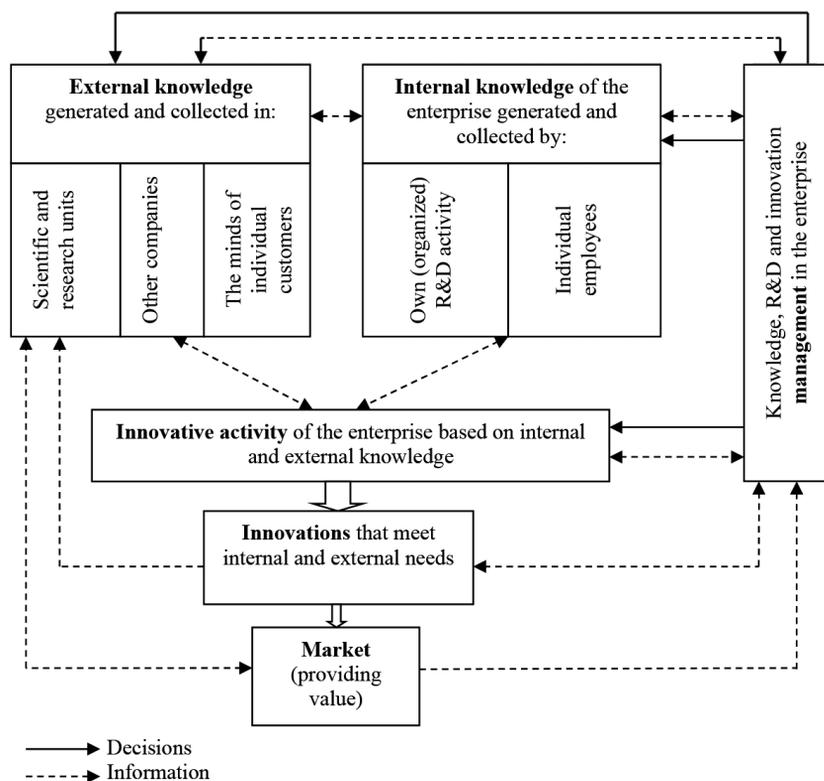
- 1) basic research, which is experimental or theoretical work carried out with a view to acquiring new knowledge about specific phenomena

governing nature and specific facts without indicating specific applications;

- 2) applied research, also undertaken to acquire new knowledge but focused on a specific practical goal or intention. The results of such research are usually trial models of products, processes or methods;
- 3) development work, which is is methodically carried out activity based on knowledge obtained as a result of basic and applied research, practical experience and generating additional knowledge aimed at the production of new products or processes, or at improving already manufactured products and processes, including the preparation of prototypes or pilot installations. Usually, development work includes construction, structural, design-technological and experimental work (Baruk, 2014, p. 57).

R&D activities are carried out by organizations and cooperating natural persons whose work is creative and is undertaken in order to increase knowledge resources, as well as to create new possibilities for its application. In particular, the contractors of R&D work are statistical units established to conduct R&D activities in the following sectors (GUS, 2018b, p422; OECD, 2015, p. 98): enterprises, government, higher education and private non-commercial institutions. Innovation is a manifestation of such successful work. It should be realized that the development of innovations that can have a radical impact on the development of a company, increase its competitiveness, and increase the ability to originally meet the current and future needs of individual customers requires the generation of new knowledge. It is therefore necessary to conduct a rational R&D policy including: 1) organizing their own sphere of R&D, 2) systemic use of external knowledge arising in scientific and research organizations, in other enterprises, 3) acquiring knowledge and experience of individual customers or joint use of internal and external knowledge acquired as part of systemic cooperation or purchasing, 4) systemic shaping of the culture of learning and sharing knowledge, 5) creating an environment of experience, creating structural and process conditions for generating knowledge and materializing it in innovations, etc. (see Figure 2).

**Figure 2. Model of integration of internal and external knowledge with the innovative activity of the enterprise through management**



Since enterprises operate and develop in a dynamic environment, it becomes a natural necessity to systematically renew the resources of internal and external knowledge, multiply it, store it, as well as sharing silent knowledge and transforming it into knowledge commonly available to enterprises (Swaty & Kumar, 2021, p. 56; Probst, Raub & Romhardt, 2004, p. 143). The role of management is therefore to create a climate and culture conducive to creative behavior (social innovations), to organize teamwork integrating all categories of knowledge, experience, thinking styles, to stimulate knowledge employees to reveal it, share it with other people, etc. (Suvaci, 2018, p. 4). We should be aware that innovative activity is based on various categories of knowledge: technological, organizational,

market, commercial, economic, managerial, social and methodological knowledge.

