EU MUST HELP EUROPEAN COUNTRIES TO INVEST 0.75 % OF GDP IN GOVERNMENT RESEARCH

Proposal for a 20-year Programme 2026-2045

Ugo Amaldi, Roberto Antonelli, Luciano Maiani and Giorgio Parisi

EXECUTIVE SUMMARY

The quantity considered in this Report is the 'government R&D intensity', defined as the ratio between GBARD = *'Government Budget Allocations for R&D*'– the investment made by the government in 'basic research' and 'applied research' – and GDP:

$$\text{(government R\&D Intensity in the } k^{th} \text{ year)} = \mathbf{I_k} = GBARD_k / GDP_k. \quad (1)$$

Many studies have illustrated the correlation between long-term economic development and R&D intensity – sum of the government I_k and business J_k intensities – and highlighted the other factors, listed at the bottom of page 3, which influence it and should not be overlooked.

In the first part of this Report, EUROSTAT data from 2022 illustrate a serious disparity between EU countries: the 27 government R&D intensities are distributed over a very wide range, from 0.14% (Romania) to 1.1% (Germany). Moreover, the ratio 6.1 between the averages of the two highest and two lowest values is *three times larger* than those for two other fundamental government activities: Education and Health (Fig. 2, p. 5). This ignored disparity between the 27 EU countries is unacceptable because it implies that many European countries

- do not have the necessary means and research facilities to contribute to Europe's long-term development;
- cannot train their young researchers preparing them to produce good science and, thus, to compete for *European Research Council* (ECR) grants, which are awarded based on scientific quality alone;
- do not offer their research teams the minimum conditions to work at the research frontiers and apply to European calls having a reasonable chance of success.

The *second part* (p. 6) and *Appendix 1* (p. 20) describe the economic model used to calculate the investment needed to remedy this situation with a *20-year Programme 2025-2044* in which the *GBARDs of 2022* are used for the year 2024 – taken as 'reference year'. In *Appendix 2* (p. 29) it is shown that – by taking for the 'reference year' 2025 the GBARDs of 2023 – the investments needed for the *20-year Programme 2026-2045* are the same.

The assumptions are a maximum increase in GBARD of 7% per year and a GDP growth of 3% per year (with 2% due to inflation) so that the maximum rate of increase in public R&D intensity is 3.88% (1.07/1.03 = 1.0388).

The Programme 2026-2045 (Appendix 2, p. 29) requires an investment of *about 180 billion* euro in 20 years and involves the 21 countries for which the government R&D intensity I_{24} in 2024 is below 0.75%. It is easily seen that only the countries, which have I_{25} greater than 0.35% in 2025, can reach 0.75% in no more than 20 years: $0.75/1.0388^{20} = 0.35$. The 13 countries of this '*Group II*' are: Sweden (arrives in 1 year), Croatia (5 y), Belgium (5 y), France (5 y), Italy (5 y), Luxembourg (5 y), Spain (6 y), Greece (8 y), Czechia (10 y), Poland (11 y), Cyprus (14 y), Latvia (18 y) and Slovakia (19 y). By contrast, the 8 countries in '*Group I'* cannot reach 0.75%; among them are Hungary (reaching 0.67%), Portugal (0.64%), Bulgaria (0.48%), Ireland (0.44%) and, with a big gap, Romania (0.32%) which starts very low: $I_{25} = 0.15\%$.

To make the Programme attractive the European Union must participate in the investments. Two hypotheses are made: 35% (text and Appendix 1) and 50% (Appendix-2). Having choosen 50% – for the Plan 2026-2045 – the Union will have to invest *90 billion*, which, considering an inflation rate of 2% per year, corresponds to *73 billion euro of the year 2025*. Over the 2026-2045 period the average is *3.7 billion per year*, a small correction to the *750-800 million* that, according to the Draghi Report, Europe will have to invest for improving its productivity, supporting the ecological transition and maintaining sovereignty.

Each Country will choose year by year what to do and the Union will compensate a year later.

For UE the *maximum* financial burden is only 50% larger than all the grants distributed annually by the *European Research Council* to European researchers. It is more than reasonable to spend as much to achieve the three objectives listed above and, in particular, to give to all the scientists *from all European countries* the same means to achieve excellence[1].

(*The final Section of p. 14 provides other useful information without too many details*)

1. An unacceptable disparity

A Government finances '**government**' research - the combination of '**basic**' and '**applied**' research - by investing an annual sum called **GBARD** = *'Government Budget Allocation for R&D'*. Universities produce mainly basic research while specialised Agencies devote themselves to both basic and applied research. Eq. (1) says that the ratio of **GBARD to nominal GDP** (i.e. GDP at current prices) is the ***'government R&D intensity'*** For brevity in this Report the term 'government' is almost always dropped.

Businesses do both 'applied' research and 'experimental development', with the aim of improving products, and for all these activities they invest resources globally called BERD = *Business Enterprise R&D*. This, divided by nominal GDP, gives the **'Business R&D intensity**'.

$$(\textit{business}\ \text{R\&D intensity in the k}^{\text{th}}\ \text{year}) = \mathbf{J_k} = \text{BERD}_k / \text{GDP}_k. \qquad (2)$$

The sum of the two intensities is what is usually called 'R&D intensity':

$$(\text{R\&D intensity in the k}^{\text{th}}\ \text{year}) = \mathbf{I_k} + \mathbf{J_k}. \qquad (3)$$

In 2000, the EU Heads of State and of Government used this economic parameter in launching the 'Lisbon Strategy' with which Europe would "*become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion*." Three targets were chosen:

- an average European employment rate of 70%;
- an employment rate for women of 60%;
- **a (total) R&D intensity of EU countries of no less than 3 %.**

In 2002, the Commission published a Communication: *'More Research in Europe – Towards 3% of GDP*'. In 2005, the new Commission published another Communication: *'More Research and Innovation - A Common Approach*'[2]. The seventh guideline[3] stated "*To increase and*

[1] In April 2025, *Corriere della Sera* published an Appeal by *Accademia dei Lincei* denouncing the unacceptable disparity and proposing the Plan: www.lincei.it/it/notizie/appello-la-ricerca-pubblica-dellunione-europea

[2] https://ec.europa.eu/invest-in-research/pdf/download_en/mep_en01bat3_051219.pdf

[3] Page 33 of https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:205:0028:0037:EN:PDF

improve investment in R & D, in particular by private business, the overall objective for 2010 of 3 % of GDP is confirmed with an adequate split between private and public investments".

Five years later, in 2010, the new *'Europe 2020*' strategy still wanted "*to reach the target of investing 3% of GDP in R&D, in particular by improving the conditions for the private sector to invest in R&D*"[4].

Without it being written in official documents, it is generally implied that the **Government should contribute one third** (I_k **= 1%**) and **business two thirds** (J_k **= 2%**) to the 3%. Table 1 shows that the 1% has not been reached even 22 years after Lisbon.

Table 1: *After 22 years, the Lisbon target for European government R&D intensity has not been reached while the other two are surpassed.*

	Total employment	**Female employment**	**R&D government intensity**
Target 2022	**70%**	**60%**	**1.0%**
EU 2000[5]	63.1%	53.8%	0.61%
EU 2022[6]	74.6%	69.3%	0.74%
Fraction in 2022	**106%**	**116%**	**74%**

In 2020, the final '*Europe 2020*'[7] report recognised that: "*The (total) R&D intensity' reached 2.32%, a 15% improvement on the 2.02% in 2013 but below the overall target of 3%*".

An increase of 15% with a target of 50% testifies to a failure that the EU has deliberately forgotten in the following years to the extent that in the 42-page presentation of the current *'Horizon Europe*' programme[8] - which covers the years 2021-2027 and is depicted on the next page in Fig. 1 - the **3% figure is not mentioned**, not even under *'Reforming and strengthening the European research system*'.

This absence is partly justified by the fact that, over the past two decades, it has been realised that R&D intensity is important, but that the transfer of knowledge, from basic and applied research to companies and the resulting development, is determined by many factors[9]:

- the excellence of research, particularly basic research (Pillar 1 of Fig. 1, p. 4),
- the focus of government researchers on knowledge transfer,
- the tools and facilities that foster this transfer,
- the effectiveness of partnerships between universities, public research organisations and companies,
- the ability of companies to take up and use the knowledge transferred,
- their investments in applied research and experimental development,
- the quantity and quality of 'venture capitals',

[4] Page 32 of https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF
[5] https://ec.europa.eu/eurostat/web/products-statistics-in-focus/-/ks-nk-01-008
[6] https://amblav.it/eurostat-i-tassi-di-occupazione-nel-2022-rispetto-agli-obiettivi-ue-per-il-2030/
[7] Page 58-59 of https://eur-lex.europa.eu/resource.html?uri=cellar:b5a1da8b-be92-11ee-b164-01aa75ed71a1.0001.02/DOC_1&format=PDF
[8] https://research-and-innovation.ec.europa.eu/system/files/2022-06/rtd-2021-00013-03-00-it-tra-01.pdf
[9] See for example: www.vttresearch.com/sites/default/files/2021-05/OECD-TIP-RD-intensity-case-studies-synthesis-report.pdf

- the quality and quantity of private researchers,
- the facilities granted to companies investing in R&D.

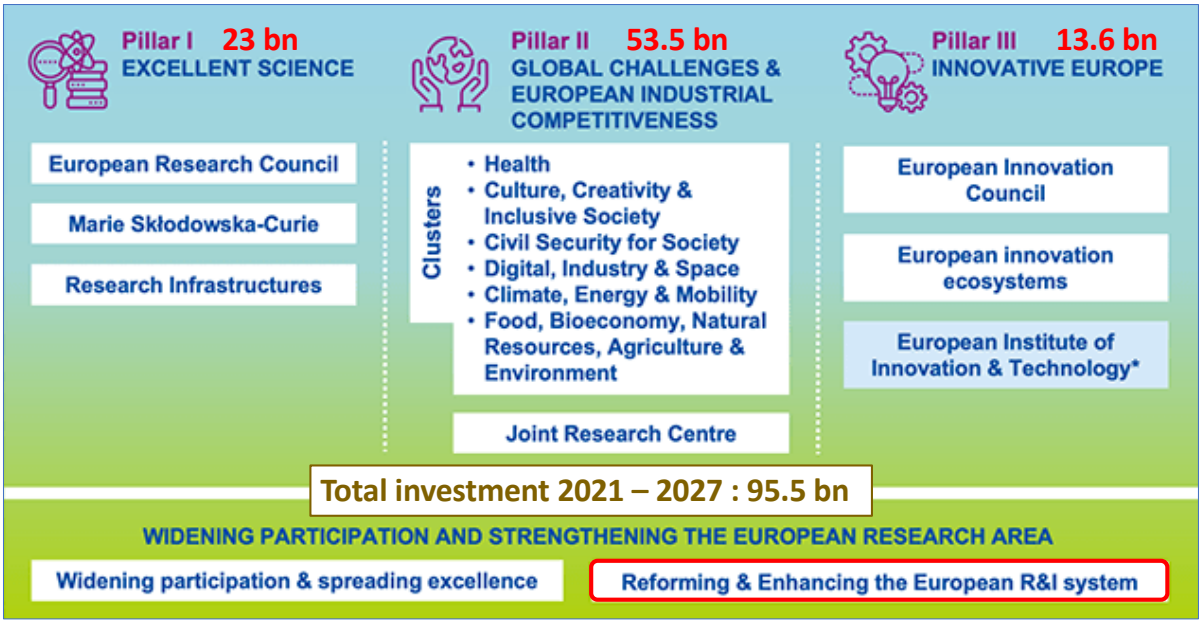

Figure 1. *Scheme of the current* 'Horizon Europe' *programme, which consists of three vertical 'pillars' (the first of which includes basic research) and one horizontal 'pillar'.*

Many of these topics are addressed by the *'Horizon Europe*' Programme, which is a very positive thing. However, diverting attention, and for so many years, from the government R&D intensity has created a seriously unbalanced situation, as is illustrated by the data in columns (5) and (7) of Table 2 and the three histograms in Fig. 2 (p. 5).

