Business Research and Development: Is There a Substitution Effect of Public Support?

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Abstract: The importance of research and development is reflected in the fact that one of the main priorities of the EU's development policies is increasing spending on research and development in EU member states (EC, 2010). Enterprises do not always have enough internal financial resources to launch their own innovation projects, and therefore they turn to external resource providers (Wang et al., 2016). The paper is aimed at examining the impact of corporate expenditures on R&D from the point of view of their funding sources and analysing the occurrence of the substitution effect of public support for R&D in EU 27 countries. These countries also have the highest level of public financing of research and development, that is, they use the public support of business innovations to the highest extent. The analysis showed that in the EU 27, the substitution effect of public support for research and development is not significant, or rather the complementarity of both types of expenditure prevails at the national level, as public funding of corporate research and development seems to have a positive effect on private research and development and investments. Our analysis is based on available secondary data for 27 EU member states. for a twenty-year observation period (2000-2020). The results have been achieved by using a methodology that includes cluster analysis, panel regression and correlation analysis. We bring new empirical evidence on the relationships between public support and business research and development expenditures. The research results showed the main sources of funding for corporate research and development. It concerns the business enterprises, government and abroad. The cluster analysis determined three clusters, divided according to the structure of the financing of R&D enterprises in EU countries. The results of the cluster analysis were partially in line with the current results of the European Innovation Review. Our findings provide policy implications for the public support policy.

Keywords: R&D funding, Public support policy, Substitution effect, Public, Panel regression and correlation analysis

1. Introduction

According to several previous studies, innovation is considered an important determinant of economic growth (Akcali, and Sismanoglu, 2015, Blanco et al., 2015, Falk, 2007), as well as the competitiveness of companies (Abdal et al, 2016). Although research and development ("R&D") and innovation are not the same thing, research and development is a key component of innovation. Innovation and research and development are becoming a significant part of the policies of countries and transnational unions such as the European Union. This is shown by the EU's "Europe 2020" strategy, which calls on member states to invest 3% of their GDP in research and development (EC, 2020). However, it is important not only to look at R&D spending as one aggregate indicator but also to consider the contributions of different innovation actors to R&D funding. Since it is known that companies are the main innovation actors that create the largest number of innovations in the national innovation system, the contribution is aimed at financing corporate research and development. The problem for companies is the lack of resources for starting their innovative activities. Their effort is to obtain financial resources in various forms. In this direction, public support for innovation from government sources to businesses is significant, which does not always bring the desired effects and can crowd out private investments. In addition to examining the impact of corporate spending on research and development in the EU 27 countries from the perspective of their funding sources, our research deals with this unwanted effect of public support.

2. Literature Review

R&D spending is known as a driver of innovation and productivity (Diaconu, 2019) from the perspective of government as well as businesses. Foreign studies have documented that there is a significant correlation between business R&D spending and national competitiveness, economic growth, government spending, employment growth, etc. (Olakojo, King, 2023; Diaconu, 2013; Coad, Rao, 2010; Nekrep, Strašek, Boršič, 2018). According to foreign studies, we can say that BERD has a huge potential for the country from both the macroeconomic and microeconomic levels.

According to the OECD survey (2019), many companies do not engage in innovation activities, even though discussions about the importance of innovation in the economy and the importance of business investments in research and development have a positive impact on its competitiveness. However, there are real barriers that limit business investment in research and development. These are, for example, factors preventing companies from investing in (Spielkamp and Rammer, 2009) and financial restrictions that prevent companies from investing in innovations (D' Este et al., 2012). Companies do not always have enough internal financial resources to launch their own innovation projects and therefore they turn to external resource providers (Wang et al., 2016). The practice also points to the absence of financial resources for the introduction of innovations as a barrier to support investment in innovations in enterprises (EK, 2014). A firm's access to financial resources varies depending on the size of the firm as well as its specialization (OECD, 2004). Foreign sources for financing innovative and research and development activities can be obtained from various economic entities. Companies most often obtain these resources from other companies (e.g. banks).

OECD (2015) lists five main innovation actors that can finance corporate R&D. These are business enterprises, government, universities, private non-profit organizations, and institutions from abroad. These entities help to finance private innovation projects and overcome obstacles to innovation. In addition to private investment (EIB, 2019), the most important source of financing for innovative businesses is the public sector through the government. No less important is the help of universities and private non-profit organizations, their support is mainly non-financial, mainly in the form of cooperation and joint research (Perkmann, Walsh, 2007; Abidin et al., 2014; Rybnicek, Königsgruber, 2018).

