THE ROLE OF R&D SECTOR ON FOSTERING ECONOMIC GROWTH. INSIGHTS FROM ROMANIA

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ABSTRACT
The start-up sector in Romania, particularly in the North-West Development Region (NW), is experiencing rapid growth and driving innovation and economic development. Understanding this sector and its connection to Research and Development (R&D) is vital for regional progress. The NW Region has become a prominent hub for start-up activity in Romania. Examining the start-up sector in these regions is essential as it contributes significantly to economic growth. Start-ups introduce disruptive technologies, create new market opportunities, and promote regional diversification. The impact of the R&D sector on economic growth cannot be underestimated. R&D activities drive innovation, laying the groundwork for the emergence and success of start-ups. Investing in R&D fosters knowledge creation, technological advancements, and intellectual property, which are crucial for entrepreneurial ventures. By understanding the interplay between start-ups and the R&D sector, stakeholders can develop targeted strategies for fostering innovation-driven economic growth. This article aims to provide valuable insights into the start-up sector in Romania's NW Region, its relationship with R&D, and the connection between total expenditure on R&D and economic growth in both Romania and the NW Region.

KEYWORDS: *economic growth, start-ups, R&D, Romania, NW Region.*

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1. INTRODUCTION

Creative and innovative sectors are at the forefront of societal change and are one of the main drivers of development, be it economic, social, environmental, or managerial, favoring both human and organizational well-being. In Romania, the number of individuals involved in research activities per population is four times lower than the average at EU level; what is more, throughout the year 2014, it has reached a level of almost 3% economic growth (as opposed to 2013 values), but even so, Romania has only managed to allocate 0.25% from the Gross Domestic Product (GDP) toward Research, Development and Innovation (RDI) activities and only 3 % (instead of the 6% European average) for education, this information being shown in numerous country reports concerning Romania, and well documented in the 2014 OECD Research and Innovation Observatory (RIO) Report for Romania (2015). Based on information from the European Commission (EC) website, "R&D funded by GOV (% of GDP)" at 2017 levels were 0.18% of GDP, whereas in the OECD report, this level for 2017 research expenditure has increased to 0.48% of GDP (European Commission, 2018). In accordance with the 2019 European Innovation Scoreboard (EIS), Romania is last at EU level in terms of innovation performance, whereas Sweden, Finland, and Denmark are the top 3 innovation leaders; whereas Denmark has a country score of 141 (out of 160 maximum points) in

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2018 (the value for 2018 being the same as the value for 2017), Finland has a country score of 146 in 2018 (its country score increasing by 11 points since 2017) and Sweden, having a country score of 148 in 2018 (here again, we notice no difference since 2017 values, the country score for Sweden remaining unchanged) (Hollanders & European Commission, 2019). At world level, the Artificial Intelligence (AI) start-up sector proves just how important and revolutionary it can be: private equity investments aimed at AI start-ups have had a total value of 16 billion dollars in 2016, and in 2018, at world level, AI start-ups have managed to be at the center of private equity investments, attracting over 12% of total world equity investments in start-ups (OECD, 2019).
In 2016, at national level, Romania has had only 2925 companies which are to be considered as innovative; this figure (2925) represents a decrease by half as compared to 2012 figures. Out of the total of 2925 companies deemed as being innovative, the NW Region has 592 companies (20% of the total): Most of these innovative companies are located in the Bucharest - Ilfov Region (714, a strong decrease from 1186 in 2012). Out of a sample of 4482 companies in the NW Region, only 13.2% were considered innovative in 2016. In the last 10 years, in the NW Region, the share of enterprises that have implemented product innovations has increased from 6% in 2006, to 36% in 2012, to 46% in 2016. When referring to the NW Region, more than 50% of all business sectors find themselves concentrated in Cluj and Bihor counties (NW Regional Development Agency, 2020).
Throughout this paper, as a main objective, we have sought out to investigate the relationship between economic growth (GDP) and the total expenditure on R&D (EXP), in Romania, in the NW Region. By analyzing these factors, we aim to shed light on the potential impact of R&D investment on regional economic development. The findings will contribute to a better understanding of the role of R&D expenditure in fostering economic growth and inform policymakers and stakeholders on potential strategies to promote regional development. Analyzing R&D efforts in Romania is of significant importance due to its potential impact on GDP growth. R&D plays a crucial role in driving innovation, technological advancement, and economic growth. By examining R&D efforts in Romania, policymakers, researchers, and stakeholders can gain insights into the country's innovation capacity and identify opportunities to enhance its economic performance. Moreover, analyzing R&D efforts in Romania helps identify potential gaps and challenges that hinder innovation and economic development. It can shed light on factors such as funding availability, infrastructure, human capital, and collaboration between academia, industry, and government. Understanding these factors can guide policymakers in formulating targeted strategies and policies to foster R&D activities and promote sustainable economic growth.
The present paper is structured in 5 parts. Following this first introductory part, the Literature review will highlight the most important findings that impact the present realities of the R&D sector and its impact upon economic growth followed by chapter on main aspects pertaining to current R&D efforts that exist within Romania. In the next chapter, we will investigate the relationship between economic growth and the total expenditure on R&D in Romania, and then in the NW Region. The paper ends with the conclusion section, highlighting the main findings of the paper.