Table 2. *Indices of expenditure variability in three fields of Government intervention*[10]*.*

	(1) Countries	(2) min max	(3) % of GDP (*) $I_{22}^{average}$	(4) Ratio $\frac{I_{22}^{max}}{I_{22}^{min}}$	(5) Normalized ratio	(6) σ / aver. (**)	(7) Normalized σ / aver.
R&D intensity. [11]	Ireland+Romania	min	0.165%	**6.10**	**3.05**	**0.375**	**3.40**
	Finland+Germany	max	1.005%				
Education [12]	Ireland+Romania	min	2.95%	**2.15**	**1.05**	**0.11**	**1.00**
	Belgium+Sweden	max	6.30%				
Health [13]	Hungary+Latvia	min	4.60%	**2.00**	**1.00**	**0.18**	**1.65**
	Austria+ Czechia	max	9.20%				

(*). Average of the countries of column (1).

(**) These three ratios have been computed by excluding the countries of column (1).

[10] The quantities in columns (5) and (7) do not depend on the purchasing power in the different countries.

[11] Table 3, p. 7.

[12] - https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_on_education

[13] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_on_health

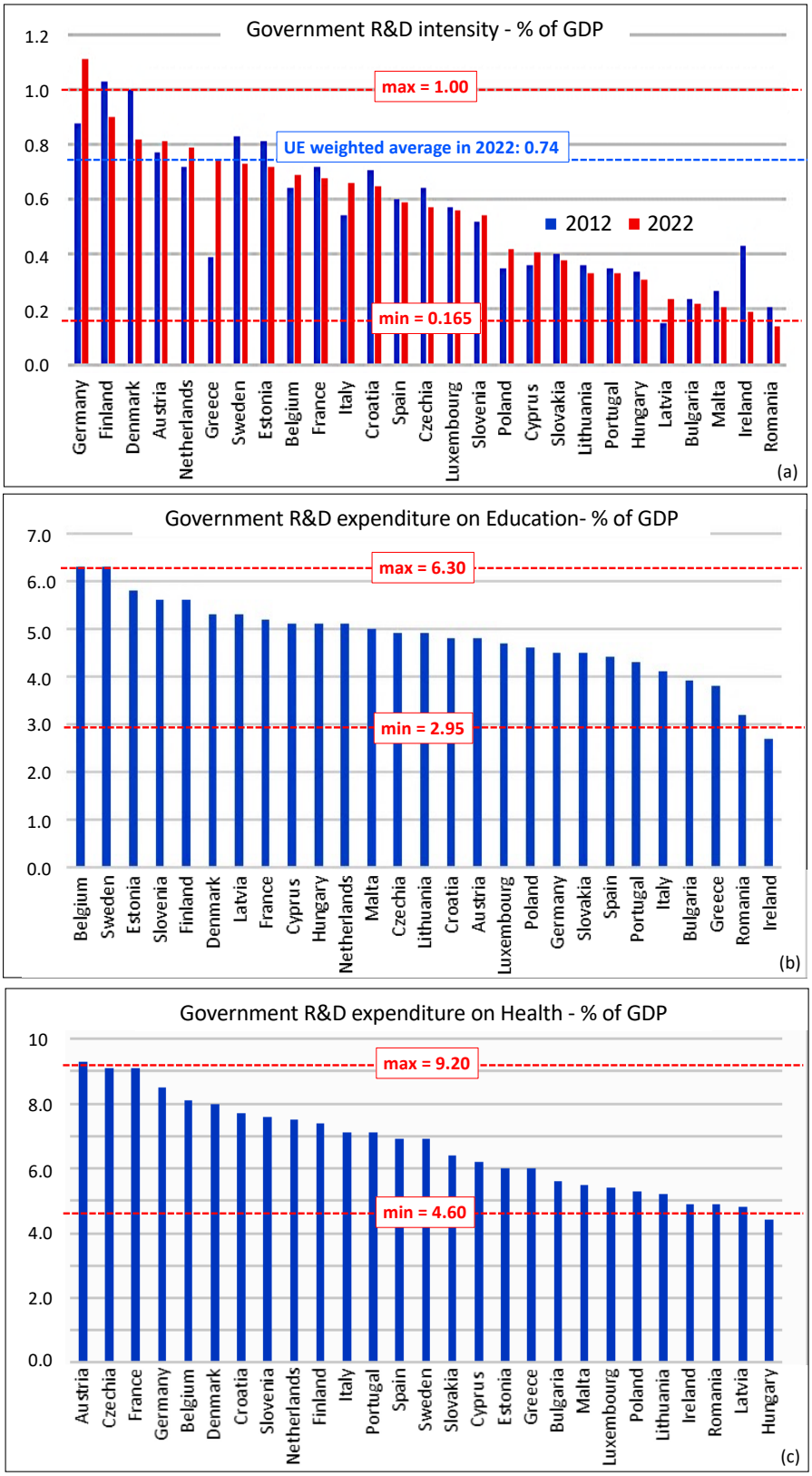

***Figure 2**. (a) Between 2012 and 2022, government R&D intensity increased in 14 countries - including Greece, Germany, and Italy - and decreased in 13 other countries - including Denmark, Finland, Ireland, and Sweden. Ireland and Romania also decreased and are at their lowest. (b) The same two countries are also at a minimum in government Education while for Public Health they are Latvia and Hungary. In Education, Belgium and Sweden are at the maximum. (c) In government Health, Austria and the Czech Republic are at the maximum.*

Fig. 2a shows that the weighted average of the EU's (government) R&D intensity **was 0.74% in 20**22, a value obtained by adding the GBARDs of countries with very different intensities: 1.11% of Germany and 0.14% of Romania. Furthermore, column (4) of Table 2 shows that **6.1 is the ratio between the I_{22}^{max}** value (av. of two countries) and the I_{22}^{min} value (two countries).

The same column (4) shows the max/min ratios for two other important public activities, **Education** and **Health**, which are used as a comparison in column (5) by normalising the three figures to the minimum value.

As a second parameter, the ratio of **standard deviation σ** to the **mean** was chosen, calculated by discarding the two maximum and minimum values so that the data in column (7) are independent of those in column (5). The values 3.05 and 3.40 of the two parameters say that funds for government research vary from country to country **three times more** than those for Education and Health.

A **three times greater disparity** in government research between countries than in Education and Health is unacceptable because it implies that many European countries

1. do not have the *means* and *research fac*ilities to contribute to Europe's development;
2. cannot train their young researchers and also prepare them to compete for *European Research Counci*l grants, which are awarded on the basis of scientific quality alone;
3. are not able to offer their *research teams* the minimum conditions to do good research and to participate in European calls for proposals with a reasonable chance of success.

To remedy, at least partially, this situation, a **20-year Programme** is proposed in the remainder of this Report, partially financed by the EU, which subsidises the **21 countries** – whose R&D intensity in 2022 was **I_{22} < 0.74** – to bring them, in no more than 20 years, **to 0.75%** or close to this value.

2. Resources needed for the 20-year Programme

Assuming the Programme starts in 2025, **2024 was taken as the reference year**. However, as the GBARDs of 2023-24 are not available**, in the main text and in Appendix 1 the GBARD values of 2022 have been adopted for the year 2024.**

To update the Plan by one year, in Appendix 2 the GBARDs of 2023 have been used for 2025, taken as reference year.

With these assumptions, Table 3 lists, for the 27 countries of the European Union

- column (3): the ratio **$Debt_{24}$ /GDP_{24}** = **D_{24}** in 2024[14],
- column (4): the GBARD in 2024 **G_{24}** expressed in millions of euros[15],
- column (5): the **GDP_{24}** in 2024[16],
- column (6): the R&D intensity of 2024.

Data from some non-European countries are collected in the lower part of Table 3, from which it can be seen that at present the average of South Korea and Japan is 1.5%.

[14] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_finance_statistics#General_government_gross_debt

[15] https://ec.europa.eu/eurostat/databrowser/view/GBA_FUNDMOD/default/table?lang=en&category=scitech.rd.gba

[16] https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp/default/table?lang=en

Table 3. *Duration* ***n, GBARD*** *grow rate and needed* ***Resources*** *with GDP at* ***+3% per year****.*