Skilful management of knowledge, i.e., its creation, acquisition, storage, processing, distribution, transformation (from hidden knowledge to available knowledge) and use, is becoming increasingly more important in today's conditions of enterprise functioning than the mere transformation of raw materials into finished products in accordance with known manufacturing technologies and supplying customers with them. Particular attention should be paid to the creation of the company competences, i.e., those areas of knowledge that are (Baruk, 2007, p. 140):

- 1) key competences, determining the identity of the company, dynamizing its market position. An example of this type of competence is R&D. Key competences can be shaped through the implementation of social innovations, rational HR policy, employment, training, learning, knowledge management, rationally organized R&D and innovation activities and cooperation policy with scientific and research organizations,
- 2) unique competences, constituting the basis for the company to achieve an advantage over competitors in terms of originality, modernity, quality and compliance with customer expectations of all technical, technological, organizational and managerial solutions. This requires activity by management staff in the field of rational management of R&D work, hiring researchers and specialists from various scientific disciplines, providing them with significant freedom to choose research directions, unlimited contact with customers, innovative experience environment, etc.

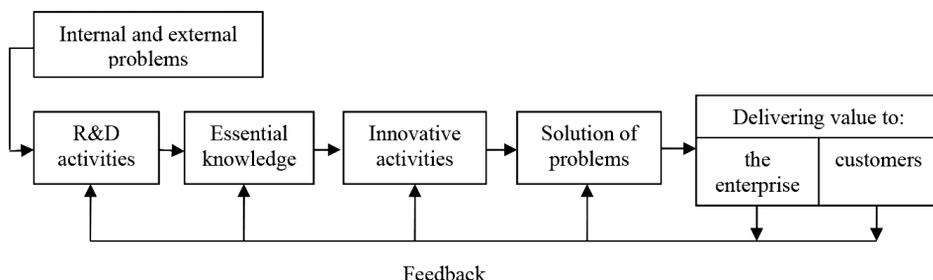
In the processes of systemic creation of knowledge and its materialization in innovation, it is necessary to convince managers that: 1) the diffusion of knowledge through the innovation system is a key element in the effectiveness of any innovation process, which is why it should be rationally managed, 2) systematic expansion of the knowledge base in enterprises through organized R&D activities, cooperation with external entities and individual customers or acquisition of new knowledge through purchases, becoming a necessity today, 3) the most important role in R&D

activities and innovation processes is played by people of knowledge, which is why they should be rationally managed, conditions for learning should be created, employees should be encouraged to share knowledge, as part of a systemic R&D and innovation policy (Janasz & Koziół, 2007, pp. 78–79).

The term R&D policy and innovative enterprise should be understood as a specific set of managerial, economic, social, organizational, financial and technical decisions leading to the integration of science — technology — production — distribution, focused on the systemic acquisition of external and internal knowledge, materialized in innovations providing customers with the expected value faster than competitors. In other words, R&D policy and innovation policy are a series of rational decisions and actions resulting in the organization of efficient structures (in a static and dynamic sense), stimulating research resulting in the generation of knowledge, indicating ways to materialize it in product and business process innovations, solving an enterprises technological and financial problems, as well as satisfying individual and the institutional needs of customers (Baruk, 2020, p. 7). These policies include the creation of R&D and innovation objectives, as well as the selection of means and methods to achieve these goals (Janasz & Koziół, 2007, p. 96). Primarily, this is about the economic, social, organizational, human resources, and financial solutions necessary for the efficient course of research work (acquiring knowledge, indicating the possibilities of its application) and development, as well as innovation creation processes.