Falk (2006) brought significant results, which showed the compatibility of BERD and GERD based on the use of the GMM model. The study yielded the findings that R&D expenditures conducted by universities are significantly positively related to business sector R&D expenditures, suggesting that public sector R&D and private sector R&D are complementary. Direct R&D subsidies and the share of high-tech exports are significantly positively related to the R&D intensity of the business sector.

The main reason for the involvement of the public sector (and other innovation actors) in the financing of business research and development is the fact that otherwise, the market would invest in innovation activities less than is socially acceptable. Intellectual property rights and state-funded R&D subsidies should therefore stimulate innovation (Leibowicz, 2018). The effects of public support on private R&D investments can have a positive or negative impact (the so-called substitution effect) on private R&D investments. Despite the many advantages of public support for innovation, according to the economic literature, there are also limitations, which we call state failures (Guellec and Pottelsberghe, 2000).

From the perspective of several foreign studies, it can be argued that it is the variable "higher education" that represents a statistically significant variable in the BERD assessment (Aruzhan et al., 2016; Falk, 2006). Government R&D funding represents a less efficient source of funding than BERD, but the synergy of BERD and GERD has a positive impact in terms of patents in the country (Aruzhan et al., 2016).

Shelton and Leydesdorff (2011), through multivariate linear regression models, showed the synergy of GERD and BERD resulted in long-term and sustainable benefits in publications. Research focusing on the impact of scientific productivity on business efficiency has yielded findings that scientific productivity is positively associated with business efficiency (Van Looy, et al., 2011).

These failures are closely related to the issue of complementarity, where we can encounter several types of negative effects: displacement, substitution, leakage, and dead weight (McPherson, McDonald, 2010). Many authors deal with the substitution and displacement effect of subsidies. Guo, Guo, and Jiang (2016) argue that research on the effects of government R&D support programs is inconclusive. It has been proven that businesses that have been given government subsidies achieve higher productivity and profitability. It was also found that these enterprises grow faster, have better access to external financing, invest more funds in research and development and show a higher social return. On one hand, many studies found an additionality between public support and private R&D investment (Ali-Yrkkö, 2005; Sadraoui, Zina, 2009; Afcha, López, 2013; Liu, Li, Li, 2016; Carboni, 2017) According to their results R&D subsidies stimulate private R&D investments in enterprises.

On the other hand, many studies suggest that public R&D support programs do not stimulate business performance. Moreover, several studies have even found that government R&D subsidies crowd out private R&D (Hussinger, 2008, Görg. 2008, Zúñiga-Vicente et al., 2014). Firms awarded with public support could

reduce their own investment into R&D beyond the level that would have been performed without this support (Zúñiga-Vicente et al., 2014).

The occurrence of the substitution or effect of subsidies therefore varies depending on the region and industry in which the company operates (Capron, Van Pottelsberghe de la Potterie, 1997; Jin, Shang, Xu, 2018). Therefore, it is appropriate to examine the regional dimensions of their operation, for example in a specific EU member state.

3. Material and Methods

The contribution is aimed at examining the potential effect of corporate expenditures on R&D from the point of view of their funding sources and analysing the occurrence of the substitution effect of public support for R&D in EU 27 countries. The objective contains two research questions:

RQ1: Do private companies use enough of their own resources to finance corporate R&D in EU 27 and thus contribute to the structure of corporate spending on R&D?

RQ2: How does public support for corporate R&D increase corporate investment in R&D? Is there no substitution effect?