(1)	**(2)** Country (No-euro in brackets)	**(3)** Debt/ GDP 2024 **D_{24}** (%)	**(4)** GBARD 2024 **G_{24}** (mn)	**(5)** GDP 2024 **GDP_{24}** (bn)	**(6)** R&D Inten. 2024 **I_{24}** (%)	**(7)** Years **f** Eq (5) with **r = 1.07**	**(8)** Years **n** – Growth rate of GBARD from Eq (5) **(r-1)**	**(9)** **New Resources** Eq. (7) **$R_{25-(24+n)}$** (mn)
UE	Union Eur.	83.5	**117 425**		**0.74**			
1-RO	(Romania)	47.2	397	284	0.140	44.1	20–7.00%	9471
2-IE	Ireland	44.4	964	506	0.191	35.9	20–7.00%	23 003
3-MT	Malta	52.3	37.1	17.4	0.213	33.1	20–7.00%	886
4-BG	(Bulgaria)	22.6	187	85.8	0.218	32.5	20–7.00%	4463
5- LV	Latvia	41.0	93.4	38.4	0.243	29.6	20–7.00%	2231
6-HU	(Hungary)	73.9	518	168.9	0.307	23.5	20–7.00%	12 363
7-LT	Lithuania	38.1	219	67.4	0.325	22.0	20–7.00%	5226
8-PT	Portugal	112.4	802	242.3	0.331	21.5	20–7.00%	19 137
GROUP I (0.10% ≤ I_{24} < 0.35%)								**76 780**
9-SK	Slovakia	57.8	412	109.6	0.376	18.1	19–6.81%	8303
10-CY	Cyprus	85.6	115.2	27.8	0.414	15.6	16–6.89%	1563
11-PL	(Poland)	49.3	2768	654.6	0.423	15.1	16–6.75%	36 421
12-SI	Slovenia	72.3	307	57.0	0.539	8.68	9–6.86%	1142
13-LU	Luxemb.	24.7	430	77.5	0.555	7.91	8–6.95%	1269
14-CZ	(Czechia)	44.2	1567	276.3	0.567	7.35	8–6.67%	4409
15-ES	Spain	111.6	8002	1346	0.595	6.08	7–6.47%	16 503
GROUP IIA (0.35% ≤ I_{24} < 0.60%)								**69 610**
16-HR	Croatia	68.2	445	68.0	0.654	3.76	5–5.86%	423
17-IT	Italy	141.7	12 843	1963	0.654	3.60	5–5.86%	12 210
18-Fr	France	111.8	17 900	2639	0.678	2.65	5–5.10%	14 661
19-BE	Belgium	104.3	3822	554	0.690	2.19	5–4.73%	2889
GROUP IIB (0.60% ≤ I_{24} < 0.70%)								**30 183**
20-EE	Estonia	18.5	260.3	36.0	0.722	1.00	2–4.91%	41
21-SE	(Sweden)	32.9	4094	562	0.728	0.78	2–4.54%	566
GROUP IIC (0.70% ≤ I_{24} < 0.74%)								**607**
TOTAL			**61 242.3**	21 countries with I_{24} < 0.74%				**177 180**
22-EL	Greece	172.6	1537	206.6	0.744	-	-	-
23-NL	Netherlan.	50.1	7533	959	0.786	-	-	-
25-AT	Austria	78.4	3606	447	0.807	-	-	-
24-DK	(Denmark)	29.8	3108	381	0.816	-	-	-
26-FI	Finland	73.3	2402	268	0.896	-	-	-
27-DE	Germany	66.1	43055	3876	1.110	-	-	-
TOTAL			**56 182.7**	6 countries with I_{24} ≥ 0.74%				**0**

Non-EU countries in $ ppp (1 $ ppp 2022 = 0.621 EUR)					
	Japan	254	(104 000)	6140	1.69
	S. Korea	58	(38 400)	2780	1.38
	Switzer.	38	(7460)	754	0.99
	USA	144	(170 600)	25 460	0.67
	UK	104	(24 000)	3720	(0.65)
(1)		(2)	From (3) and (4)	(3)	(4)

(1) https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

(2) https://data.oecd.org/gga/general-government-debt.htm

(3) www.imf.org/external/datamapper/PPPGDP@WEO/OEMDC/ADVEC/WEOWORLD

(4) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_budget_allocations_for_R%26D_(GBARD)&oldid=573250

Since for many years the UK has not distributed the data, the value in parenthesis has been estimated.

The GBARD of each country G_{24+k} increases, compared to the one of the previous year G_{24+k-1}, by an amount $\mathbf{\Delta G_{24+k}}$ obtained by multiplying $\mathbf{G2_{4+k-1}}$ by **(r - 1) > 0**. The larger r is, the faster the target of 0.75% will be reached but it is not possible to increase much the available resources and yet spend them all effectively. A **first rule** was therefore adopted:

A. The annual increases $\mathbf{\Delta G_{24+k}}$ of GBARD over the previous year may not exceed **7% per year**:

$$1 + \Delta G_{24+k}/G_{24+k-1} = \mathbf{r} \leq \mathbf{1.07} \qquad (1 \leq k \leq 20) \qquad (4)$$

so that, with a "nominal GDP" growing by 3% per year ($PIL_{24+k} = p^k\ PIL_{24}$ with **p =1.03**) – of which 2% due to inflation – the "**government R&D intensity**" $\mathbf{I_{24+k}} = G_{24+k}/PIL_{24+k}$ does not increase by more than **3.88% per year** (r/p = 1.07/1.03 =1.0388).

The Programme – for the management of which a special structure is to be set up in Brussels – targets the 21 countries for which the public R&D intensity I_{24} in 2022 was below 0.74%, the European average for that year. Since $0.75/(r/p)^{20} = 0.75/1.0388^{20} = 0.35\%$, only countries with I_{24} greater than 0.35% can reach the target in no more than 20 years. The values $\mathbf{I_{24+k} = 0.35\%}$ and $\mathbf{I_{24+k} = 0.74\%}$ divide the EU countries into three Groups:

- **GROUP I**: 8 countries that, having $\mathbf{I_{24} < 0.35\%}$, **will not be able** to reach $I_{24+k} = \mathbf{0.75\%}$ in the 20 years of the Programme;
- **GROUP II**: 13 countries that, having $\mathbf{0.35\%} \leq I_{24} < \mathbf{0.74}\%$, **will be able** to reach $I_{24+k} = \mathbf{0.75\%}$ in less than 20 years;
- **GROUP III**: 6 countries that, having already $I_{24} \geq \mathbf{0.74\%}$, do not have to increase it.

Note that the groups would change if the rate of increase was reduced from 7% to 6% per year, as this would result in $\mathbf{I_{24} < 0.42}\%$, instead of $I_{24} < 0.35\%$, as the minimum threshold for achieving 0.75% in 20 years, and Slovakia and Cyprus would move from Group II to Group I.

Eq. (A3) in the Appendix 1 (p. 19) – with the GDP factor **p = 1.03** – and its inverse

$$\mathbf{f} = \ln(0.75/\mathbf{I_{24}}) / \ln(\mathbf{r}/1.03) \qquad \mathbf{r} = (0.75/I_{24})^{1/\mathbf{f}} \qquad (5)$$

give one of the infinite pairs of values **(r, f)** that in **f years** (with f being a fractional number) lead from $\mathbf{I_{24}}$ to **0.75%**. The **f** values listed in column (7) of Table 3 were calculated with the value **r= 1.07** established by rule A, and with **p = 1.03** so that $f = 26.25\ \ln(0.75/I_{24})$.

The numbers **n** in column (8) are integers **greater than f** and less than or equal to 20. Substituting n for f in the second Eq. (5) gives the **growth rates r** in the same red column.

Depending on the value of **n**, the countries in Group II are divided into **3 subgroups** so that:

- **n = 20** and (r-1) = 7.0%, for the 8 **Group I** countries ($0.10\% \leq I_{24} < 0.35\%$);
- **6 ≤ n < 20** and $6.5\% \leq r\text{-}1 < 7.0\%$, for the 7 **Group IIA** countries ($0.35\% \leq I_{24} < 0.60\%$);
- **n = 5** years for the 4 countries of **Group IIB** ($0.60\% \leq I_{24} < 0.70\%$) which reach 0.75% in 5 years with $4.7\% \leq r\text{-}1 < 5.9\%$, rates less demanding than the 6.5-7% of Groups I, IIA;
- **n = 2** years for Sweden and Estonia, **Group IIC** ($0.70\% \leq I_{24} < 0.74\%$), close to 0.75%.

To achieve these results, it will be necessary to invest the new resources $\mathbf{R_{25-(24+n)}}$ in column (9), which, for each country, are the sums of the $\mathbf{DG_{24+k}}$ **increases over** $\mathbf{GBARD_{2024}}$:

$$\mathbf{R_{25-(24+n)}} = \Sigma_{k=1 \to n}\ \mathbf{DG_{24+k}} \qquad (6)$$

Each DG_{24+k} is the sum of the annual increases $\Delta G_{24+k} = \mathbf{r}\ G_{24+k-1}$ of the previous k years[17]:

[17] Example: the annual investments needed, with respect to the reference year 'zero', to pass – in 1 billion steps and in 5 years – from $GBARD_0$ = 10 million to $GBARD_5$ =15 million are: 1 + 2 + 3 + 4 + 5 = 15 billion.

$$\mathbf{R_{25\text{-}(24+n)} = G_{24}\ [H_n(r) - n]} \quad \text{with} \quad H_n(s) = s\,(s^n - 1)/(s - 1), \qquad (n = 1\text{-}20) \qquad (7)$$

as demonstrated in the Appendix 1 on page 19. The factor multiplying G_{24} increases rapidly with the number n of years, as is shown by the **red** (**green**) curve in Fig. 3, and, for n = 20 and r = 1.07, is **23.87** (**17.98**).

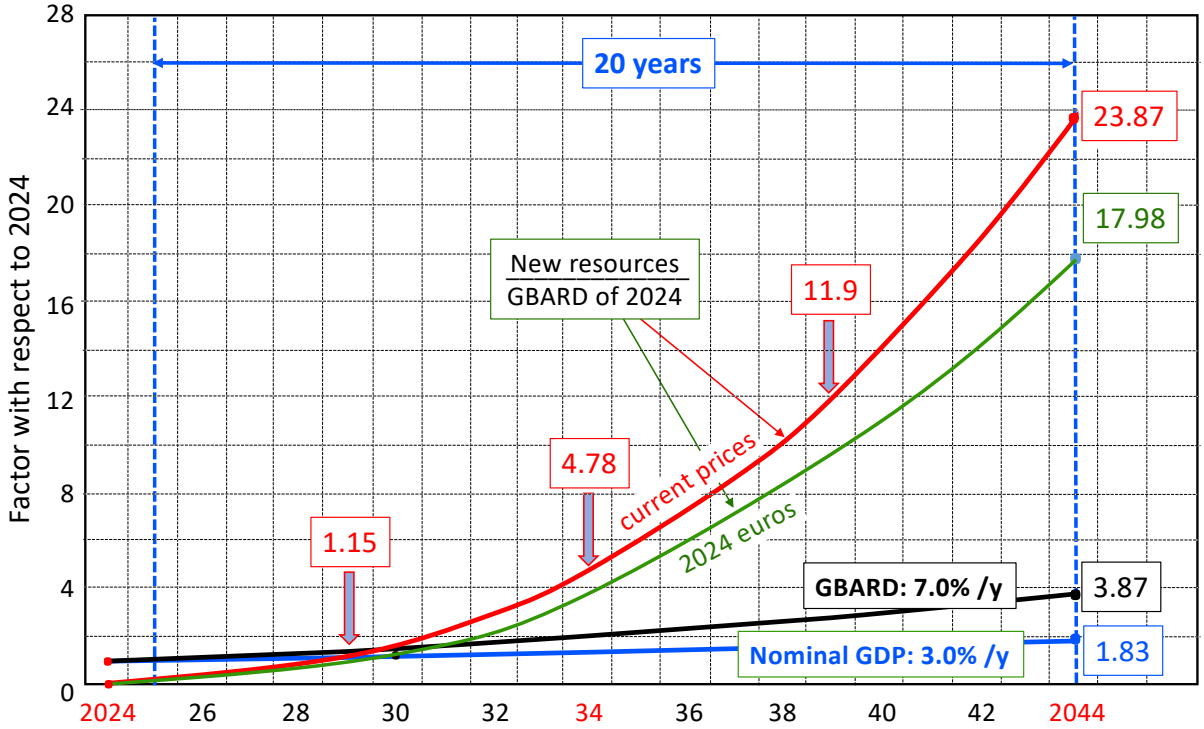

Figure 3. *Trends in nominal GDP (blue curve) and GBARD (black curve). The **red curve** represents the ratio $R_{25\text{-}(24+n)} / G_{24}$ of Eq. (7). The **green curve** is the factor expressing the new resources in **2024 euro**, as discussed on pages 19-24 of the Appendix 1.*