Undoubtedly, rational answers to the following questions can facilitate the creation of an R&D policy for an enterprise: 1) what problems (internal, market) the company may encounter in the short, medium and long terms? 2) what innovations can be conducive to solving these problems? 3) what knowledge is necessary or will be required to generate innovation and solve these problems? 4) from what sources (internal, external, mixed) should this knowledge be acquired? 5) what material, financial and human resources will determine the smooth course of R&D and innovation processes? 6) what role can and should individual customers play in these processes? 7) what organizational (structural and process), technical and social changes should be introduced to ensure high efficiency of R&D and innovative processes? In general, R&D and innovation policies should be based on the following mechanism (see Figure 3):

**Figure 3. Scheme of the mechanism facilitating the development of R&D policy in an enterprise**



When above considerations are compared to economic practice, two questions arise: 1) what are the level and dynamics of expenditures on R&D activity in Poland, treated as an instrument of R&D policy? 2) what are the level and dynamics of expenditures on R&D activity in the Polish enterprise sector, treated as an instrument of R&D policy?

Possible answers to these questions are presented in the following sections of the article.

## Expenditures on R&D activities in Poland in 2015–2019

R&D activities require specific financial outlays. One of the basic measures of this activity is gross domestic inputs (GERD index). They constitute the amount of total internal expenditures on R&D activities carried out on the territory of a given country in the indicated reporting period (GUS, 2020a:19). The level of these expenditures in the years 2015–2019 is presented in Table 1. In 2015, they amounted to PLN 18.1 billion. In the following year, a decrease in this metric by 0.7% was recorded. In the following years, these expenditures increased compared to 2015 by 13.9% in 2017, by 42.0% in 2018 and by 67.7% in 2019, respectively, which should be considered a positive phenomenon, even after accounting for the inflation rate.

The ratio of gross domestic inputs to gross domestic product (GDP) was also used to analyse the dynamics of R&D activity. In the period analyzed, this indicator was characterized by a slight increase, except for 2016, when this ratio was 0.96%. In subsequent years, this rate exceeded 1% and in 2019 it amounted to 1.32%.

**Table 1. Selected measures of R&D activity in Poland in 2015–2019**

Specification	Years				
	2015	2016	2017	2018	2019
Gross domestic expenditure on R&D (GERD) in PLN million	18,061	17,943	20,578	25,648	30,285
Ratio of gross domestic expenditure on R&D to gross domestic product (GDP) in %	1.00	0.96	1.03	1.21	1.32
Share of gross domestic inputs in GDP — European Union (28) in %	2.04	2.04	2.08	2.11	2.14
Number of entities conducting R&D activities	4,427	4,871	5,102	5,779	5,863
Research staff per 1000 employees	5.1	5.4	5.9	6.0	6.1

**Internal expenditures on R&D activities in total and by executive sectors in PLN million:**

— Total	18,061.0	17,943.0	20,578.5	25,647.8	30,284.8
— Enterprises	8,411.4	11,782.5	13,271.9	16,950.8	19,030.9
— governmental	4,405.8	451.0	470.2	498.6	384.2
— higher education	5,215.2	5,630.4	6,764.9	8,121.7	10,779.4
— private non-profit institutions	28.4	79.1	71.4	76.7	90.3

Based on data from: GUS (2020a, p. 20; 2019a, pp. 20, 22; 2018a, pp. 15, 20; 2017, pp. 15–17, 22–23); Eurostat (2021).

The universality of R&D activity may be measured by the number of entities that engage in it. In 2015, there were 4,427 such entities. Compared to 2015, their number increased by 444 in 2016, by 675 in 2017, by 1,352 in 2017 and by 1,436 in 2019. As in any job, people with

appropriate professional training must also be involved in R&D activities. In this activity, one of the most important groups of employees are scientific and research workers. In the analyzed period, there was an average of from 5.1 research workers per 1,000 employees in 2015 up to 6.1 in 2019. Year on year, this measure slightly but successively increased by 0.5 in 2016 and in 2017, by 0.1 in 2018 and 2019.

Involvement in R&D activities can also be assessed on the basis of the internal expenditures, defined as all current expenditures and gross capital expenditures on fixed assets related to R&D activities, carried out in the entity (GUS, 2020a, p. 19). In total, these expenditures increased from PLN 18.1 billion in 2015 to PLN 30.3 billion in 2019. The exception was 2016, when compared to 2015, the sum of these expenditures decreased by PLN 118 million.

The basic classification used in the analysis of data on R&D activities is the classification of institutional sectors developed by the OECD, including: the corporate sector, the government sector, the higher education sector, the sector of private non-commercial institutions and abroad. According to the classification of executive sectors, entities conducting research and development activities are divided into four categories: the enterprise sector, the government sector, the higher education sector and the sector of private non-commercial institutions (GUS, 2020a, pp. 25–26).

