CONSIDERATIONS REGARDING THE EVOLUTION OF GROSS DOMESTIC EXPENDITURE ON R&D (GERD) IN ROMANIA AND EU COUNTRIES.
PART I- TIME SERIES INDICATORS

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The Gross domestic expenditure on R&D (GERD) is one of the most important indicators of the Research and Development area, part of Science and Technology and Digital Society branch on the data navigation tree of the EUROSTAT Database. In this paper we analyzed the evolution of GERD in Romania and EU countries on the last ten years with the available data (2013-2022).

Key words: *GERD, time series, indicators, sectors of performance*

1. INTRODUCTION

Gross domestic expenditure on R&D (GERD) at national and regional level provides users with data about R&D expenditure and R&D personnel broken down by the following institutional sectors: business enterprise (BES); government (GOV); higher education (HES); private non-profit (PNP), total of all sectors.

2. METHOD

For the analysis of the data we used the relative and average indicators of time series for the years 2013 to 2022. First we calculated the dynamic indices with fixed base

$$i_{t/1\%} = \frac{y_t}{y_1} \cdot 100 \quad (1)$$

and the dynamic indices with

$$i_{t/t-1\%} = \frac{y_t}{y_{t-1}} \cdot 100$$

chain base $\quad . (2)$
Second we calculated the changing rates of dynamic rhythms with fixed base

$$r_{t/1\%} = (i_{t/1} - 1) \cdot 100 \quad (3)$$ and the
changing rates of dynamic rhythms with chain base.

$$r_{t/t-1\%} = (i_{t/t-1} - 1) \cdot 100 \quad . (4)$$

Third, we calculated the mean

$$\bar{y} = \frac{\sum_{t=1}^{n} y_t}{n} \quad (5),$$ the average of absolute change

$$\overline{\Delta} = \frac{\sum_{t=2}^{n} \Delta_{t/t-1}}{n-1} = \frac{\Delta_{n/1}}{n-1}$$

(6), the average of dynamic indices

$$\bar{i} = \sqrt[n-1]{\prod_{t=2}^{n} i_{t/t-1}} = \sqrt[n-1]{i_{n/1}}$$

(7) and the average rhythm of changing

$$\bar{r}_{\%} = \bar{i}_{\%} - 100$$

(8).

3. RESULTS AND DISCUSSION

3.1. All sectors of performance

Regarding GERD by sector of performance in all sectors in Romania we obtained for the average indicators of time series the results in Table 1.

Table 1 Average indicators of time series for all sectors in Romania

the mean	924.173
the average absolute change	82.894
the average of dynamic indices	1.099
the average rhythm of changing	9.894

In Romania the annual mean of GERD in all sectors is 924.173 million euro per year. From one year to another we have on average an increase of 82.894 million euro. This increase represents 9.894% or an increase by a factor of 1.099.

We made also a graphical comparison between the data from Romania and the composite average at the level of EU-27, as we can see in Figure 1.
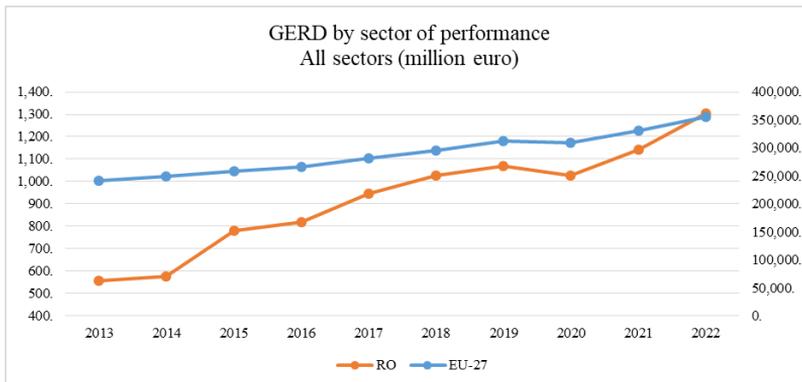

Fig. 1 The evolution of GERD in all sectors in Romania and EU-27

In Table 2 to Table 4 we have calculated the dynamic rhythms with fixed base and with chain base. We can observe that in Romania in 2016 compared to 2013 we have an increase with 46.736% of the GERD. This increase was the maximum value between all the EU-27 countries. Also in 2017 compared to 2013 we have a maximum increase of 69.408%. The same for 2018 compared to 2013 – 83.727% increase.