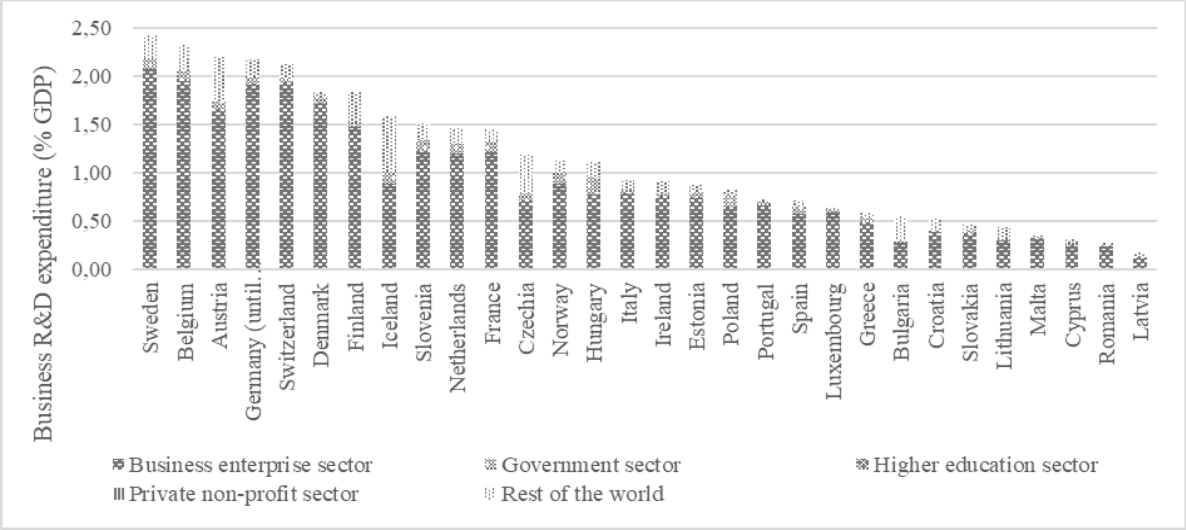
As part of the analysis, secondary data are used from the Eurostat, OECD databases within the "Innovation Indicators" section. The key indicator (GERD - Gross Domestic Expenditure on R&D) examined in the paper expenditure on research and development of the EU member states according to the source of funding. Eurostat distinguishes five possible financial sources that can be used to finance research and development: sources of business enterprises, governments, universities, private non-profit organizations and sources from abroad (e.g. FDI), development aid, remittance flows). As for aid from EU sources, up to 70% of the volume of interventions is significantly redistributed through the EU budget in the form of shared financing through government sources. The redistribution of the sources is further decided by the government of the member state (EC, 2021). Since business enterprises are generally identified as the key innovation actors involved in most R&D activities in the country, we focus on the financial resources used to finance business R&D (BERD - Business Enterprise R&D Expenditure). We used cluster analysis, panel regression and correlation analysis based on secondary data analysis.

From the point of view of the preferences of the importance of public support, in this research we focus on updating the structure of research and development financing in the long-term perspective of the created clusters, consisting of countries with a comparable structure of their financing, as well as on the possible extent of occurrence of the substitution effect, mainly between public support and corporate innovations (Pisár, et.al., 2020). From the available data we obtained, we performed a cluster analysis that illustrates clusters of countries with a comparable corporate R&D funding structure. A hierarchical agglomerative algorithm was also used in combination with Ward's method. The given method was used due to the fact that this procedure was applied to a sample of updated secondary data for the monitored twenty-year period (2000-2020), as it appeared to be the most suitable due to the contour coefficient achieved.

To determine the degree of substitution effect due to the negative impact of public support, we will perform a regression and correlation analysis on panel data, specifically on a sample of all 27 EU member states for the years 2000-2020. The regression is also based on a combination of least squares and cross-sectional fixed effects model. The logarithms of the data will be used in the regression analysis to achieve a normal distribution of the data. To test the causality of the selected variables of this analysis, we will use the granger causality hypothesis.

4. Results and Discussion

Public support from EU resources and increasing the growth of member states' expenditure on research and development is one of the main priorities of the EU 27. As part of the group of innovative actors, we will examine the scope of companies' expenditures on research and development, since a large part of these expenditures takes place in enterprises.