As shown in Table 1, during the period considered, the largest expenditure on R&D was incurred by companies. In 2015, they amounted to PLN 8.4 billion, which accounted for 46.6% of gross domestic expenditures on R&D activities. Year on year, expenditures on R&D in enterprises increased by PLN 3.4 billion in 2016, by PLN 1.5 billion in 2017, by PLN 3.7 billion in 2018 and by PLN 2.1 billion in 2019. In the last year, enterprises spent PLN 19 billion on R&D activities. This amount represented 62.8% of gross domestic expenditure for this purpose. In other years, this indicator was: 65.7% in 2016, 64.5% in 2017, and 66.1% in 2018. In other executive sectors, these shares were: 1) in the government sector: 24.4% in 2015, 2.5% in 2016, 2.3% in 2017, 1.9% in 2018, and 1.3% in 2019; 2) in the higher education sector: 28.9% in 2015, 31.4% in 2016, 32.9% in 2017, 31.7% in 2018 and 35.6% in 2019; 3) in the sector of private non-profit institutions: 0.2% in 2015, 0.4% in 2016, 0.3% in 2017, 0.3% in 2018 and 0.3% in 2019.

The level of the measures of R&D activity above in individual executive sectors indicates the leading role of the enterprise sector. This sector was characterized by the highest internal expenditures on R&D, growing in successive years, and the largest share of these expenditures in gross domestic expenditures. This was followed by the ministries of higher education, government and private non-profit institutions. The latter sector was characterized by a marginal involvement in financing R&D activities.

### **Expenditures on R&D activities in the sector of Polish enterprises in 2017–2019**

Since the enterprise sector was characterized by the greatest involvement in R&D activities, it is worth analyzing the development of internal expenditures in this sector depending on the size of enterprises and their sectoral affiliation. The development of this indicator in 2017–2019 is presented in Table 2.

The analysis of internal expenditures incurred on R&D indicates an increasing absolute value in all cross-sections, i.e., in total in the country, in total in enterprises and in individual categories of enterprises. Compared to 2017, in 2019 the total amount of these expenditures increased by PLN 9,706.3 million, i.e., by 47.2%. In the corporate sector, this increase was 30.3%. In the case of micro enterprises, expenditures increased by 44.9%, in small enterprises by 45.2%, in medium-sized enterprises by 34.3%, in large enterprises by 30.4%, and in great enterprises — by 52.1%. In private enterprises, an increase in expenditures by 47.5% was recorded, while in public enterprises by 22.7%.

Based on the sum of internal expenditures on R&D activities in 2017–2019, it can be concluded that R&D policy in Poland was first focused on development work, then on basic research and finally on applied research. This conclusion is confirmed not only by the absolute values of expenditures allocated to individual types of R&D activities, but also by the percentage shares of these expenditures in total expenditures. In 2017, these shares were 29% for basic research, 17.6% for applied research and 53.4% for development. In 2018, the ratios were 32.5%, 13.2% and 54.2%,

respectively. Finally, in 2019, the share of expenditure on basic research in total expenditures accounted for 40.1%, for applied research — 13.4%, and for development work — 46.5%.