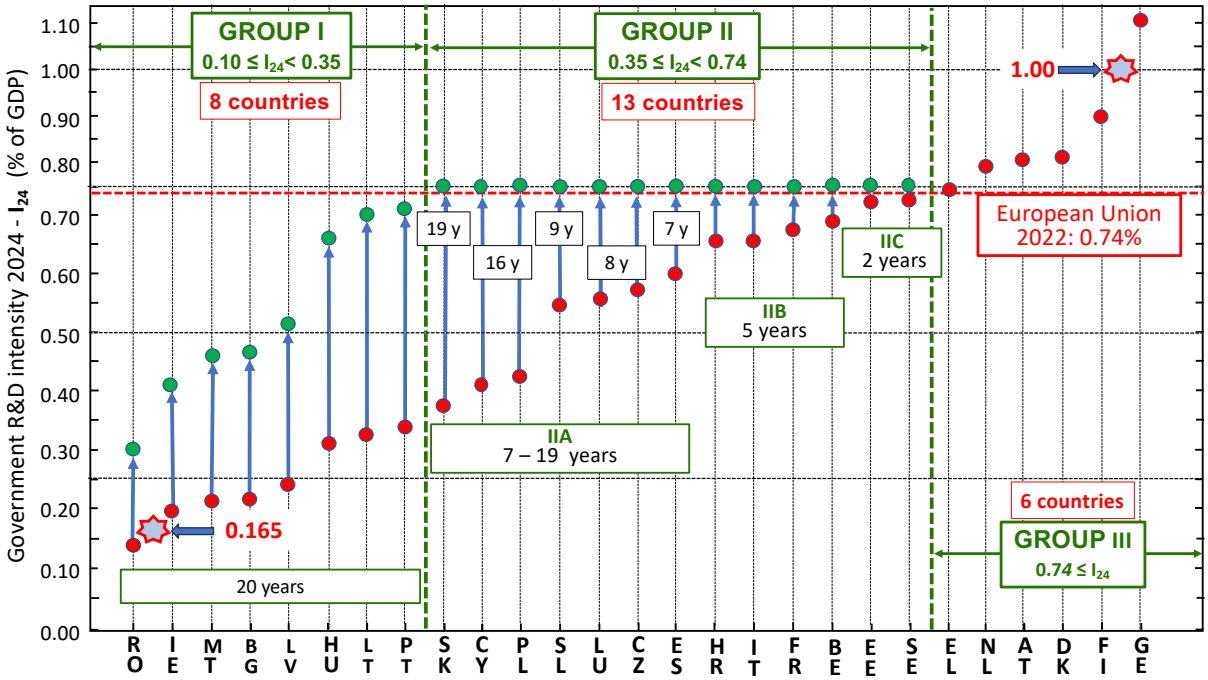

Figure 4*. The figure shows that **in 2024** the R&D intensities of the 27 countries were **evenly distributed between 0.165% and 1.00%** (Table 3, p. 7).*

The model used to calculate the required resources is simplistic because

i. it uses data from 2022 for the reference year 2024,
ii. it assumes a constant **nominal GDP** increase of **3% per year**,
iii. it chooses a maximum GBARD increase of **7% per year** so that the government R&D intensity increases by a maximum of **3.88% per year**.

However, applying this results in four interesting pieces of information:

- **€177.2 billion** (current prices)[18] is needed over 20 years to complete the Programme, about **70%** of which is concentrated on **6 countries**: Poland (36.4 billion), Ireland (23.0), Portugal (19.1), Spain (16.5), France (14.7) and Italy (12.2);
- **for 8 Group I countries** (Bulgaria, Hungary, Latvia, Lithuania, Malta, Ireland, Portugal, Romania and Hungary) 0.75% is an unachievable target over the 20 years of the Programme – with 3.88% being the yearly maximum increase in government R&D – butsignificant progress will be made with Romania going from 0.14% to 1.0388^{20} x 0.14 = 0.30% and Lithuania and Portugal reaching 0.70% (see Fig. 4 at p.9);
- **for the 7 countries of Group IIA** (Czechia, Cyprus, Luxembourg, Poland, Slovenia, Slovakia, and Spain), it takes between 7 years for Spain and 19 years for Slovakia to reach the 0.75% target at steps of 3.88% per year.
- **for the 4 countries in Group IIB** (Belgium, Croatia, France, and Italy) the annual increase in GBARD to reach 0.75% in 5 years is less than 5.9% so that, as mentioned above, they are easier to maintain.
- Estonia and Sweden, of **Group IIC**, are close to 0.75% and need a small fraction of G_{24}.

3 European Union subsidies

The disparity between the countries, illustrated by Fig. 2a on p. 5 and Fig. 4 on p. 9, is the result of the EU's substantial lack of interest over the past twenty years in the balanced funding of government research in the member states despite many proclamations, starting with the Lisbon Strategy of the year 2000.

The more than twenty years' development of this issue leads to the conclusion that motions and recommendations are not enough: this disparity will not be reduced **without lasting targeted EU interventions**. To achieve this goal, a 20-yearProgramme of financial support quantified by two rules is proposed:

B. Countries, which have an intensity $\mathbf{I_{24} < 0.74\%}$ in 2024 and which increase their GBARD by $\mathbf{DG_{24+k}}$ in the k-th year compared to 2024, will receive from the EU - in **the following year** - a subsidy $\mathbf{S_{25+k}}$ equal to a fraction of DG_{24+k}:

$$\mathbf{S_{25+k} = F\ DG_{24+k}.} \qquad (1 \le k \le 20) \qquad (8)$$

C. The value

$$\mathbf{F = 0.35} \qquad (9)$$

is used in the following to compute the resources that the EU should invest but the choice is political and will ultimately be made by the EU institutions.

[18] **In this Report the millions of euros - sum of annual amounts - are either followed by 'current prices' or have no specification. The inflation adjusted amounts are, instead, always accompanied by the specification '2024 euros'.**

The steps necessary to calculate the EU subsidy are presented in Table 4, which requires a preliminary remark: 35 % of the annual investments will be reimbursed by the EU in the following year, but, of course, if investments are lower some years, the subsidy will decrease proportionally, as stipulated in Eq. (8).

***Table 4**. Five-year EU subsidies expressed in millions of euros (current prices).*

	(1) Country	(2) I_{24} %	(3) Years – GBARD grow rate in % n – (r-1)	(4) G_{24} (mn)	(5) Subsidies S_{26-30} (mn)	(6) Subsidies S_{31-35} (mn)	(7) Subsidies S_{36-40} (mn)	(8) Subsidies S_{41-45} (mn)	(9) Total subsi. S_{26-45} (mn)
GROUP I	Romania	0.140	20–7.00%	397	160	504	987	1664	3315
	Ireland	0.191	20–7.00%	964	389	1224	2397	4041	8051
	Malta	0.213	20–7.00%	37.1	15	47	92	156	310
	Bulgaria	0.218	20–7.00%	187	75	238	465	784	1562
	Latvia	0.243	20–7.00%	93.4	38	119	232	392	781
	Hungary	0.307	20–7.00%	518	210	658	1288	2171	4327
	Lithuania	0.325	20–7.00%	219	88	278	545	918	1829
	Portugal	0.331	20–7.00%	802	323	1019	1994	3362	6698
			Partial sums	**3218**	**1298**	**4087**	**8000**	**13 488**	**26 873**
IIA	Slovakia	0.376	19–6.81%	412	161	506	984	1255	2906
	Cyprus	0.414	16–6.89%	115.2	46	144	280	77	547
	Poland	0.423	16–6.75%	2768	1074	3359	6528	1785	12 746
	Slovenia	0.539	9–6.86%	307	121	279	0	0	400
	Luxemb.	0.555	8–6.95%	430	172	272	0	0	444
	Czechia	0.567	8–6.67%	1567	600	943	0	0	1543
	Spain	0.595	7–6.47%	8002	2964	2822	0	0	5776
			Partial sums	**13 625**	**5138**	**8326**	**7791**	**3 117**	**24 372**
IIB	Croatia	0.654	5–5.85%	445	148				148
	Italy	0.654	5–5.86%	12 843	4274				4274
	France	0.678	5–5.10%	17 900	5131	-	-	-	5131
	Belgium	0.690	5–4.73%	3822	1011	-	-	-	1011
			Partial sums	**34 537**	**10 564**	-	-	-	**10 564**
IIC	Estonia	0.722	2–4.91%	260.3	14	-	-	-	14
	Sweden	0.728	2–4.54%	4094	198	-	-	-	198
			Partial sums	**4346**	**212**	**-**	-	-	**212**
	Totals (mn, current prices)			**55 726**	**17 212**	**12 413**	**15 791**	**16 605**	**62 021**
	Totals (bn, 2024 euros) (Data taken from Table A4 – p. 24)				**16.0**	**10.6**	**12.2**	**11.7**	**50.5**

In the table, **I_{24}**, **n**, **(r-1)** and **G_{24}**, (columns 2-4) were taken from Table 3 (p. 7). By introducing the values of n and r of column (3) into Eq. (7) (p. 9), the new resources in the 4 five-year periods were calculated which, multiplied by F = 0.35, give the subsidies of columns (5) – (9).

The sums of the four five-year grants are given in column (9) for **a total of 62 billion** (current prices), which is, of course, 35% of the 177.2 billion in Table 3 and is distributed over the four five-year periods in the sequence 17.2 billion, 12.4 billion, 15.8 billion and 16.6 billion. These values – translated in Table A4 (p. 24) into 2024 euros with a 2% inflation rate – correspond to **16.0** billion, **10.6** billion, **12.2** billion and **11.7** billion for a total of **50.5 billion** (2024 euros). The **2.5 billion** per year average (2024 euros) is equal to the amount paid in 2022 by the ***European Research Council***[19] and is therefore reasonable, as discussed in detail on p. 17.

For **Group I** countries, the factor multiplying **G_{24}**, to obtain column (9) from column (4), is 8.35, which is nothing else than the 23.87 of Fig. 3 on p. 8 multiplied by F = 0.35:

$$\mathbf{S_{26\text{-}(25+n)} / G_{24} = 0.35\,[H_n(r) - n] = 8.35}, \quad (r = 1.07,\ n = 20 \text{ years}) \qquad (10)$$

with $H_n(s)$ defined on page 9 by Eq. (7).