2. LITERATURE REVIEW

In terms of importance for regional development, both start-ups and enterprises in R&D sectors are attributed with increasing both economic performances and market and regional dynamics or flexibility, by making markets (and thus sectors, regions) more adaptable to certain disturbances. What is more, the effects of entrepreneurial activity and start-up formation is associated to the formation of new capital/wealth and distribution of it, increased income opportunities for the respective regions, employment facilities and capabilities, increased standards of living and a superior economic independence, along with increased innovative outputs linked to economic performance, and, among other important effects of entrepreneurship and start-up creation for regional development, they contribute to levelling or balancing of development across regions (Dhaliwal,

2016). In respect to aspects related to innovation, it is common to think about entrepreneurs as entities that manage to "move" innovation from one place, person or company to other entities, be them, individuals, companies, or regions (Ranjan, 2019).
According to Romer (1990) research, development and innovation are essential factors of long-term productivity growth, basic elements that explain the performance of the world's developed economies (Guloglu & Tekin, 2012).
As research shows, in terms of diffusing innovation so as to increase regional development, successful enterprises need to be proficient in the following fields: entrepreneurial outlook (general innovativeness of the start-up), orientation towards market results, networking capabilities, focus on innovation driven from a technological perspective, and take charge of government policies and opportunities (Buli, 2017). Ultimately, authors such as Lee and Kim (2019), have shown in their study that factors such as innovativeness, proactiveness, and risk taking of entrepreneurs had a positive effect on the performance of the start-ups as well as business sustainability.
In terms of innovation and the effects that it has on regional development, it is by attracting talent (when using the term talent, we refer to individuals that possess skills and competences and by the use of the term "attracting" we refer to finding ways of grouping individuals together in a certain location so as to facilitate communication and the creative working process by which products, goods, services, and technologies are created) and creating working groups in various locations that enable the "trickle down" of the benefits arising from the start-ups. Innovation and innovation output not only influence the survival of a start-up, but innovation will act as a magnet for the regions in which start-ups operate; constant increase of innovation level of regions will attract new individuals to relocate to such regions. Berlin, San Francisco (more specifically Silicon Valley), London, are all example that this situation is a norm, and that this is affecting everyday life. Innovation has a dual effect: on one hand, innovation increases survival boosting and increasing characteristics and virtues (such as market power, decreasing cost levels), but in the same time, given associated risk and uncertainties, innovation also acts as a burden for start-ups (increased market pressure, and/or pressure arising from venture capitalists that have funded start-ups and which would like to see a faster return on their investment) (Hyytinen et al., 2015), but even with this dual role, present day clusters, hubs, and cities prove that innovation, even though it is riskier in its nature, attracts and pools funding, talent, streams of ideas and resources into specific geographical locations in which start-ups operate. In terms of start-ups' survival though, the previous research by Hyytinen et al. (2015) suggest that non-innovative start-ups have a higher survival rate with 6-7% than innovative start-ups.
Investments in research and development generate intangible capital and technological accumulations, enhancing the competitive advantage of countries and contributing to economic growth and diversification (Coccia, 2011; Dechezleprêtre et al., 2019), in a virtuous circle of innovation, growth, and investment (Herte, et al., 2021; Rodríguez, 2010). Researchers have found that R&D investments have a positive impact on the growth, consolidation, and performance of firms (Acs & Audretsch, 1987; Audretsch & Lehmann, 2005; Thornhill, 2006), but also that the factors underlying innovation success are highly unevenly distributed in space (Rodríguez, 2001). R&D stimulates productivity, helps firms improve the quality of products and services, reduce production costs, and diversify and enhance the range of final products or intermediate inputs (Celli, et al., 2021; Simut, et al., 2021; Badulescu & Badulescu, 2014). The ease of access to financing, innovation sources, or scientific and technological infrastructures, as well as the quality and quantity of human capital, are often mentioned as essential factors in stimulating entrepreneurial initiatives (Feldman & Audretsch, 1999; Andersson & Noseleit, 2011), with a direct influence on regional development (Dejardin & Fritsch, 2011; Howells, 2005), clusters, and growth poles (Saxenien, 1994; Audretsch et al., 2005).
The intensity and strength of educational systems pose an important impact upon start-up creation, research and development, regional distribution of start-ups and regional development levels, as previously shown by Motoyama et al. (2014). One would argue that given this important implication