**Table 2. Internal expenditures on R&D activities in the enterprise sector by type of R&D activity**

Specification	Years	Total	Expenditure on research:		
			Basic	Applied	Development
		in PLN million			
Total in the country	2017	20,578.5	5,971.5	3,620.4	10,986.5
	2018	25,647.8	8,346.5	3,395.7	13,905.6
	2019	30,284.8	12,146.5	4,064.8	14,073.5
Total enterprises	2017	13,271.9	618.3	2,514.5	10,139.1
	2018	16,950.8	1,866.6	2,189.0	12,895.3
	2019	19,030.9	3,331.9	2,669.0	13,030.0
<b>Enterprises by number of employees:</b>					
— up to 9 people — micro-enterprises	2017	402.5	35.6	112.0	254.9
	2018	443.0	96.1	77.0	269.9
	2019	583.2	176.5	120.1	286.7
— 10 to 49 persons — small	2017	1,256.1	122.7	322.0	811.5
	2018	1,680.5	269.0	278.5	1,132.9
	2019	1,824.2	435.1	315.9	1,073.2
— 50 to 249 persons — medium	2017	2,970.2	240.8	724.5	2,005.0
	2018	3,508.3	415.3	587.8	2,505.2
	2019	3,989.8	828.1	649.1	2,512.7
— 250 to 499 people — large	2017	2,380.2	129.8	572.2	1,678.2
	2018	2,911.5	292.6	531.5	2,087.4
	2019	3,104.6	544.5	531.1	2,029.0
— 500 people and more — great	2017	6,262.8	89.4	783.8	5,389.6
	2018	8,407.5	793.5	714.1	6,899.9
	2019	9,529.1	1,347.9	1,052.8	7,128.5
<b>Enterprises by ownership sector:</b>					
— private	2017	11,075.1	364.4	1,693.1	9,017.6
	2018	14,444.7	1,568.0	1,430.8	11,446.0
	2019	16,336.0	2,861.7	1,845.3	11,628.9
— public	2017	2,196.9	253.9	821.4	1,121.5
	2018	2,506.2	298.7	758.2	1,449.3
	2019	2,694.9	470.2	823.7	1,401.1

Based on data from: GUS (2021, p. 31; 2020b, p. 31; 2019b, p. 32).

In the corporate sector, the priority for R&D policy was development work, which absorbed the most cash in the period analyzed. In 2017, they accounted for 76.4% of total expenditures. In the case of applied research, this share was 18.9%, and in the case of basic research — 4.6%. In 2018, these relations were at the level of: 11.0% in the case of basic research, 12.9% in the case of applied research, and 76.1% in the case of development work. In the next year of the analysis (2019), expenditures on basic research accounted for 17.5% of total expenditures, in the case of applied research — 14.0%, and 68.5% — in the case of development work. The level of these measures indicates that the priority of R&D policy in enterprises in general was development work, followed by applied research and finally basic research, with the exception of 2019, when the share of expenditure on basic research was slightly higher (by 3.5 percentage points) than on applied research.

Taking into account the size of enterprises expressed in the number of employees, it should be stated that the priority of R&D policy in the period under investigation was development work in all groups of company sizes. This is evidenced by the shares of expenditures on individual types of R&D activities in total expenditures. In the case of micro-enterprises, these shares amounted to: in 2017 for basic research, 8.8%, for applied research 27.8%, and for development work 63.3%. In 2018, these relations were as follows: 21.7% for basic research, 17.4% for applied research and 60.9% for development work. Finally, in 2019, these measures took the following values: 30.3% for basic research, 20.6% for applied research, and 49.1% for development work.

In small enterprises, R&D policy was also focused mainly on financing development work. In 2017, the share of expenditure on development work in total expenditures was 64.1%, in the case of applied research — 25.6%, and in the case of basic research — 9.8%. In 2018, these indicators reached the following values: 67.4% for development work, 16.6% for applied research and 16.0% for basic research. In 2019, the share of expenditures on development works in total expenditures was 58.8%, in the case of applied research — 17.3%, and in the case of basic research — 23.8%.

Similar phenomena occurred in medium-sized enterprises, where R&D policy focused mainly on development work. This is evidenced by the indicators of the share of expenditures of individual types of research in total expenditures. In 2017, they amounted to: 67.5% for development work, 24.4% for applied research and 8.1% for basic research. The situation was similar in 2018: 71.4% of total expenditure was allocated to development, 16.7% to applied research and 11.8% to basic research. In 2019, these relations were at the level of: 63.0% for development work, 20.7% for basic research and 16.3% for applied research.

A similar structure of expenditure characterized large enterprises, in which in 2017 70.5% of total expenditures were allocated to financing development work, 24.0% to applied research and only 5.5% to basic research. In 2018, the percentages of these expenses were at the level of 71.7% for development work, 18.2% for applied research and 10.0% for basic research. In 2019, the structure of expenditure was similar. The largest amount of funding was allocated to development work — 65.3% of total expenditures, 17.1% to applied research and 17.5% to basic research.

The R&D policy of large enterprises was also dominated by development work. In 2017, 86.0% of total expenditure was allocated to it, with only 12.5% for applied research and 1.4% for basic research. A similar distribution of these indicators took place in 2018, when development work was mainly financed. It accounted for 82.1% of total expenditure, for applied research only 8.5% and for basic research — 9.4% of all funds. In 2019, a similar structure of expenditure was recorded. 74.8% of total expenditures on development work, 11.0% on applied research and 14.1% on basic research.