Column (9) of Table 4 shows that the most heavily subsidised countries are Poland (12.7 bn, current prizes), Ireland (8.1 bn), Portugal (6.7 bn), Spain (5.8 bn), France (5.1 bn) and Italy (4.3 bn). However, looking at absolute figures is misleading because EU subsidies are **proportional to G_{24}**, the GBARD of the reference year 2024, and countries with a smaller G_{24} necessarily receive fewer subsidies. Furthermore, different countries have different programme durations, and for a comparison it is necessary to consider inflation (chosen to be 2%) by calculating the subsidies in 2024 euros and dividing them by G_{24}, as done in Fig. 5.

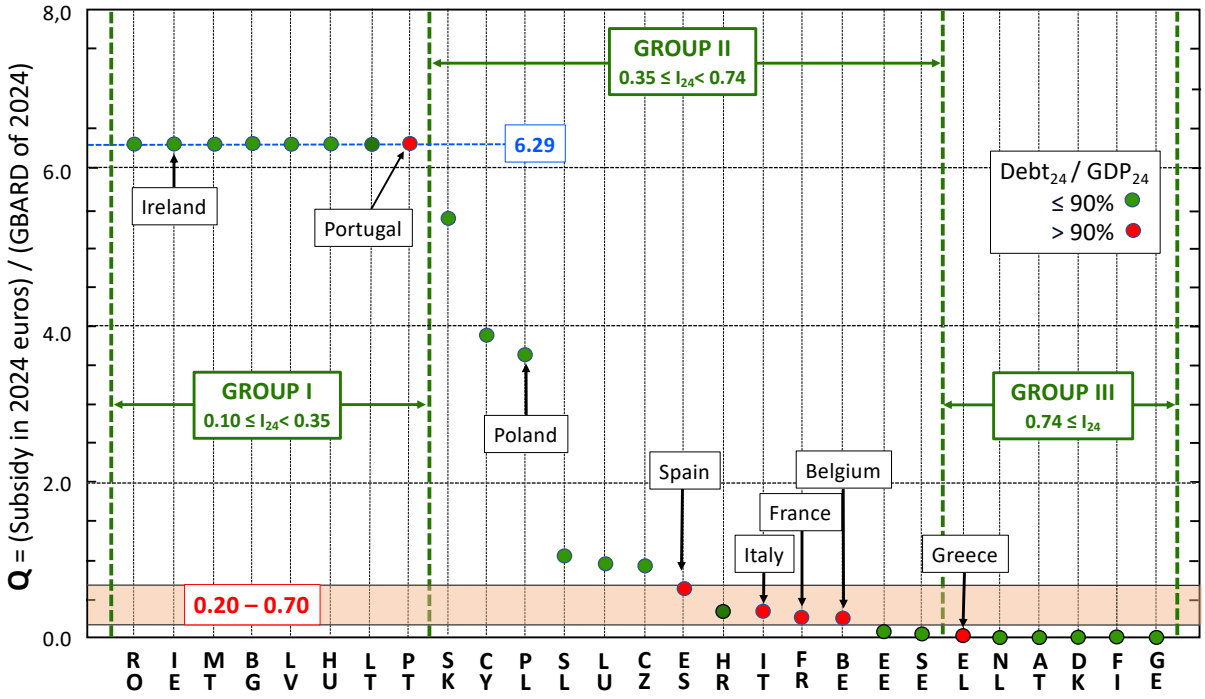

Figure 5. *For Group I countries, which do not reach 0.75% in 20 years, Fig. 3 shows that the ratio Q is equal to 0.35 x 17.98 = 6.29. This and the other data, used to draw this figure, are taken from Table A3 in the Appendix 1 (p. 22).*

[19] See p. 21 of https://op.europa.eu/en/publication-detail/-/publication/3a11d526-ceab-11ed-a05c-01aa75ed71a1

Indeed, in the figure the ratios **Q = (subsidy in 2024 euros) / (GBARD of 2024)** are plotted because these quantity measures the **real benefit** each country will derive from the 20-year Programme. The values for each country, taken from the last column of Table A2 (p. 21), were calculated from formula (A14) (p. 20):

$$\mathbf{Q =} \text{ (subsidy in 2024 euros) / } G_{24} = \mathbf{0.35}\ [\mathbf{H_n}(\frac{r}{g}) - \mathbf{H_n}(\frac{1}{g})]. \qquad (H_n(s) \text{ from Eq. (7)} \qquad (11)$$

Figure 5 shows that for **Estonia** and **Sweden**, which are in Group IIC, the ratio is below 0.10; as mentioned, these countries might decide to forego subsidies.

On the other hand, **Slovakia**, **Cyprus**, and **Poland**, with Q > 3.5, have a definite advantage, which is greatly reduced for **Slovenia**, **Luxembourg**, and **Czechia**.

Spain, **Croatia, Italy**, **France,** and **Belgium** are in the coloured band **0.20 ≤ Q< 0.70**, which indicates a lower advantage by a factor of ten compared to the Group I countries, to the extent that some of these countries might be induced not to join the Programme. This should be avoided so that all 27 countries, including those in Group III, participate in the structure that will be set up by the EU to implement the Programme.

In order to make the **Programme more attractive** for countries that are in the 0.20-0.70 coloured band one can choose to increase **F from 35% to 50%**, obviously for all countries. This is certainly a possibility, but it implies an increase in EU resources from EUR **50.5 billion** (2024 euros) to **72 billion**, with an annual average of 3.6 billion (2024 euros), **one and a half times** the resources distributed by the EU for scientific excellence.

Another measure, which can be considered as an alternative or additional, is **to decouple from the European Stability and Grow Pact** the additional government research investments. This change would benefit high-debt countries, four of which are among the five in the coloured band in Fig. 5, which indicates the countries that have the least to gain with respect to the GBARD of the year 2024.

It is appropriate, therefore, to leave open the possibility of adding a fourth rule, while emphasising the fact that it will be very difficult to get it approved by the so-called 'frugal' countries, which, by the way, belonging to Group III, have no direct benefit from the 20-year programme, although they do have indirect ones for increasing the long-term competitiveness of the Union.

In any case, it is necessary to place a limitation on unbundling, as done in this formulation:

D. For all 27 EU countries, increases in GBARDs compared to G_{24} in 2024

$$\mathbf{DG_{24+k} = (G_{24+k} - G_{24})} \qquad (1 \le k \le 20) \qquad (12)$$

are **not considered for** the purposes of the Stability and Grow Pact.

The fraction of the state budget may not be greater **than 1% of nominal GDP.**

Table A6 in the Appendix 1 (p. 25) shows that **Romania** reaches the 1% limit after 14 years, **Portugal** after 9, **Poland** after 8 and **Spain** after 7 years, right at the end of its Programme.

By contrast, the countries in Groups IIB and IIC never reach the 1% limit. Indeed, column (6) of Table A6 shows that **Italy**, **France**, and **Belgium** after 5 years, i.e. in 2029, are at **0.54%, 0.48%** and **0.45%** of GDP.

4. Overview

To mitigate the present unacceptable disparity in government R&D intensity, the adopted economic model foresees that, for the 21 countries whose 2024 level is less than 0.74%, the **sum of the GBARDs must be increased by 178 billion** (current prices) over 20 years. The effects of this investment can be seen qualitatively from Fig. 4 (p. 9) and, quantitatively, from the comparison of columns (4) and (8) in Table 5.

Table 5. *GDP, GBARD and government R&D intensity at the beginning and end of the Programme, which – as indicated in column (5) – has a different duration for each country.*

	(1) Country	(2) GDP 2024 GDP_{24} (bn)	(3) GBARD **2024** G_{24} (mn)	(4) Initial R&D intens. I_{24} %	(5) Duration **n** years – GBARD grow rate **(r-1)** %	(6) GDP 24+n G_{24+n} (bn)	(7) GBARD 24+n G_{24+n} (mn)	(8) Final R&D intens. I_{24+n} %	(9) Final GBARD 2024 € G'_{24+n} (mn)
GROUP I	Romania	284	397	0.140	20–7.00%	513	1536	0.300	1034
	Ireland	506	964	0.191	20–7.00%	914	3730	0.408	2510
	Malta	17.4	37.1	0.213	20–7.00%	31.5	144	0.456	97
	Bulgaria	85.8	187	0.218	20–7.00%	155	724	0.467	487
	Latvia	38.4	93.4	0.243	20–7.00%	69.5	361	0.520	243
	Hungary	168.9	518	0.307	20–7.00%	305	2004	0.657	1349
	Lithuania	67.4	219	0.325	20–7.00%	122	847	0.695	570
	Portugal	242.3	802	0.331	20–7.00%	438	3103	0.709	2088
IIA	Slovakia	109.6	412	0.376	19–6.81%	192	1440	**0.750**	988
	Cyprus	27.8	115.2	0.414	16–6.89%	44.6	33.5	**0.750**	244
	Poland	654.6	2768	0.423	16–6.75%	1050	7871	**0.750**	5734
	Slovenia	57.0	307	0.539	9–6.86%	74.4	558	**0.750**	467
	Luxemb.	77.5	430	0.555	8–6.95%	98.2	736	**0.750**	628
	Czechia	276.3	1567	0.567	8–6.67%	350	2627	**0.750**	2242
	Spain	1346	8002	0.595	7–6.47%	1655	12 411	**0.750**	10 805
IIB	Croatia	68.0	445	0.654	5–5.85%	78.8	591	**0.750**	535
	Italy	1963	12 843	0.654	5–5.86%	2276	17 074	**0.750**	15 464
	France	2639	17 900	0.678	5–5.10%	3059	22 954	**0.750**	20 790
	Belgium	554	3822	0.690	5–4.73%	642	4816	**0.750**	4362
IIC	Estonia	36.0	260.3	0.723	2–4.91%	38.2	286.5	**0.750**	275.4
	Sweden	562	4094	0.728	2–4.54%	596	4474	**0.750**	4300

In the economic model defined by **Rule A** (p. 8)

1. nominal GDP increases by 3% per year,
2. government R&D intensity grows no more than 3.88% per year,
3. the growth rate of GBARD is between 4.5% per year and 7% per year, as seen in column (5) of Table 5.

Obviously, at the end of its programme each country, in order to maintain the achieved government R&D intensity, will have to **continue to increase GBARD by 3% per year** – at its own expense – thereby offsetting the increase in nominal GDP.

It is unthinkable that a multi-annual programme of this importance should be adopted by (almost) all 27 countries **outside a general framework** approved by the EU and **without adequate incentives**. This is why **Rules B and C** (p. 10) stipulate that the EU will reimburse the countries **35%** of the resources (GBARD) invested to increase the R&D intensity (Table 4, p. 11), i.e. a total of **62 billion** (current prices), which corresponds to **50.5 billion** (2024 euros).