Table 2 Dynamic rhythms with fixed base and with chain base (a)

R	2014/ 2013	2015/ 2013	2015/ 2014	2016/ 2013	2016 /2015	2017 /2013	2017/ 2016
MIN	-12.056	-9.174	-6.775	-21.011	-30.890	-14.194	-1.308
Country	EE	FI	FI	LV	SK	SI	DK
MAX	27.439	63.022	38.475	46.736	15.863	69.408	24.909
Country	BG	BG	SK	RO	CY	RO	LV

Table 3 Dynamic rhythms with fixed base and with chain base (b)

R	2018/ 2013	2018/ 2017	2019/ 2013	2019/ 2018	2020/ 2013	2020/ 2019
MIN	-4.522	-3.165	0.464	1.567	3.719	-4.689
Country	SI	SE	FI	DK	FI	IT
MAX	83.727	35.025	105.074	23.884	112.230	16.228
Country	RO	LV	PL	EE	PL	LT

Table 4 Dynamic rhythms with fixed base and with chain base (c)

R	2021/ 2013	2021/ 2020	2022/ 2013	2022/ 2021
MIN	12.073	2.326	18.731	-7.123
Country	FI	DK	FI	HU
MAX	140.167	15.906	177.607	32.291
Country	PL	MT	PL	HR

3.2.Business enterprise sector

Regarding GERD by sector of performance in business enterprise sector in Romania we obtained for the average indicators of time series the results in Table 5.

Table 5 Average indicators of time series for business enterprise sector in Romania

the mean	507.218
the average absolute change	71.078
the average of dynamic indices	1.189
the average rhythm of changing	18.876

In Romania the annual mean of GERD in business enterprise sector is 507.218 million euro per year. From one year to another we have on average an increase of 71.078 million euro. This increase represents 18.876% or an increase by a factor of 1.189.

We made also here a graphical comparison between the data from Romania between 2013 and 2022 and the composite average at the level of EU-27, as we can see in Figure 2.
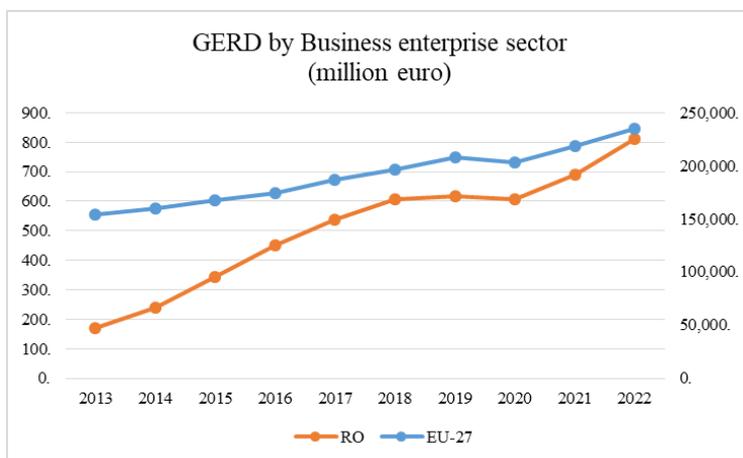

Fig. 2 The evolution of GERD in business enterprise sector in Romania and EU-27

In Table 6 to Table 8 we have calculated the dynamic rhythms with fixed base and with chain base. We can observe that in Romania in 2015 compared to 2013 we have an increase with 101.238% of the GERD. This increase was the maximum value between all the EU-27 countries. Also in 2015 compared to 2014 we have a maximum increase of 44.350%. The same for 2016 compared to 2013 – 164.21% increase, and for 2017 compared to 2013, an increase of 213.380%, and for 2018 compared to 2013, an increase of 255.598%.