of education in the overall stability of regions and for the upward trend of the economic cycle, focus, from a policy perspective, should be a highly desirable and sought-after trend, and thus policies should be focused on advancing educational levels, so as to have higher country wise advancements in the fields of research, development and innovation. While the research, development and innovation system is centralized and mostly concentrated at national institutes, in terms of private sector RDI activities, these private attempts are almost absent; what is even more striking concerning the country situation of Romania is the fact that even though it has a relatively large numbers of PhD's, given low funding, and lack of promotion and opportunities granted to the private sectors for research activities, the innovative and research output of Romania as a country tends to be hindered and negatively affected.

Regarding the relationship between R&D/innovation focused SME's and several key indicators, evidence suggests that, for a variety of countries, we find a confident relationship between the activities and presence of start-ups and unemployment rates. As shown by a variety of authors, the presence of start-ups in a given region is influenced by a multitude of factors; it is precisely this presence of start-ups which is shaped, motivated and influenced by: GDP, unemployment, and evolution of interest rates (Fritsch et al., 2013). On the other hand, numerous researchers point out that private resources allocated to research and development tend to fall below the socially optimal level for various reasons. As a result, public policies are necessary to stimulate firm-level innovation, reduce costs associated with R&D (Bronzini & Piselli, 2016; European Commission, 2021). The most prominent example is the Cohesion Policy promoted at the European Union level, which comprises a set of extensive regional mechanisms and policies supporting public and private investments in research and development to enhance regional competitiveness, particularly in lagging regions, reduce territorial disparities, and stimulate economic growth.

Celli et al. (2021) examine the impact of such expenditures on regional convergence and the role of high R&D investment in fostering economic growth in the European Union's least developed regions. Surprisingly, their findings indicate that while these allocations have a positive and significant effect on regional economic growth, this effect is not determined by the proportion of R&D spending. In other words, among the lagging regions, those that invest more in research and development do not experience a higher growth rate compared to other regions. The authors suggest that other factors contribute to these results, including the practical implementation of R&D outcomes, education, the presence of innovative firms and human capital, and the connection to the innovative value chain. Supporting this, Koo and Kim (2009) also affirm that factors such as entrepreneurship, academic research, and the quality of human and social capital significantly influence the allocation mechanisms of research and development outcomes at the regional level. However, they emphasize the importance of carefully investigating the impact of other regional characteristics to ensure the success of regional development policies.