In general, the R&D policy of the enterprise sector was dominated by development work, to a much lesser extent was it decided to finance basic and applied research. There were years when slightly more money was spent on basic research than on applied research, e.g., 2019 (enterprises in general), 2018 and 2019 in micro-enterprises, 2019 in small, medium, large and great companies, and 2018 in large companies.

The last cross-section of the analysis is the distribution of internal expenditures on R&D in enterprises depending on the sector of their ownership. In both sectors, total expenditures increased in individual years of the analysis. The absolute amount was higher in the private sector by PLN 8.9 billion in 2017, i.e., by 80.2%; by PLN 11.9 billion in 2018, i.e., by 82.6% and by PLN 13.6 billion in 2019, i.e., by 83.5%. In each of these sectors, R&D policy was mainly focused on financing development work. This conclusion is confirmed by the shares of expenditures on individual types of activities in total expenditures. In 2017, the private sector accounted for 81.4% of total investment, for applied research for 15.3% and for basic research for 3.3%. In the following year, the level of the metric was: 79.2% for development work; 9.9% for applied research and 10.8% for basic research. In 2019, it was at the level of: 71.2% for development work, 11.3% for applied research and 17.5% for basic research.

In 2017, public sector enterprises accounted for 51.0% of total expenditure on development, 37.4% on applied research and 11.6% on basic research. In 2018, funds for development work accounted for 57.8% of total expenditure, 30.2% for applied research and 11.9% for basic research. In the last year of the period investigated, i.e., in 2019, 52.0% of the total financial resources were allocated to development work, while 17.4% and 30.6% of the expenditures incurred were allocated to basic and applied research respectively.

## Summary

The assessment of the position of the Polish and the business sector in terms of its commitment to R&D financing will be more objective if the results are compared with those obtained in the European Union (EU). Compared to the average values achieved in the EU, the share of domestic expenditures on R&D in the gross domestic product in Poland was lower by 0.82 p.p. in 2019, 0.9 p.p. in 2018, 1.05 p.p. in 2017, 1.08 p.p. in 2016 and 1.04 p.p. in 2015, in the years 2015–2019, the average value of this indicator in Poland was lower than its average value in the EU by 0.98 p.p.

It should be emphasized that in the enterprise sector, the share of internal expenditures on research and development in gross domestic expenditure on R&D activities in 2019 amounted to 62.8% (with a 66.6% share in the EU) and was much higher than such shares in other sectors: government by 61.5 percentage points, higher education by 27.2 percentage points. and private non-commercial institutions by 62.5 percentage points.

The ratio of internal expenditures on R&D activities to GDP, defined as the intensity of R&D work, in 2019 amounted to 1.32% and was lower than the value of this indicator for the EU by 0.82 p.p., which placed Poland 16th among member states. In 2019, the index increased by 0.11 p.p. compared to 2018 and by 0.32 p.p. compared to 2015 (GUS, 2021, p. 25). Thus, we can talk about the relative backwardness of the Polish and the corporate sector in relation to the EU in terms of the amount of expenditures on R&D and their share in the gross domestic product.

A valuable source of information about R&D policy is indicators of the share of expenditures on individual types of R&D activities. It turns out that in 2017–2019 this policy was focused mainly on financing development work, to a lesser extent on financing basic research and to the smallest extent — applied research. Interesting conclusions emerge from the analysis of the measure studied in the cross-section of types of R&D activities and executive sectors. In the analyzed period, the expenditures incurred on development work dominated in all executive sectors, i.e., in micro, small, medium, large and great enterprises, as well as in companies from the private and public sectors. This situation indicates the short-term nature of R&D policy.

The level and dynamics of expenditures on R&D activities in the sector of Polish enterprises indicate that: 1) R&D activity in the analyzed sector was relatively low, as evidenced by relatively low and diversified expenditures on R&D; 2) R&D activity, treated as a source of knowledge for innovative processes, was not a priority in the information and decision-making processes of the management of most companies, especially micro and small, as well as in the R&D policy; 3) in the sector of Polish enterprises, R&D policy had a more ad hoc, random character, to a small extent focused on the systemic creation of knowledge and its use in innovative processes; 4) in all cross-sections of the analysis, the real R&D

policy of the enterprise sector was clearly focused on financing development work consuming knowledge. Less importance was attached to the development of basic and applied research, aimed at creating knowledge and searching for the possibility of its practical use as part of development work, 5) R&D policy in the sector of Polish enterprises was more determined by current needs, to a lesser extent by the vision of development and the resulting strategy. This policy was not sufficiently focused on systemic cooperation with national and international organisations leading to rational results in R&D and innovation (Chen et al., 2021, p. 244).