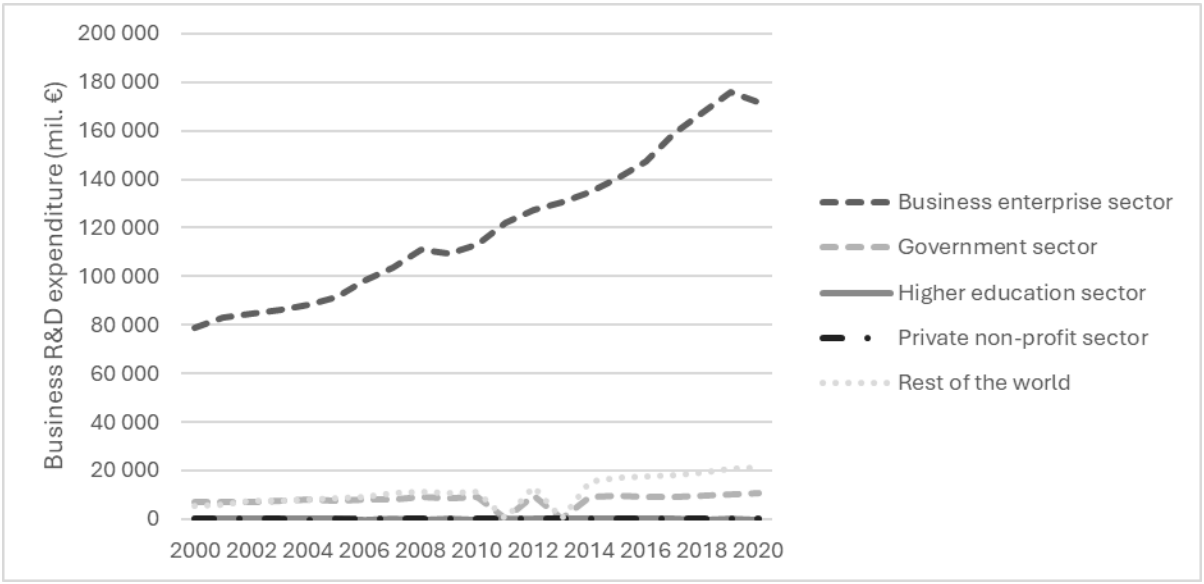


Source: Own research, Eurostat Database.

Figure 1: Business R&D funding in the EU member states in 2019 (% of GDP)

Other innovative actors thus participate in the financing of corporate research and development (Figure 1). The graph shows the difference in investments in research and development between EU countries. In countries such as Sweden, Germany or Belgium, companies spend more than 2% of national GDP on research and development, but elsewhere this value is lower than 0.5% (e.g. Cyprus, Latvia or Romania). In almost all surveyed countries, firms mostly use private financial resources, which means that they mostly use their own profit or resources from other private enterprises (e.g. commercial banks).

Abroad sources (especially FDI) constitute the second important source of financing for business innovations. However, the amount of funds from abroad is different in individual EU countries. Abroad resources used to finance business R&D appear to be mostly used in countries with open economies. There are different results on the level of public financing in the monitored countries. In countries such as Hungary, Slovenia, Sweden, public support using subsidy resources from the EU budget represents a significant part of their R&D expenditures. On the contrary, in other countries their use is small (e.g. Latvia, Lithuania or Romania).



Source: Own research, Eurostat Database.

Figure 2: Development of business R&D funding of innovation actors between 2000 - 2020 (as aggregate value of the EU, mil. EUR)

Graph 2 shows the financing of corporate R&D from the sources of other innovative actors, namely universities and private non-profit organizations. It is interesting that in all EU member countries the values are almost

negligible. It proves that the share of institutions in their financing is not that significant, which is also supported by the economic theory. We also examined the evolution of corporate R&D funding in the EU over a longer period, the contributions of different innovation instigators to corporate R&D expenditure as the aggregate value of all EU Member States are also examined. The results of the analysis, based on the development over time, confirmed that from 2020 the company's own resources are participating in the financing of R&D expenses for a long time. This is a level of 67% of the total corporate expenditure on R&D with a growing tendency over time.

In the monitored period, the share of foreign acquisitions in public financing represented 6-7% of the total R&D expenditures of companies in EU countries. The increase in the share of external resources (from the public sector or from abroad) in absolute numbers was caused by the drawing of subsidy resources from the EU budget and the growth of public expenditure on FDI. As a result of the growth of corporate resources, the share of external resources in corporate R&D records the same level. Using the available data for a twenty-year period (2000-2020), we performed a cluster analysis. We have grouped individual clusters with a comparable corporate R&D funding structure (Table 1).