3. THE ROLE OF R&D IN THE ECONOMIC DEVELOPMENT OF REGIONS

The dual role that decision makers (both private and public) play upon the R&D sector makes it even more so interesting, and even more so dynamic in its nature. Whereas public authorities have so far deployed a reactive approach in terms of the development of this sector (as opposed to a proactive, market maker type of approach used by the start-up business sector), a shift as regards this approach by local and national administration needs to occur diligently and at faster rates (Ernst and Young, 2017). According to 2020 data taken from the OECD STIP data base, there are currently 42 policy initiatives at Romanian national level aimed at fostering sciences, innovation and technological development, structured in the following manner: 14 governance policies, 10 policy initiatives in reference to the public research system, 11 initiatives as regards entrepreneurial innovation, 6 initiatives as regards science industry knowledge sharing and transfer, 4 policy initiatives as regards human resources for research and innovation, 4 policy initiatives aimed at research and innovation

for societal purposes, and 1 policy initiative as regards emerging trends in Science, technology and innovation (STI) policy (OECD STIP Compass, 2020).
In terms of EU-28 average for 2017 levels, all SMEs are attributable/have contributed with a 29% increase in GDP values, whereas micro and small SMEs account for an increase of 10.1%, respectively 8.4% increase of GDP (European Commission, 2018). In the case of Romania, micro and small SME's have contributed with 7.2% and 4.9% respectively, while all SMEs at 2017 Romanian level are accountable for 16.1% increase in GDP.
For 2017 levels, we notice that from an economic standpoint, Romania has performed quite well, the GDP growth increasing by 6.9%, and as RDI activities go, research expenditure has increased to 0.48% of GDP, a slight decrease as opposed to 2015, when research expenditure was 0.49% of GDP; even though business sector expenditure of/for research has noticed a slight upward trend, the 0.27% of GDP Romanian business sector expenditure for 2016 still remains lower than the EU average, this being 1.30% of GDP (Chioncel & del Rio, 2018).
The information from the European Innovation Scoreboard and the Regional Innovation Scoreboard shows that Romania finds itself on the 54th position out of 130 economies from around the world, having an index score of 45.51 points in terms of country innovativeness levels (Cornell University, INSEAD, and WIPO, 2019). The same report points out to the fact that in terms of Business Sophistication, Romania ranks 51st, having a score of 33.6 points, this indicator consisting of the following dimensions: knowledge workers (Romania has a 2019 score of 40.4 points), innovation linkages (Romania has a score of 19.2) and knowledge absorption (Romania has a score of 41.1 points). Of important mention is the "knowledge creation" dimension, for which Romania has only scored 10.5 (lowest score out of any dimensions for this country) under the "Knowledge and technology outputs" indicator. This low value is further evidence for the low innovation output of Romania as a country, and points to the generally low development of innovation creating and advancing sectors, such as the start-up sector. Following the chain of policy opportunities, one must argue the fact that the creation of "Regional Excellence Centers for Creative Industries" would entail numerous benefits, both for businesses and regions alike (Directorate-General for Education, Youth, Sport and Culture, European Commission, 2018). Even more so, collaboration between various regional/national, and supra-national Excellence Centers will lead to improved speed at which innovation can/will occur, better dissemination of information, and improved pooling of resources; cross-sectors or multi-sector innovation can also be achieved, together with numerous co-creation or co-innovation instances occurring throughout regions, benefiting a wider mass of individuals, businesses, regions and sectors. We must also bear in mind the fact that apart from the influence that regional legislators play upon new business creation, issues pertaining to the creation, dissemination, preserving and training resulted from such partnerships is a task deemed necessary in order for the creation process to take place constantly, and what is more, such steps needs to be taken by all involved members of the creation process, be them legislators, local governments, representatives of the business sector, or founders.
Time series made available through the effort of the National Institute of Statistics regarding to the total expenditure on research and development, by macro-regions, development regions and counties – current prices – are a good starting point for assessing the strength of regions and the propensity for start-up development. The table 1 presents the evolution of this type of spending, starting with the year 1995, for Romania.
It is worth mentioning that the NW Region has ranked 3rd nationally in 2018 as regards GDP based strength and weight as regards total GDP levels; the NW Region, having a level of 111.55 million RON, meaning 11.8% of total GDP (European Commission, 2021), (Diaconu, 2019). In the 2012-2017 time-period, the GDP of the NW Region has increased by 67.41 percentage points, with an average annual growth of 8.22%. Furthermore, in real terms, between the years 2012 and 2017, the GDP of this region has recorded an average annual growth of 7.95%, the highest such growth being

manifested during 2017, when an increase of 10.21% occurred. Having 14.3% of the country's territory and 13.11% of the country's total population, the North-West area has contributed with 12.23% to the formation of the national GDP in 2017, thus winning the 2nd place at Romanian national level, with a value of 104,848 million RON, this representing an increase of 36.8% when comparing the data to 2014 levels (NW Regional Development Agency, 2020).