Table 6 Dynamic rhythms with fixed base and with chain base (a)

R	2014/ 2013	2015/ 2013	2015/ 2014	2016/ 2013	2016/ 2015	2017/ 2013	2017/ 2016
MIN	-19.776	-12.061	-34.948	-31.602	-28.191	-16.150	-3.831
Country	EE	FI	LV	LV	LV	SI	DK
MAX	46.422	101.238	44.350	164.121	87.832	213.380	38.889
Country	LV	RO	RO	RO	CY	RO	LV

Table 7 Dynamic rhythms with fixed base and with chain base (b)

R	2018/ 2013	2018/ 2017	2019/ 2013	2019/ 2018	2020/ 2013	2020/ 2019
MIN	-8.159	-6.692	-4.226	0.674	0.910	-11.966
Country	FI	LU	FI	DK	FI	LU
MAX	255.598	31.664	315.684	55.967	381.633	50.721
Country	RO	CY	CY	EE	CY	LV

Table 8 Dynamic rhythms with fixed base and with chain base (c)

R	2021/ 2013	2021/ 2020	2022/ 2013	2022/ 2021
MIN	11.958	1.149	17.263	-11.521
Country	FI	IT	FI	HU
MAX	394.982	20.004	411.825	54.322
Country	CY	LV	CY	HR

3.3.Government sector

Regarding GERD by sector of performance in business enterprise sector in Romania we obtained for the average indicators of time series the results in Table 9.

Table 9 Average indicators of time series for government sector in Romania

the mean	308.663
the average absolute change	9.943
the average of dynamic indices	1.032
the average rhythm of changing	3.184

In Romania the annual mean of GERD in government sector is 308.663 million euro per year. From one year to another we have on average an increase of 9.943 million euro. This increase represents 3.184% or an increase by a factor of 1.032.

We made also here a graphical comparison between the data from Romania between 2013 and 2022 and the composite average at the level of EU-27, as we can see in Figure 3.
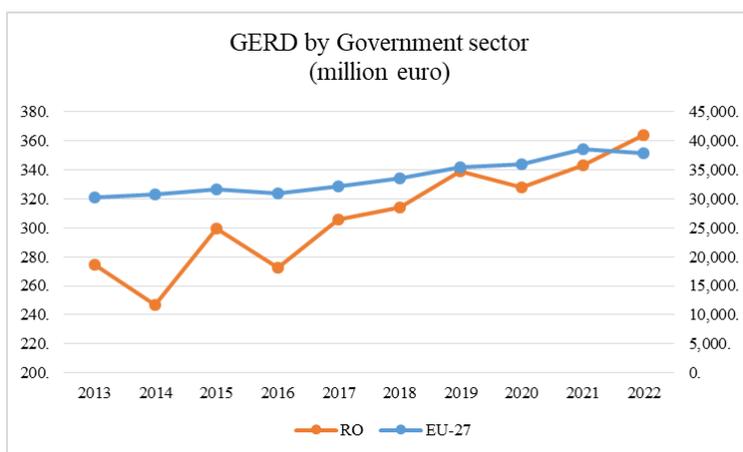
Fig. 3 The evolution of GERD in government sector in Romania and EU-27

In Table 10 to Table 12 we have calculated the dynamic rhythms with fixed base and with chain base. This time Romania is not among the countries with minimum or maximum values among all EU-27 countries, but we can provide some intermediate values. For example in 2014 compared to 2013 we had in Romania a maximum decrease of -10.028, followed by a decrease of -9.017 in 2016 compared to 2015. Talking about increases, we had in Romania the maximum one in 2022 compared to 2013 (32.591%), and the next value of 24.869% in 2021 compared to 2013.

Table 10 Dynamic rhythms with fixed base and with chain base (a)

R	2014/ 2013	2015/ 2013	2015/ 2014	2016/ 2013	2016/ 2015	2017/ 2013	2017/ 2016
MIN	-10.992	-16.801	-11.881	-88.788	-93.519	-89.215	-20.654
Country	SI	FI	FI	PL	MT	PL	MT
MAX	51.662	109.719	95.349	85.846	64.126	89.841	36.781
Country	SK	MT	MT	AT	AT	AT	DK

Table 11 Dynamic rhythms with fixed base and with chain base (b)