Table 1: Structure of R&D funding of EU 27 countries in 2019 (statistical variables per country cluster)

Member country cluster	Business enterprises	Government	Abroad
Cluster 1 (FR, HU, NL, PL, SI)	1,01 (0,248)	0,122 (0,031)	0,136 (0,040)
Cluster 2 (BG, CR, CY, DK, EE, GR, IE, IT, LV, LT, LU, MT, PT, RO, SK, ES)	0,54 (0,377)	0,0275 (0,019)	0,075 (0,062)
Cluster 3 (AT, BE, CZ, FI, DE, SE)	1,633 (0,458)	0,08 (0,018)	0,312 (0,093)

Source: Own research, Eurostat Database.

Note: the table shows the specific values of the statistical variables. These are mean values and standard deviation values in parentheses (.)

The resulting Silhouette coefficient (value 0.59) confirmed the appropriateness of choosing a cluster algorithm by classifying EU member countries into three clusters. The results of processing the average values of the corporate R&D financing structure brought several conclusions. In the cluster of 3 EU member countries (namely Austria, Belgium, the Czech Republic, Finland, Germany and Sweden), the highest private support for corporate R&D, including the use of foreign resources, can be noted precisely as a result of FDI support. They are also dominant with the highest innovative performance. We assume that these resources (both corporate and foreign) are one of the success factors of these countries in the areas of innovation and R&D support. Through cluster analysis, we achieved results that were partially comparable to the European Innovation Scoreboard (2021), which confirms the fact that corporate financing of research and development is a factor in the country's innovation performance. The conclusions of the analysis showed that corporate R&D is financed mainly from private sources and funds from abroad, primarily from FDI and also shared financing from EU budget sources. These are countries with a medium level of innovation performance, included in cluster 1 (France, Hungary, the Netherlands, Poland and Slovenia).

Table 2: Correlation matrix of R&D expenditure funded by actors in EU members in 2000-2020

	Business enterprises sector	Government sector	Higher education sector
Business enterprise sector	1	0.9879	0.7146
Government sector	0.9879	1	0.7129
Higher education sector	0.7146	0.7129	1

Source: Own research, EViews based on data from Eurostat.

Based on the existence of a relationship between corporate and public financing of corporate R&D, we examine the possible impact of the substitution effect of public financing of R&D in EU countries. According to

the data in Table 2, correlation and regression analysis were performed between these relationships. We also examine the impact of higher education financing on corporate R&D, since the higher education sector also takes the form of public universities. We included possible time lags in the effect of government and university funding sectors on corporate R&D investment in the regression analysis. As part of the analysis, we do not take into account the potential effects of government support on corporate R&D, as companies do not yet use this form of support.

Table 3: Granger causality analysis of innovation actors in EU member states based on 2000-2020 2 time lags (model research results)

Null Hypothesis:	Observations	F-Statistic	Probability
GOV does not Granger Cause ENT	500	4.77426	0.0088
ENT does not Granger Cause GOV		4.19205	0.0157
UNI does not Granger Cause ENT	500	20.1425	4.E-09
ENT does not Granger Cause UNI		7.25737	0.0008

Source: Own research, EViews based on Eurostat data and published methodology by the authors Pisar, et. al. (2020).

The analysis further showed a positive correlation between the investigated variables (Table 3). The relationship between government and education funds shows a positive correlation, and there is also a very high positive correlation between corporate and government spending. Granger causality was further used to determine whether selected variables were suitable for regression analysis, as correlation does not necessarily imply causation. The conclusion of the Granger causality tests confirmed the rejection of the hypothesis that government funding and university funding does not cause Granger funding of businesses, as it is clear that this test runs both ways, i.e. from government funding and university funding (at the 1% significance level) to business funding in both cases.

Table 4: The impact of selected innovative actors on private investments in the EU in the years 2000-2020 with different time lags (results of regression analysis)

	T	T-1	T-2
Constant	-0.05314***	-0.05345***	-0.05345***
	(-6.5741)	(-6.6011)	(-6.5880)
Government expenditure	0.85528***	0.10111***	0.85544***
	(98.6578)	(98.6074)	(98.5045)
Higher education expenditure	0.06058**	0.06149**	0.06148**
	(-2.11825)	(2,14715)	(2.1448)
R^2	0.9761	0.9760	0.9760
R^2 adjusted	0.9760	0.97595	0.9759
Observations	502	501	500
Durbin Watson statistics	1.8067	1.8075	1.7874
Akaike info criterion	-1.9695	-1.9687	-1.9667

Source: Own research, EViews based on Eurostat data and published methodology by the authors Pisar, et. al. (2020).