Table 1. GDP evolution (million RON- current prices) during 1995-2022 in Romania

Year	Value		Year	Value
1995	7610.6		2009	530894.4
1996	11387.7		2010	540336.3
1997	25500.1		2011	587203.3
1998	37007.7		2012	621268.7
1999	55126.4		2013	631602.9
2000	80873.1		2014	668876.4
2001	117391.4		2015	712543.6
2002	152271.5		2016	752116.4
2003	191917.6		2017	851619.7
2004	244688.3		2018	959058.6
2005	286861.9		2019	1063794.6
2006	342762.6		2020	1066780.5
2007	425691.1		2021	1068800.5
2008	539834.6		2022	1070821.5

Source: Adapted by the author based on Romanian National Institute of Statistics (2021)

4. STATISTICAL ANALYSIS, RESULTS AND DISCUSSION

In order to investigate the relationship between economic growth (GDP, expressed in current prices - million RON) and the total expenditure on R&D (EXP, expressed in current prices - million RON), in Romania and in the North-West Region, this analysis employs the Johansen cointegration test, the VECM model and Granger causality. We have used data provided by the Romanian National Institute of Statistics (2021). Given the limited availability and accessibility of data, this study refers to the 1995–2019 period. Table 2 presents the descriptive statistics for the dataset in Romania.

Table 2. The descriptive statistics of the variables - GDP, total expenditure on R&D (EXP) during the 1995-2019 time period

Variables	Min	Max	Mean	Median	Std. Dev.	Skewness	Kurtosis
Romania							
GDP	7648.9	957554	411069.7	425691.1	310750.5	0.218027	-1.20984
EXP	577148	9528718	3278001	2786830	2086427	1.444748	2.458032
NW Region							
GDP	911.1	162865.8	49891.85	51229	41306.6	0.850533	0.707835
EXP	23113	386870	204135.4	204056	100169.5	0.007063	-0.85062

Source: own contribution based on data provided by Romanian National Institute of Statistics (2021)

So as to easily interpret the parameters and to avoid problems regarding the heteroscedasticity, we have transformed the variables with the help of the natural logarithms. Thus, we will note the variables

as follows: LGDP – natural logarithm of GDP, LEXP - natural logarithm of the total expenditure on R&D and economic growth.

In the econometric analysis of the time series, we have started from the hypothesis according to which the observed series are stationary. According to literature, most time series do not satisfy this condition of stationarity due to the many changes that occur in/throughout economic environment. Thus, the testing of stationarity conditions become very important in the analysis of these time series. In order to test the relationship and the causality between the three selected variables in the cases of Romania, the NW Region, the first step has been to examine the stationarity of all of the variables. Following this, we then tested the cointegration to determine a long-term equilibrium relationship between the selected variables. The third step has involved the testing the testing of causality in order to identify the direction of the relationship between these variables.

Starting from these two variables, i.e. GDP, EXP we have stated and tested the following three hypotheses in the case of Romania and the NW Region:

H1a: There is a long-run equilibrium that characterizes the relationship between economic growth (GDP) and total expenditure on R&D (EXP).

H2a: There is a unidirectional relationship between economic growth (GDP) and total expenditure on R&D (EXP).

H3a: There is a bidirectional relationship between economic growth (GDP) and total expenditure on R&D (EXP).

In order to test the stationarity of these variables by applying the ADF test (Augmented Dickey Fuller), **the following equation will provide the starting point** (Mester, 2021):

$$\Delta Y_t = \delta Y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta Y_{t-j} + \alpha + \beta t + u_t$$

where:

ΔY_{t-1} is the variable that refers to the first difference with k lags;
u_t is the variable that adjusts the autocorrelation error;
δ, γ, α and β are the initially estimated coefficients.