The passive nature of R&D policies in the sector of Polish enterprises may be the result of the following factors:

- 1) insufficient involvement of company managers in identifying current and future problems (internal and external), the solution of which requires the creation of new knowledge, sharing silent knowledge and transforming it into organizational knowledge;
- 2) the dominance in management information and decision-making processes of thinking from the perspective of solving the current needs of the company and individual units, an organizational instead of a systemic approach to the implementation of the organization's development goals through the integration of R&D, marketing and innovative activities. This entails a comprehensive combination of the concepts of research, development, innovative activity and marketing research (R&D+I+M) into one cycle of the research system (Jasiński, 2020, p. 5; Mate & Molero, 2021, p. :2);
- 3) a prevalence of managers thinking in terms of past successes instead of creating the future based on information systematically obtained from the market, from individual customers and offensive strategies for the development of the organization;
- 4) low ability and inclination of the management staff to introduce social innovations and innovations in management (Heij et al., 2020, p. 278);
- 5) limited financial, organizational, social capabilities, technical and managerial enterprises;

- 6) insufficient capacity and propensity to systematic learning and management of knowledge and innovation according to model indications, especially network models (Baruk, 2021, pp. 14–27);
- 7) lack of inclination in management to create an innovative experience environment, conducive to employee interaction with individual customers, aimed at co-creating knowledge, innovation and values (Prahalad & Ramaswamy, 2005, p. 62; Baruk, 2020, p. 5);
- 8) a relatively low level of organizational culture, limited interest among management in creating an organizational culture aimed at creating knowledge and materializing it in innovation;
- 9) an excessive preference for traditional organizational solutions and favoring them to the creation of changes based on the characteristics of excellent innovative companies, such as (Peters & Waterman, 2000, pp. 45–48): willingness to act; proximity to the customer (learning from people); autonomy and entrepreneurship; development in the stage of progress, efficiency thanks to employees and individual customers; active involvement, guided by values; remaining with what you know; simple form, less administration; a combination of slackness and rigidity;
- 10) the limited tendency of managers to systematically shape technical and social architecture supporting a culture of knowledge creation and innovation, learning and knowledge sharing (Prahalad & Krishnan, 2010, p. 66).

If there are weaknesses in R&D policies and management processes, systemic actions are necessary to eliminate these weaknesses and optimize existing solutions. Such action may involve the integration of R&D, innovative, production and market relations functions, achieved as a result of creating and implementing innovations in management, treated as a contextual variable, affecting the effectiveness of R&D work and innovative activities from the point of view of effective identification and solving an enterprise's own problems, as well as customer problems. It should be realized that innovations in management dynamize R&D work, which in turn promotes an increase in the level of innovative activity that translates

into the company's economic results and customer satisfaction. Innovations in management are conducive to the effective creation of all categories of knowledge, which is a prerequisite for the effectiveness of innovative processes (Heij et al., 2020, p. 287).

R&D policy should therefore be aimed at increasing the dynamics of internal R&D activities based on the optimal use of internal resources with full openness to the acquisition and use of external resources, especially financial and human resources, in accordance with the open innovation model (Baruk, 2021, pp. 21–22; Mate and Molero, 2021, p. 8) and the models presented in Figures 1 and 2.

## **Proposals for further research**

In the context of the results of the research presented in this article, further empirical research should be done on the methodology of shaping R&D and innovative policy in Polish enterprises and translating it into everyday activities. The following questions should be addressed:

- 1) Will these policies support the systemic, prospective development of enterprises, based on the use of various sources of knowledge materialized in innovation?
- 2) What is the culture of shaping and implementing R&D and innovation policy in enterprises?
- 3) What is the role of customers in R&D and innovation policy?
- 4) Are managers substantively and mentally prepared to create such a policy based on model solutions?
- 5) Are enterprises able to raise the funds necessary for the systemic development of R&D and innovation activities?

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