Table 6 shows how this 62 billion is distributed over the five-year periods of the Programme among the 21 countries in Groups I and II.

Table 6. *The subsidies of the European Union (in million euro at current prices), shown in rows 5-8, are justified by the data in Table 4 on page 11.*

		(1) Latvia Lithuania Bulgaria Malta Ireland Portugal Romania Hungary (**8 countries**)	**(2)** Belgium Czechia Cyprus Croatia Estonia France Italy Luxemb. Poland Slovenia Slovakia Spain Sweden (**13 countries**)	**(3)** Austria Denmark Finland Germany Greece Netherland (*) (**6 countries**)	**(4)** **Totals**
		GROUP I	**GROUP II**	**GROUP III**	
2024-END	1. R&D intensity (%) **in 2024.** I_{24}	0.14 – 0.34	0.35 – 0.74	0.75 – 1.1	
	2. Sums of **GBARD in 2024** G_{24}	3218	52 966	61 241	**117 425**
	3. **Duration** of the Programme **n**	20 anni	2-19 anni	-	
	4. R&D intensity **%** **end of Programme**	**0.30 – 0.71**	**0.75 – 0.75**	**(1.0 – 1.5)**	
SUBSIDIES	5. UE subsidies S_{26-30} First five years	1298	15 914	-	17 212
	6. UE subsidies S_{31-35} Second five years	4087	8326	-	12 413
	7. UE subsidies S_{36-40} Third five years	8000	7791	-	15 791
	8. UE subsidies S_{41-45} Fourth five years	13 488	3117	-	16 605
	9. UE subsidies S_{26-45} **Totals - bn current prices**	**26.9**	**35.1**	-	**62.0**

(*) The final intensities of the Group III countries are in brackets because it is not known by how much they will increase. The 1.5% maximum assumes that Germany will reach today's average of Japan and Korea (Table 3 on p. 7).

Table 4 also shows that the **six most subsidised countries** – which will receive about **70%** of the EU subsidies – are: Poland (12.7 bn), Ireland (8.1 bn), Portugal (6.7 bn), Spain (5.8 bn), France (5.1 bn) and Italy (4.3 bn) These numbers, however, give a distorted view of the

advantages because the EU resources have to be compared with G_{24}, which is the investment of each country in 2024, also taking inflation into account – as is done on page 12 in **Fig. 5** . This figure shows that the countries in **Group I** and, in addition, **Cyprus**, **Poland** and **Hungary** are actually the most advantaged.

Quite differently, **Belgium**, **Czechia**, **Croatia**, **France**, **Italy**, and **Spain** have a ratio of subsidies (in 2024 euros) to GBARD that is between **0.20 and 0.70**, which indicates a **lower advantage** by a factor of about ten compared to the Group I countries.

Since some of these countries could decide not to participate in the Programme, it is useful to consider ways to make the Programme more attractive.

There are at least **two alternatives**:

- to Increase the EU reimbursements from, say, **35% to 50%** of the required resources,
- to decouple GBARD increases from the **limits of the Stability and Grow Pact**, up to a maximum of 1% of GDP (Rule D, p. 13).

It has to be said that the **two measures are not comparable** because the former would increase the resources the EU would have to invest in the Programme by 40% – from 50.5 billion (2024 euros) to 72 billion – but this is just more resources, whereas the latter would give an additional advantage to four of the five countries in the coloured band in Fig. 5 (p. 13) but would change the EU's economic rules by going in a direction not easily acceptable to countries with low public debt.

* * *

Before closing this 'Overview', it is necessary to add an important specification and three remarks.

To manage the 20-year programme, the European Union will have to create a **dedicated structure**, in which **all 27 countries** will have to participate, even those that - being part of Group III - will not receive subsidies. In fact, these are the countries that have all the necessary expertise to help others achieve the Programme's objectives.

Three final remarks.

First, the **20-year Programme is fair** because,

- with rules B and C it subsidises all Group I and Group II countries **equally**,
- with rule D, should it be adopted, it would allow **all 27 EU countries** to decouple from the Stability and Grow Pact increases, with respect to 2024, in their own and the EU's total investment in research.

Secondly, **the 20-year Programme is ambitious** because – as shown in Fig. 4 on page 9 – after 5-20 years the R&D intensity of the 21 EU countries, currently below 0.75%, will be:

- 0.75% **for 13 countries** (Group II): Belgium, Czechia, Cyprus, Croatia, Estonia, France, Italy, Luxembourg, Poland, Slovakia, Slovenia, Spain and Sweden;
- around 0.70% **for 3 countries** in Group I: Lithuania, Portugal and Hungary;
- between 0.40% and 0.50% **for 4 Group I countries**: Bulgaria, Latvia, Malta and Ireland;

- 0.30% for **Romania**, starting in 2024 with an intensity of 0.14%.

It has to be underlined that, in order to maintain the R&D intensity achieved, each country – after the **n years** indicated in column (5) of Table 5 – must continue to increase its GBARD **at its own expense** by 3% per year to compensate for nominal GDP growth.

Thirdly, **the EU investment is reasonable**. As shown in Fig. 6, over the four five-year periods the EU will have to invest **16.0** billion – **10.6** billion – **12.2** billion – **11.7** billion for a **total of 50.5 million** (2024 euros)[20]. In the 2025-2044 period, the average investment of **2.5 billion per year** (2024 euros) will be equal to the resources spent by the EU in 2022, and carried over to 2024, on grants from the **European Research Council**[21] that subsidise European researchers, especially young ones, regardless of nationality but solely on the basis of scientific excellence.

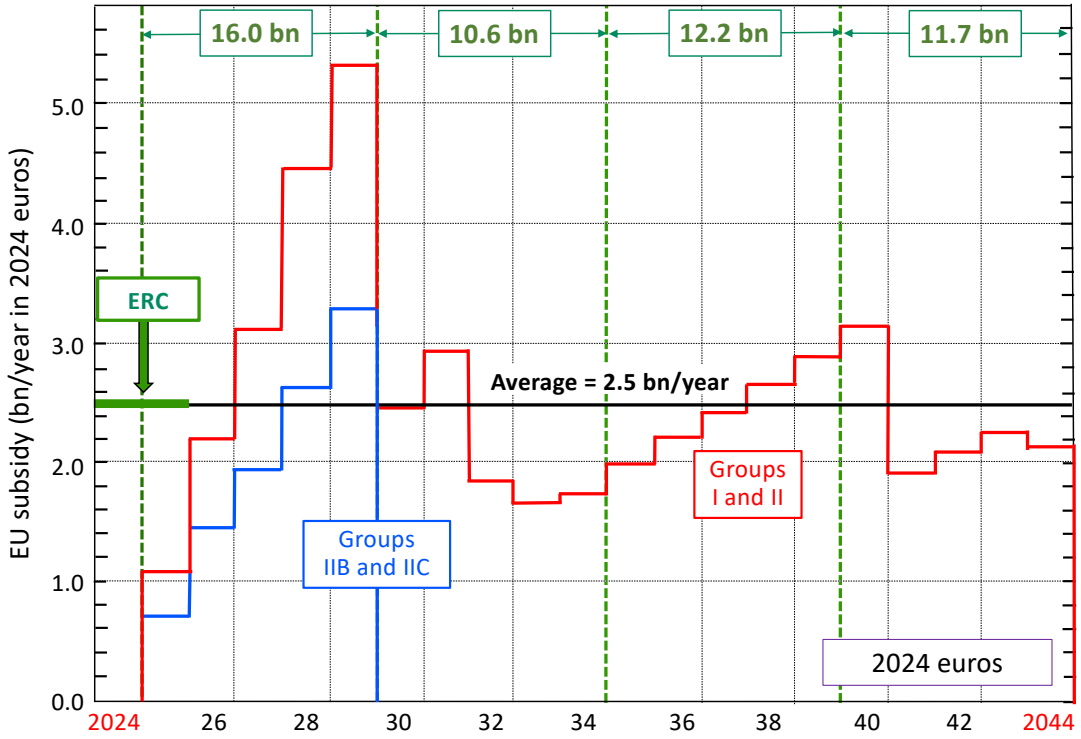

***Figure 6**. The red histogram (from Table A4 on page 24) gives the distribution of the **50.5 billion** (2024 euros) invested by the EU. The peak at 5 years is due to the Group IIB and IIC countries, which reach the target in 5 years (blue histogram). The other countries need between 7 and 20 years.*

It is, indeed, more than reasonable to **invest as much** in the Union's government research systems in order to create the necessary conditions so that researchers, especially young researchers, and teams of researchers from **all the countries** of the Union have at their disposal the means and research infrastructures they need to contribute to Europe's long-

[20] In Table A7 (p. 26) it is shown that, in the simple model used, this amount *does not change* when the inflation rate is increased from 2.0% to 2.5% so that the GDP growth rate goes from 3.0% to 3.5%. However, the final R&D intensities of Group I countries decrease by 10% and the durations of the programmes of Group IIA countries increase by about 15%. As shown on p. 27, the same effects happen if the GBARDs increase by 6.5% per year, instead than by 7.0% per year, and the inflation by 2.0% per year.

[21] See p. 21 of https://op.europa.eu/en/publication-detail/-/publication/3a11d526-ceab-11ed-a05c-01aa75ed71a1

term development and can also compete, under the same conditions as other European researchers and without the need to emigrate, in the Union's programmes focused on scientific excellence.

* * *

In conclusion, it must be strongly emphasised **that the investments made over the 20 years of the Programme will only be effective for Europe's long-term development if, in parallel, each country will promote specific programmes, centred on the themes listed in Section 1 on page 3.**

Acknowledgements

We are very grateful to Rossana Camilloni and Giovanni Stefani for their stimulating critical remarks, thorough re-reading, checking of calculations and suggestions for corrections and improvements.