It is said that a series is not stationary if the value of the coefficient δ is equal to 1 (when the series has a unit root). Thus, the hypotheses are:

H0: $\delta = 1$, there is a unit root
H1: $\delta < 1$, the time series is stationary.

The value for the test statistics is:

$$ADF_{calc} = \frac{\hat{\gamma} - 1}{\sigma_{\hat{\gamma}}} \quad (1)$$

So as to determine which hypothesis is being tested, we can compare the calculated ADF statistic with a tabulated critical value. In case that the calculated ADF statistic is more negative than the tabulated critical value, we reject the null hypothesis of a unit root. Also, we can take into consideration the p-value. If the p-value is less than 0.05, we can state that the null hypothesis is rejected, and as such, the time series is stationary.

The unit root test results (ADF test) indicate that the null hypothesis is rejected at the 5% significance level after the first difference for almost all the variables, whereas for the LGDP variable in Romania's case, the null hypothesis is rejected only at the 10% significance level after the first difference. Therefore, it can be concluded that all variables have a unit root. Because the time series are stationary at the first difference, we can conclude that these are integrated of order one, I(1). If the data series are non-stationary at that level, they can be cointegrated, i.e. there is at least one linear combination between them that is stationary. Given that in our case all the variables have the same order of integration I(1) for 10% significance level, the condition to be cointegrated is respected.

Table 3. Unit root test results (ADF test) of the variables – GDP, total expenditure on R&D

H_0: the series has a unit root **H_1: the series is stationary**		**Natural logarithm**	
		LGDP (p-value)	**LEXP (p-value)**
Romania	ADF (level)	-0.749787 (0.8692)	-2.741102 (0.2304)
	ADF (1st diff)	-1.705948 (0.0829)	-4.77894 (0.0046)
	The order of integration	**I(1)**	**I(1)**
North-West Region	ADF (level)	-1.225689 (0.9387)	-2.7756 (0.2191)
	ADF (1st diff)	-3.194084 (0.0028)	-4.725654 (0.0052)
	The order of integration	**I(1)**	**I(1)**

Note: p-values are in () and the optimal lag length is determined based on Akaike, Schwarz and Hannan-Quinn info Criterion.
Source: own contribution using Eviews 9

In order to examine the existence of a cointegration between the selected variables, we will use the procedure proposed by Johansen and Juselius (1990) according to which the null hypothesis of non-cointegration will be tested. Starting from this procedure, we will use the following two tests: the Maximum Eigenvalue test and the LR (likelihood ratio) tests, namely the Trace test (LRtr) (Johansen & Juselius, 1990; Andrei & Bourbonnais, 2017). In the case of test Maximum Eigenvalue test, we have the following hypotheses:

H0: r cointegration relationship, against the alternative
H1: r+1 cointegration relationship, for r = 0, 1, ..., n–1.

The statistic is:

$$LR_{max}\left(r/n+1\right) = -T \cdot \log(1-\hat{\lambda}) \quad (2)$$

Where λ represents the Maximum Eigenvalue and T represent the sample volume.
In the case of the Trace test, we have the following hypotheses:
H0: r cointegrating relations, against the alternative
H1: n cointegrating relations, where n represents the number of variables.

The Trace statistic is:

$$\text{Trace} = -T\sum_{i=r+1}^{k}\log(1-\hat{\lambda}_{r+1}) \quad (3)$$

The results show that the null hypothesis of the no cointegration relationship between the variables is rejected and we accept the alternative one that suggests the presence of at least 1 cointegration equation between the LGDP and LEXP in the Romanian economy at a 5% significance level. Also, the null hypothesis of the no cointegration relationship between the variables is rejected and we accept the alternative one that suggests the presence of at least 1 cointegration equation between the LGDP and LEXP in the NW Region at 5% significance level.