R	2018/ 2013	2018/ 2017	2019/ 2013	2019/ 2018	2020/ 2013	2020/ 2019
MIN	-87.310	-10.386	-90.303	-23.586	-86.585	-9.765
Country	PL	LT	PL	PL	MT	LT
MAX	100.304	42.010	114.951	36.413	116.732	60.895
Country	AT	MT	AT	BG	AT	PL

Table 12 Dynamic rhythms with fixed base and with chain base (c)

R	2021/ 2013	2021/ 2020	2022/ 2013	2022/ 2021
MIN	-81.698	0.408	-80.008	-12.314
Country	PL	LU	PL	DE
MAX	134.701	100.000	154.000	26.851
Country	AT	MT	AT	EE

3.4. Higher education sector

Regarding GERD by sector of performance in business enterprise sector in Romania we obtained for the average indicators of time series the results in Table 13.

Table 13 Average indicators of time series for higher education sector in Romania

the mean	105.603
the average absolute change	1.668
the average of dynamic indices	1.014
the average rhythm of changing	1.432

In Romania the annual mean of GERD in higher education sector is 105.603 million euro per year. From one year to another we have on average an increase of 1.668 million euro. This increase represents 1.432% or an increase by a factor of 1.014, the lowest values until now, compared to the other sectors.

We made also here a graphical comparison between the data from Romania between 2013 and 2022 and the composite average at the level of EU-27, as we can see in Figure 4.
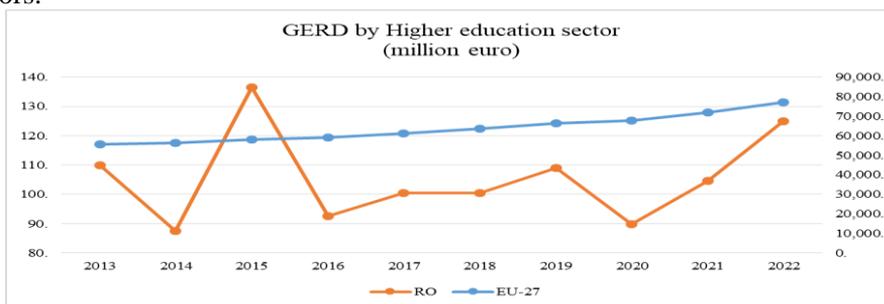

Fig. 4 The evolution of GERD in higher education sector in Romania and EU-27

In Table 14 to Table 16 we have calculated the dynamic rhythms with fixed base and with chain base. This time Romania is among the countries with

minimum values among all EU-27 countries. In 2014 compared to 2013 in Romania we had a decrease of -20.405%, in 2020 compared to 2013 a decrease of -18.280, in 2020 compared to 2019 a decrease of -17.505, and in 2021 compared to 2013 a decrease of -4.817%.

Table 14 Dynamic rhythms with fixed base and with chain base (a)

R	2014/ 2013	2015/ 2013	2015/ 2014	2016/ 2013	2016/ 2015	2017/ 2013	2017/ 2016
MIN	-20.405	-10.775	-21.675	-30.362	-56.262	-26.519	-5.459
Country	RO	SI	BG	EE	SK	LT	HR
MAX	29.788	100.807	76.201	51.817	44.387	58.054	45.445
Country	BG	SK	SK	HR	HR	PL	HU

Table 15 Dynamic rhythms with fixed base and with chain base (b)

R	2018/ 2013	2018/ 2017	2019/ 2013	2019/ 2018	2020/ 2013	2020/ 2019
MIN	-15.778	-15.535	-3.275	-3.384	-18.280	-17.505
Country	LT	IE	SK	SE	RO	RO
MAX	89.553	51.398	149.469	62.363	153.506	18.854
Country	PL	LV	PL	BG	PL	LT

Table 16 Dynamic rhythms with fixed base and with chain base (c)

R	2021/ 2013	2021/ 2020	2022/ 2013	2022/ 2021
MIN	-4.817	0.324	7.539	-0.501
Country	RO	EL	IT	SE
MAX	184.509	22.466	209.132	23.209
Country	PL	HU	HR	LV

3.5.Private non-profit sector

Regarding GERD by sector of performance in private non-profit sector in Romania we obtained for the average indicators of time series the results in Table 17.