APPENDIX 1

Calculation of Programme Durations for Different Countries and Required Resources

Using the symbol **f** to denote the (fractional) number of years that are needed to go – with a GBARD grow rate oequal to (r-1) – from $\mathbf{I_{24}} = G_{24}/PIL_{24}$ (initial government R&D intensity) to $\mathbf{I_{24+f}} = G_{24+f} / PIL_{24+f} = \mathbf{0.75\%}$, with a **3% annual increase** in nominal GDP (**p = 1.03**), one can write

$$r^f G_{24} / (p^f PIL_{24}) = (r/p)^f I_{24} = 0.75\%, \qquad (A1)$$

from which one derives

$$\mathbf{r} = (0.75/\mathbf{I_{24}})^{1/\mathbf{f}}, \qquad (\mathbf{I_{24}} \text{ in \%; } p = 1.03) \qquad (A2)$$

and also

$$\mathbf{f} = \ln(0.75/\mathbf{I_{24}}) / \ln(\mathbf{r}/1.03). \qquad (\mathbf{I_{24}} \text{ in \%; } p = 1.03) \qquad (A3)$$

Having fixed the intensity I_{24}, Eqs. (A2) and (A3) give the infinite number of pairs f - (r -1) leading to 0.75%. In the specific case r = 1.07 and p = 1.03, Eq. (A3) becomes

$$\mathbf{f} = 26.25 \ln(0.75/\mathbf{I_{24}}) \qquad (r = 1.07;\ p = 1.03) \qquad (A4)$$

* * *

To calculate the **new resources** $\mathbf{R_{25-(24+j)}}$ during the n years of each country's Programme, it is useful to consider the case n = 5 and calculate the sum $\Sigma_{k=1\to n}\, DG_{24+k}$ of the increases $DG_{24+k} = (G_{24+k} - G_{24})$ **with respect to 2024**, with k ranging from 1 to 5:

$$\mathbf{R_{25-(24+n)}} = \Sigma_{k=1\to n}\, \mathbf{DG_{24+k}} = G_{24}(r^1 - 1) + G_{24}(r^2 - 1) + G_{24}(r^3 - 1) + G_{24}(r^4 - 1) + G_{24}(r^5 - 1) =$$

$$= \mathbf{G_{24}}\,[\,\mathbf{r}\,(\mathbf{r^n} - 1)/(\mathbf{r} - 1) - \mathbf{n}\,]. \qquad (n = 1, 20;\ \text{in the example: } n = 5) \qquad (A5)$$

where the sum of a geometric progression $\sum_{k=1}^{n} x^k = x\,(x^n - 1) / (x - 1)$ was used.

It is useful for the following to define the function

$$\mathbf{H_n(s)} = s\,(s^n - 1)/(s - 1) \qquad \text{so that} \qquad \mathbf{R_{25-(24+n)}} = \mathbf{G_{24}}\,[\mathbf{H_n}(r) - \mathbf{n}]. \qquad (A6)$$

To obtain the subsidies paid in n years by the EU (the following year), one has to multiply Eq. (A6) by the F-factor of rule C (p. 10):

$$\mathbf{S_{26-(25+n)}}\ \ \mathbf{F\ R_{25-(24+n)}} = \mathbf{F\ G_{24}}\,[\mathbf{H_n}(r) - \mathbf{n}]. \qquad (n = 1, 20) \qquad (A7)$$

For r = 1.07, n = 20 and F = 0.35 this equation becomes

$$\mathbf{S_{26-45}} = 23.87\ \mathbf{F\ G_{24}} = \mathbf{8.35\ G_{24}} \qquad (F = 0.35;\ r = 1.07;\ n = 20) \qquad (A8)$$

(In the following, and **up to page 25**, the annual growth rate of GBARD is assumed to be **p = 1.03**.)

To obtain the subsidies in the time interval from m to n years, it is sufficient to calculate the difference

$$\mathbf{S_{(25+m)-(25+n)}} = \mathbf{S_{26-(25+n)}} - \mathbf{S_{26-(25+m)}}. \qquad (n > m;\ m, n = 1, 20) \qquad (A9)$$

* * *

In the above formulae the yearly amounts have been summed so that the results are at 'current prices'. To calculate the **new resources $T_{25-(24+n)}$ in '2024 euros'**, each term of Eq. (A5) has to be divided by the inflation factor g (in the model: g = 1.02):

$$\mathbf{T_{25-(24+n)}} = G_{24}\,(r^1 - 1)/g^1 + G_{24}\,(r^2 - 1)/g^2 + G_{24}\,(r^3 - 1)/g^3 + G_{24}\,(r^4 - 1)/g^4 + G_{24}\,(r^5 - 1)/g^5 + \ldots =$$

$$= G_{24}\{\,[(\tfrac{r}{g})^1 - (\tfrac{1}{g})^1] + [(\tfrac{r}{g})^2 - (\tfrac{1}{g})^2] + [(\tfrac{r}{g})^3 - (\tfrac{1}{g})^3] + [(\tfrac{r}{g})^4 - (\tfrac{1}{g})^4]\;\; [(\tfrac{r}{g})^5 - (\tfrac{1}{g})^5] + \ldots.\}$$

$$\mathbf{T_{25-(24+n)}} = G_{24}\;[\mathbf{H_n}(\tfrac{r}{g}) - \mathbf{H_n}(\tfrac{1}{g})]. \qquad \text{(A10)}$$

In writing Eq. (A10), the function $H_n(s)$ defined by formula (A6) was used.

It should be noted that – with 1/g = (1 - x) and x tending to 0 – the function $H_n(1/g)$ tends to n so that for g = 1, **Eq. (A10) becomes Eq. (A6**).

Table A1 shows (for r = 1.07 and g = 1.02) the values of the two functions $\mathbf{H_n(r/g)}$ and $\mathbf{H_n(1/g)}$ and their difference $\mathbf{L_n}$, which, for Eq. (A10), is proportional to the new resources $\mathbf{T_{25-(24+n)}}$ expressed in 2024 euros. The new resources $\mathbf{R_{25-(24+n)}}$ (**current prices**) of Eq. (6) are proportional to $\mathbf{M_n} = [H_n(1.07) - n]$.

Table A1 *Values of $H_n(x)$ and their combinations with r = 1.07; g = 1.02, r/g = 1.04902, 1/g = 0.9804; 1/(1- 1/g) = 50.00. The functions L_n and M_n are depicted on page 9 in Fig. 3.*

n	2	5	7	8	9	16	19	20
$H_n(r/g = 1.0490)$	2.1495	5.7848	8.515	9.981	11.519	24.61	31.72	34.32
$H_n(1/g = 0.9804)$	1.9408	4.712	6.469	7.325	8.159	13.57	15.67	16.35
$L_n = H_n(1.049) - H_n(0.98)$	**0.2087**	**1.0728**	**2.046**	**2.656**	**3.360**	**11.04**	**16.05**	**17.98**
$M_n = H_n(1.07) - n$	**0.2149**	**1.1533**	**2.260**	**2.978**	**3.816**	**13.84**	**21.00**	**23.87**
$Z_n = L_n / M_n$	**0.971**	0.930	0.905	0.891	0.881	0.798	0.764	**0.753**
0.72 n: exp. of Eq. A11	1.44	3.60	5.04	5.76	6.48	11.5	13.7	14.4

The penultimate line gives the ratio $\mathbf{Z_n}$ between the resources in euros of 2024 (proportional to L_n) and those in current prices euros (M_n). Z_n tells how much the value of an investment lasting **n** years changes from 2024 euros to current prices euros: the ratio decreases from 97% to 75% when the investment is spread over 20 years instead of being concentrated in 2 years.

The last row of the table says that, to a good approximation, the ratio $\mathbf{L_n / M_n}$ can be calculated using the simple formula s

$$Z_n = L_n / M_n = 1/g^{\mathbf{0.72\,n}} \qquad (r = 1.07;\ g = 1.02). \qquad \text{(A11)}$$

To compute the new resources in current prices and in 2024 euros it is useful to introduce the quantities U and V

$$\mathbf{U} = R_{25-(24+n)} / G_{24}; \qquad \mathbf{V} = T_{25-(24+n)} / G_{24}; \qquad \mathbf{P = V / U} \qquad \text{(A12)}$$

which are given by the formulae

$$\mathbf{U} = R_{25-(24+n)} / G_{24} = [\mathbf{H_n(r)} - \mathbf{j}] \qquad \text{(A13)}$$

$$\mathbf{V} = T_{25-(24+n)} / G_{24} = [\mathbf{H_n}(\tfrac{r}{g}) - \mathbf{H_n}(\tfrac{1}{g})] \qquad \text{(A14)}$$

with the function $H_n(s)$ defined in Eq. (A6).

In columns (5)-(8) of Table A2, the values of the four quantities U, V, P = V/U and Q =0.35xV with g =1.02 are collected for all countries in Groups I and II.

Table A2 *- Values of parameters U, V, and R for an inflation factor g = 1.02 with (r = 1.07 and p = 1.03 to compute n).*

	(1) Country	(2) GBARD 2024 G_{24} (mn)	(3) Resources $R_{25-(24+n)}$ (mn)	(4) Years **n** and rate **(r-1)** from Table 3	(5) **U** **(curr. prices)**	(6) **V** **(2024 euros)**	(7) **P = V/U**	(8) **Q = 0.35 V**
GROUP I		**3217.5**	**76 780**	20–7.00%	**23.865**	**17.979**	**0.7534**	**6.293**
GROUP IIA	Slovakia	412	8303	19–6.81%	20.155	15.413	0.7647	5.395
	Cyprus	115.2	1563	16–6.89%	13.538	10.803	0.7980	3.781
	Poland	2768	36 795	16–6.75%	13.158	10.503	0.7982	3.676
	Slovenia	307	1142	9–6.86%	3.7254	3.2782	0.8800	1.147
	Luxemb.	430	1269	8–6.95%	2.9532	2.6343	0.8920	0.922
	Czechia	1567	4409	8–6.67%	2.8149	2.5110	0.8290	0.879
	Spain	8002	16 503	7–6.47%	2.0660	1.8684	0.9044	0.654
IIB	Croatia	445	423	5–5.85%	0.9490	0.8818	0.9292	0.309
	Italy	12 843	12 210	5–5.86%	0.9508	0.8818	0.9275	0.309
	France	17 900	14 661	5–5.10%	0.8191	0.7611	0.9292	0.266
	Belgium	3822	2889	5–4.73%	0.7559	0.7024	0.9292	0.246
IIC	Estonia	260.3	41	2–4.91%	0.1497	0.1451	0.9692	0.051
	Sweden	4094	566	2–4.54%	0.1382	0.1337	0.9670	0.047
Totals and weighted average		**61 243**	**177 180**				**0.8135**	

Column (7) shows that the weighted average of the V/U ratios is **81.35%**. This means that the 0.35 x 177.2 billion = **62 billion** (current prices), reimbursed by the Union, corresponds to 0.8135 x 62 = 50.5 billion (2024 euros), so that in 20 years the average is **2.5 billion per year**.

The quantity Q of column (8), obtained by multiplying Eq. (A14) by F = 0.35, measures how much the EU subsidies (expressed in 2024 euros) are greater than G24:

$$\mathbf{Q = (subsidy\ in\ 2024\ euros)\ /\ G_{24}} = 0.35\ V. \qquad \text{(A15)}$$

The values of Q in column (8) are graphed in **Fig. 5** on p. 13.

* * *

To calculate the figures in Tables A3 and A4, it should be noted that the **new resources** (with respect to the previous year) expressed in **2024 euro** can be read from Eq. (A10)

$$\mathbf{T_{25-(24+n)}} = G_{24}\,(r^1 - 1)/g^1 + G_{24}\,(r^2 - 1)/g^2 + G_{24}\,(r^3 - 1)/g^3 + G_{24}\,(r^4 - 1)/g^4 + G_{24}\,(r^5 - 1)/g^5 + \ldots..$$

because they are nothing more than the terms of this progression. One has, therefore,

$$\text{(new resources needed in the k}^{\text{th}}\text{ year – 2024 euros)} = G_{24}\,[(\tfrac{r}{g})^k - (\tfrac{1}{g})^k]. \qquad \text{(A16)}$$

This is the formula used to calculate the figures in Tables A3 and A4.