*Note: T-statistics are shown in parentheses (.). Respective significance levels according to p-values are indicated as: */**/*** examined at 10%/5%/1% significance levels.*

Using the Akaike information criterion, we examined the model in detail without a time lag, with a time lag of one year, and with a time lag of two years (Table 4). We are based on the authors' published methodology (Pisár, et. al., 2020), which defined the use of the Akaike criteria in the evaluation of the influence of selected innovative actors on private investments in the EU over an earlier time period.

According to the results of this criterion, we selected a model without a time delay. A regression model examined the effect of public and university funding of corporate research on corporate investment in

corporate R&D without time lag. Based on the results of the model, changes in funding from public sources and universities explain 97.61% of changes in R&D funding of private enterprises. The regression line of the influence of public and university funding on business funding is as follows:

$$\hat{y} = -0.05314 + 0.85528gov + 0.06058uni \quad (1)$$

where gov represents the government funding coefficient and uni represents the university funding coefficient. The P-values of the T-statistics of university and government funding are statistically significant in the model. Therefore, we can interpret the impact of both public funding and university funding on corporate investment in research and development. We can conclude that in this case there is no substitution effect of public R&D support, which occurs when companies replace their investments in R&D with public support. It can therefore be said that in EU member countries, public support for R&D, especially through the use of shared financing from the EU budget, has a positive effect on private R&D investments.

Our research brings some new empirical evidence to the discussion on the relationship between public support and business R&D expenditures. Contrary to for example Görg (2008) and Zúñiga-Vicente et al., (2014) we found no evidence of the crowding-out effect. Our conclusions are consistent with the results of many authors investigating the occurrence of the substitution effect and the impact of public support on private investment in research and development, which confirm the positive effect of public support on private investment in research and development (David, Hall, Toole, 1999; Ali-Yrkkö , 2005, Choi, Lee, 2017) and are partially consistent with other studies (Aristei, Sterlacchini, Venturini, 2015). We therefore see public support for corporate research and development as an important part of financing innovation and research and development in the EU.

5. Policy Implications

The results obtained provide several conclusions and policy implications. We consider business spending on R&D to be one of the key elements of the country's innovation performance, which is also reflected in the EU's Europe 2020 strategy. It emphasizes the growth of spending on R&D as one of the strategy's main goals. Although the structure of corporate R&D expenditure financing is different in individual EU countries, public R&D support is an important part of corporate R&D funding, especially when it comes to shared funding from EU sources.

Since our results confirm the positive impact of public R&D support on private R&D investment in cluster 1 countries (namely France, Hungary, the Netherlands, Poland, and Slovenia), we propose to intensify their public R&D support. This will leverage the level of private R&D investment in these countries, with the potential to increase the innovation performance of the countries under study. One of the main contributions of our paper is an international comparison of the structure of corporate R&D funding, which provides interesting policy implications at the EU level. While many studies are concerned with investigating the effects of public support for R&D and innovation, they are not focused on the structure of corporate R&D funding, although our research is not unlimited. We did not consider in our analysis other factors that can influence private R&D investments, as we focused only on its financing. Based on the results of the analysis of the positive impact of public financing on GDP growth using regression models (Granger causality), it can be recommended to narrow the analysis of the substitution effect only to a certain group of EU countries. This would provide more concrete results that would lead to recommendations useful for public policy makers.

6. Conclusion

Published studies point to innovation as a key element in the growth and competitiveness of companies. Despite these positives, some companies do not engage in innovative activities precisely because of the lack of financial resources that are necessary to support innovative projects. Therefore, other actors also participate in the financing of entrepreneurial R&D activities.

The results showed that corporate research and development is mostly financed by private sources, followed by foreign funds and public sources. We have created three clusters of EU member countries with a similar structure of corporate funding of research and development. The results of this part of the cluster analysis were identical to the results of the European Innovation Scoreboard, which indicates the importance of the financing of corporate research and development as one of the factors of the country's innovation performance. We confirmed the assumption that the substitution effect of public support for research and development does not occur in EU member states, since public funding of corporate R&D seems to have a positive effect on private investment in R&D.

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