Table 17 Average indicators of time series for private non-profit sector in Romania

the mean	2.690
the average absolute change	0.204
the average of dynamic indices	1.070
the average rhythm of changing	6.974

In Romania the annual mean of GERD in private non-profit sector is only 2690 million euro per year. From one year to another we have on average an increase of 0.204 million euro. This

increase represents 6.974% or an increase by a factor of 1.070.

We made also here a graphical comparison between the data from Romania between 2013 and 2022 and the composite average at the level of EU-27, as we can see in Figure 5.
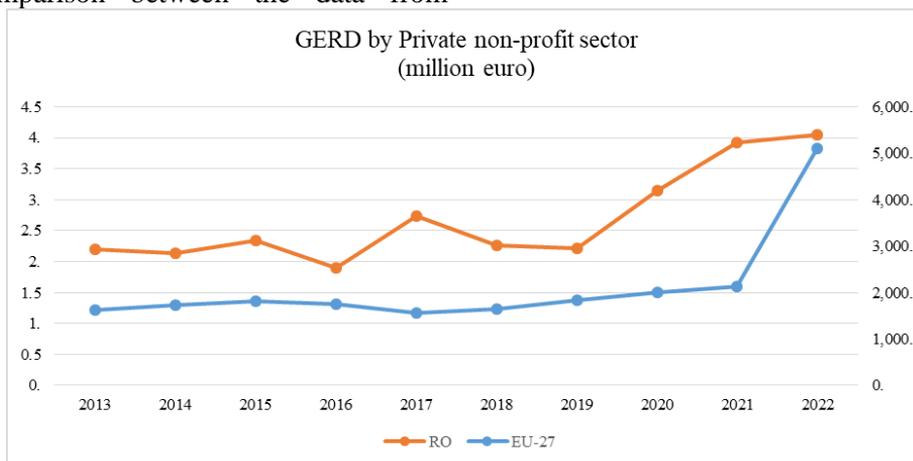

Fig. 5 The evolution of GERD in private non-profit sector in Romania and EU-27

In Table 18 to Table 20 we have calculated the dynamic rhythms with fixed base and with chain base. In 2014 compared to 2013 in Romania we had a decrease of -3.176%. Also, from other calculations in 2016 compared to 2015 we had a decrease of -18.777, and in 2018 compared to 2017 a decrease of -17.228. We had an increase in 2021 compared to 2013 of 77.904% and in 2022 compared to 2013 an increase of 83.439%.

Table 18 Dynamic rhythms with fixed base and with chain base (a)

R	2014/ 2013	2015/ 2013	2015/ 2014	2016/ 2013	2016/ 2015	2017/ 2013	2017/ 2016
MIN	-3.176	-32.799	-41.558	-46.257	-52.751	-40.672	-34.599
Country	RO	PL	PL	SI	BG	SE	SE
MAX	195.879	298.373	58.879	237.961	167.074	367.380	769.652
Country	SK	SK	EE	SK	PL	SI	SI

Table 19 Dynamic rhythms with fixed base and with chain base (b)

R	2018/ 2013	2018/ 2017	2019/ 2013	2019/ 2018	2020/ 2013	2020/ 2019
MIN	-45.483	-25.076	-74.946	-92.747	-77.223	-26.785
Country	SE	BG	SK	SK	SK	EL
MAX	697.059	70.538	1522.727	103.589	1794.385	49.905
Country	SI	SI	SI	SI	SI	EE

Table 20 Dynamic rhythms with fixed base and with chain base (c)

R	2021/ 2013	2021/ 2020	2022/ 2013	2022/ 2021
MIN	-54.989	-14.346	-54.230	-37.161
Country	SK	EE	SK	EE
MAX	2374.599	97.619	3101.070	50.032
Country	SI	SK	SI	CZ

4. CONCLUSIONS

The Gross domestic expenditure on R&D (GERD) is detailed on four sectors of activity. For business enterprise sector the amount is 54.883%. For government sector the percentage is 33.399%. For the higher education sector the value is 11.427%, and for the private non-profit sector the percentage is 0.291%.

From 2013 to 2022 the evolution of GERD in all of those sectors represented an increase. We consider that Romania needs more investments in higher education sector.

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