In order to identify a possible long-run equilibrium between the LGDP and LEXP variables, we will apply the Johansen cointegration test. According to the results obtained from the Johansen-Juselius cointegration tests, we can decide the appropriateness levels by applying the vector error correction model (VECM). After normalizing the cointegrating vector in order to estimate the error correction model (ECM) of the dynamic structure, we have (Andrei et al., 2017):

$$y_t = \alpha_1 + \beta_1 x_t + \varepsilon_t \quad (4)$$

where:
yt – is the dependent variable,
xt – is the independent variable,
α1, β1 – the coefficients,
εt – the random variable.
The error correction term can be derived from the previous equation:

$$EC_t = y_t - \alpha_1 - \beta_1 x_t \quad (5)$$

Thus, the equation becomes:

$$\Delta y_t = a_0 + \delta EC_{t-1} + \sum a_{1j} \Delta y_{t-j} + \sum a_{2j} \Delta x_{t-j} + u_t \quad (6)$$

A negative and significant coefficient of the EC shows that any short-run relationship between the dependent variable and independent variable will provide a stable long-run relationship between the variables (Greene, 2021).
Considering the results obtained after testing the cointegration between the variables, we can state that long-run relationships exists between them. Therefore, in order to test the relationship between these variables, we can apply a vector error correction model (VECM). The long-run relationship between economic growth (GDP) and total expenditure on R&D (EXP) for one cointegrating vector in the case of Romania is presented in the table 4.

Table 4. VECM and Granger causality tests in the case of Romania

Causality direction	Error correction term (ECT) [t-statistics]	Short-run Coefficient [t-statistics]	Lag coefficient [t-statistics]	R-squared	F-statistic
LEXP → LGDP	-0.033254* (0.02409) [-1.38040]	-0.808825 (1.14492) [-0.70645]	-0.047059 (0.23446) [-0.20071]	0.103464	0.70897
LGDP → LEXP	-0.167179*** (0.02163) [-7.72974]	0.026066 (0.03171) [0.82210]	-0.279369** (0.15483) [-1.80437]	0.8788	45.92457*** *

Note: *,**,*** denotes significance at 10%, 5% and 1% significance level
Source: author's estimates using Eviews 9

According to the results presented in the Table 4, we can state that the causal effect of the LGDP on the LEXP variable is significant in the long-run, the estimated adjusted coefficients being statistically significant and relevant, as the value of t-statistics is greater than 1.708 for 5% significance level. More than that, the negative sign of these coefficient indicate that a long-run equilibrium characterizes the relationship between the LGDP and LEXP variable. Regarding the long-run causal effect of the LEXP variable on the LGDP, we can also observe negative values by which we can presuppose that a long-run equilibrium characterizes the relationship between these variables. In the case of the causal effect of the LEXP on the LGDP, the causality is significant in the long-run only for 10% significance level, as the value of t-statistics is greater than 1.3160. The short-run coefficients indicate convergence from LGDP to the LEXP but only at the sample level. Therefore, at the sample level,

we can state that if the GDP at Romania's level increases by 1 unit, the total expenditure on R&D at Romanian level will increase by 0.026 units. As such, the results confirm hypotheses H1a. Regarding R-squared, we notice that the highest intensity of the correlation is found in the case of models that have as independent variable the GDP. Thus, we can say that at the sample level, GDP influences to a large extent the total expenditure on R&D. We cannot say the same thing if GDP would be the dependent variable. What is more, according to the results, we can say that GDP influences this variable (EXP) to a much greater extent than the influence of this variable upon GDP.
The results indicate the existence of a long-run bidirectional Granger causality between Romania's total expenditure on R&D and economic growth. Therefore, Romania's economic growth is the cause of Granger's development of the Romanian R&D sector (national economic growth can promote the long-run development of the total expenditure on R&D). We can also affirm that on the long-run, Romania's total expenditure on R&D is the cause of Granger's development of Romania's economic growth. The results confirm hypotheses H1a and H3a.
The long-run relationship between economic growth (LGDP) and total expenditure on R&D (LEXP) for one cointegrating vector, in the case of the NW Region, is presented in table 5.

Table 5. VECM and Granger causality tests - NW Region

Causality direction	Error correction term (ECT) [t-statistics]	Short-run Coefficient [t-statistics]	Lag coefficient [t-statistics]	R-squared	F-statistic (p-value)
LEXP → LGDP	-0.379520*** (0.15310) [-2.47882]	0.977296* (0.68317) [1.43052]	0.114409 (0.19077) [0.59973]	0.258425	2.207051
LGDP → LEXP	-0.154448*** (0.03123) [-4.94476]	0.075447* (0.04519) [1.66960]	0.010461 (0.16797) [0.06228]	0.784537	23.06074** *

Note: *, **, *** denotes significance at 10%, 5% and 1% significance level
Source: authors' estimates using Eviews 9

Starting from the results presented in Table 5, we can argue that the causal effect of the LGDP on the LEXP variable in the case of the NW Region is significant in the long-run, the estimated adjusted coefficient being statistically significant and relevant as the value of t-statistics is greater than 1.708 for 5% significance level and 2.060 for 1% significance level. Also, the negative sign of these coefficients indicate that a long-run equilibrium characterizes the relationship between the LGDP and LEXP variable. Regarding the long-run causal effect of the LEXP variable on the LGDP, we can also observe negative values which presuppose that a long-run equilibrium characterizes the relationship between these variables. In the case of the causal effect of the LEXP on the LGDP, the causality is significant in the long-run for 5% and 1% significance levels. The results confirm the hypotheses H1a. The short-run coefficients indicate convergence from LGDP to the LEXP, respectively from LEXP to LGDP. Therefore, we can state that if the GDP at Romania's NW Region's level increases by 1 unit, the total expenditure on R&D at the Romania's NW Region's level will increase by 0.07 units. Also, according to the results, we can affirm that if the total expenditure on R&D at the Romania's NW Region's level will increase by 1 unit, GDP will increase by 0.97 units. As such, the results confirm hypotheses H2a. Regarding R-squared, we noticed that the highest intensity of the correlation is found in the case of the models that have as independent variable the GDP (R-squared = 0.78 in the case of LEXP. Therefore, we can argue that at the sample level, in the case of the NW Region, GDP influences to a large extent the total expenditure on R&D. We cannot say the same thing if GDP were the dependent variable. According to the results, we can argue that GDP influences these two variables to a much greater extent than these two influence GDP.
The results of the cointegration test show the existence of a long-run, stable equilibrium between Romania's NW Region's total expenditure on R&D and economic growth.

The results indicate the existence of a long-run unidirectional Granger causality between total expenditure on R&D and economic growth in the NW Region. Thus, the regional economic growth of the NW Region is the cause of Granger's development of Romania's NW Region's total expenditure on R&D, i.e. the regional economic growth can promote the long-run development of the total expenditure on R&D. Also, we find evidence of a long-run bidirectional Granger causality between Romania's NW Region's total expenditure on R&D and economic growth. In the short-run, we have identified a bidirectional causal relationship between Romania's NW Region's total expenditure on R&D and economic growth. The results confirm hypotheses H1a and H3a.

5. CONCLUSION

As we have seen from the previous research, several hypotheses have indeed been confirmed. As has been seen, GDP exerts a greater influence on the total expenditure on research and development and individuals employed in the research and development sector than these two variables do on GDP, in the case of Romania, and, in particular, in the NW Region of this county. As such, we can surmise that regions with higher or better performing GDP levels can attract more start-ups to operate in such areas that other regions, where GDP levels are low. At the same time, we must not forget the influence that these two variables (the total expenditure on research and development and individuals employed in the research and development sector) pose for regional development. Already developed regions will go ahead and attract more resources (be them material or human resources) than other less development regions. What must also be understood is the fact that such relationships as described throughout this chapter are long term relationships, and as such, this should act as a guideline for legislators and the business sector alike, given that decisions that are aimed at GDP development, total expenditure on research and development and individuals employed in the research and development sector (and which will ultimately influence start-up performance in such regions) to bear in mind the long lasting effects of present day decisions. If the GDP at Romania's level increases by 1 unit, the total expenditure on R&D at Romanian level will increase by 0.026 units. If the GDP at Romania's NW Region's level increases by 1 unit, the total expenditure on R&D at the Romania's NW Region's level will increase by 0.07 units.

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