Table A3. *The new resources needed in the k-th year and expressed in* ***2024 euros*** *are calculated with Eq. (A16) (g = 1.02; r = 1.07; p = 1.03).*

(1) Country	**(2)** Years – per cent with inflation **n – (r/g-1)**	**(3)** G_{24} (mn) **$1/g^k$**	**(4)** **Year k =1** (mn) 0.9804	**(5)** **Year 2** (mn) **0.**9612	**(6)** **Year 3** (mn) 0.9423	**(7)** **Year 4** (mn) 0.9238	**(8)** **Year 5** (mn) 0.9057	**(9)** **Year 6** (mn) 0.8880	**(10)** **Year 7** (mn) 0.8706
Group I	20–4.902%	**3218**	**221**	**448**	**682**	**924**	**1173**	**1431**	**1697**
Slovakia	19–4.716%	412	27.5	56	85	115	146	177	210
Cyprus	16–4.804%	115.2	7.8	15.8	24.0	32.6	41.3	50.4	5.6
Poland	16–4.657%	2768	183	371	565	764	968	1179	1397
Slovenia	9–4.755%	307	20.6	41.9	6.,6	86.1	109	131	158
Luxemb.	8–4.853%	430	29.3	59.3	90.5	122	156	189	225
Czechia	8–4.578%	1567	102	208	315	426	541	658	780
Spain	7–4.372%	8002	507	1025	1558	2104	2664	3239	3829
Group IIA			**877**	**1777**	**2701**	**3650**	**4625**	**5623**	**6659**
Croatia	5–3.784%	445	25.5	51.6	78.2	105	133	-	-
Italy	5–3.784%	12 843	738	1489	2255	3036	3832	-	-
France	5–3.039%	17 900	895	1799	2715	3641	4578	-	-
Belgium	5–2.676%	3822	177	355	536	717	899	-	-
Estonia	2–3.059%	260	13.1	26.1	-	-	-	-	-
Sweden	2–2.490%	4094	182	365	-	-	-	-	-
Groups IIB and C			**2030**	**4086**	**5584**	**7499**	**9442**	**-**	**-**
Totals			**3129**	**6311**	**8967**	**12 073**	**15 240**	**7054**	**8354**
From this Table and Table A4 (p. 24):1° five-years period – **bn**						**45.72**			

(1) Country	**(2)** Years– per cent with inflation **n – (r/g-1)**	**(3)** G_{24} (mn) **$1/g^k$**	**(11)** **Year 8** (mn) 0.8535	**(12)** **Year 9** (mn) 0.8368	**(13)** **Year 13** (mn) 0.7730	**(14)** **Year 16** (mn) 0.7284	**(15)** **Year 18** (mn) 0.7002	**(16)** **Year 19** (mn) 0.6864	**(17)** **Year 20** (mn) 0.6864
Group I	20–4.902%	**3218**	**1973**	**2258**	**3507**	**4576**	**5362**	**5780**	**6215**
Slovakia	19–4.716%	412	245	279	432	561	657	706	
Cyprus	16–4.804%	115.2	69.3	79.3	113	160	-	-	-

Poland	16–4.657%	2768	1621	1853	2862	3718	-	-	-
Slovenia	9–4.755%	307	183	209			-	-	-
Luxemb.	8–4.853%	430	261	-	-	-	-	-	-
Czechia	8–4.578%	1567	905	-	-	-	-	-	-
Spain	7–4.372%	8002	-	-	-	-	-	-	-
Group IIA			**3299**	**2438**	**3403**	**4440**	**609**	**657**	**706**
Croatia	9471	445	-	-	-	-	-	-	-
Italy	23 003	12 843	-	-	-	-	-	-	-
France	886	17 900	-	-	-	-	-	-	-
Belgium	4463	3822	-	-	-	-	-	-	-
Estonia	2231	260	-	-	-	-	-	-	-
Sweden	12 363	4094	-	-	-	-	-	-	-
Group IIB e IIC	5226								
Totals		19 137	**5257**	**4674**	**6920**	**9015**	**5570**	**6019**	**6215**
Five-years periods – **bn**		**76 780**	6-10: **30.39**		11-15: **34.74**		16-20: **33.30**		

The numbers are many and at least two checks are necessary, one local and the other global.

First check.

For **France** and **Italy**, Table (A2) reads **V** = $T_{25\text{-}29}$ / G_{24} = 0.761 and 0.8842. Multiplied by G_{24}, these factors give the new resources in 2024 euros in the five-year period 2025-2029: 13,624 mn and 11,325 mn. These values coincide within 2 per thousand with the sums of the five numbers in Table A3: 13,625 mn and 11,348 mn.

Second check.

In **Table A4** (which completes Table A3) are the new resources (2024 euros) needed year by year (in blue - second and fifth rows), the subsidies (in red - third and sixth rows) – obtained by multiplying the new resources by F = 0.35 – and, in the seventh row, the **five-years new resources** (in blue) and the five-year EU subsidies (in red).

Multiplying the euros (current prices) in Table A2 by the weighted average of Q (Table A2) gives 177.18 x 0.8135 = 144.14 (2024 euros), which is equal to the sum of the five-years new resources (2024 euros) needed in the four five-year periods, which can be read in the penultimate line of Table A4 (p. 23):

45.72 + 30.39 + 34.74 + 33.30 = **144.15**.

It should be added that the histogram of **Fig. 6 (p. 17)** was constructed with the data of Table A4.

Table A4. *The new resources expressed year by year* ***in million2024 euros*** *(**in blue**), are shown in the first and third rows and give – multiplied by F= 0.3 – the EU subsidies (2024 euros; **in red**). The five-year and total amounts are shown in the last two rows.*

Year	1	2	3	4	5	6	7	8	9	10
(1) Resources	3129	6311	8967	12073	15240	7054	8354	5257	4674	5051
(2) Subsidies	1095	2209	3138	4226	5334	2469	2924	1840	1636	1768
Year	11	12	13	14	15	16	17	18	19	20
(3) Resources	5717	6276	6920	7533	8291	9015	5570	6019	6482	6215
(4) Subsidies	2001	2197	2422	2637	2902	3155	1950	2107	2269	2175

1st five-years	2nd five-years	3rd five-years	4th five-years
45-72 – 16.00 bn	30.39 – 10.64 bn	34.74 – 12.16 bn	33.30 – 11.66 bn

Totals (in **n years** for each country) (*) **= 144.2** (Resources, euro 2024) – **50.5 bn** (Subsidies, euro 2024)

(*) In order to maintain the R&D intensity achieved, each country – after the **n years** indicated in column (2) of Table A3 – must increase the GBARD **at its own expense** by 3% per year to compensate for nominal GDP growth.

* * *

To put **rule D** on p. 13 into practice, it is necessary to calculate after how many years the resources in eq. (A6) become greater than 1% of $GDP_{24+j} = 1.03^{\,j}\, GDP_{24}$ of year (24+j).

The relative inequality is

$$R_{25-(24+j)} / (1.03^j\, PIL_{24}) = \mathbf{I_{24}}\, \{\mathbf{r}\,(\mathbf{r}^j - 1) / (\mathbf{r} - 1) - \mathbf{j}\} / 1.03^j < 0.01 \qquad (j = 1, 20) \qquad (A17)$$

and, therefore, the ma**ximum j** must be found for which

$$\mathbf{100\, I_{24} < W_j(r)} \quad \text{with} \quad \mathbf{W_j(r) =}\ 1.03^j / \{\mathbf{r}\,(\mathbf{r}^j - 1)/(\mathbf{r} - 1) - \mathbf{j}\} = \mathbf{1.03^j / \{Hj(r)} - j\} \qquad (A18)$$

The values of Wj(r) are collected in Table A5 for r = 1.07 and r = 1.065.

Table A5. *The functions $\{H_j(r) - j\}$ and $W_j(r)$ have been computed for two values of r (p = 1.03).*

j	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Hj(1.07) - j					1.153	1.654	2.260
W_j(1.07)					1.010	0.722	0.544
Hj(1.065) - j					1.064	1.523	2.077
W_j(1.065)					1.090	0.784	0.592
J	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Hj(1.07) - j	2.978	3.816	4.784	5.888	7.143	8.550	10.13
W_j(1.07)	0.425	0.341	0.281	0.235	0.200	0.172	0.149
Hj(1.065) - j	2.732	3.494	4.371	5.370	6.500	7.767	9.182
W_j(1.065)	0.463	0.373	0.307	0.258	0.219	0.189	0.165
j	**15**	**16**	**17**	**18**	**19**	**20**	
Hj(1.07) - j	11.89	13.84	16.00	18.38	21.00	23.87	
W_j(1.07)	0.131	0.116	0.103	0.0926	0.0835	0.0767	
Hj(1.065) - j	10.75	12.49	14.41	16.52	18.83	21.35	
W_j(1.065)	0.145	0.128	0.115	0.1031	0.0931	0.0846	

The data from this table were used to calculate column (5) of Table A6.

Table A6. *Years needed to reach 1% of nominal GDP (column 5) and GDP percentage at the end of the programme (column 6).*

(1)	**(2)** Country	**(3)** Years– per cent increase **n – (r-1)**	**(4)** **100 I_{24} = 100 x GDP_{24}/G_{24}**	**(5)** **Years j** for 1% from G(j) of Table A5	**(6)** **%** at the end of each Programme
1-RO	Romania	**20**–7.00%	0.140	14	-
2-IE	Ireland	20–7.00%	0.191	12	-
3-MT	Malta	20–7.00%	0.213	11	-
4-BG	Bulgaria	20–7.00%	0.218	11	-
5- LV	Latvia	20–7.00%	0.243	10	-
6-HU	Hungary	20–7.00%	0.307	9	-
7-LT	Lithuania	20–7.00%	0.325	9	-
8-PT	Portugal	20–7.00%	0.331	9	-
9-SK	Slovakia	19–6.81%	0.376	9	-
10-CY	Cyprus	16–6.90%	0.414	8	-
11-PL	Poland	16–6.75%	0.423	8	-
12-SI	Slovenia	9–6.86%	0.539	7	-
13-LU	Luxemb.	8–6.95%	0.555	7	-
14-CZ	Czechia	8–6.67%	0.567	7	-
15-ES	Spain	7–6.47%	0.595	7	-
16-HR	Croatia	5–5.85%	0.654	-	0.54%
17-IT	Italy	5–5.86%	0.654	-	0.54%
18-Fr	France	5–5.10%	0.678	-	0.48%
19-BE	Belgium	5–4.73%	0.690	-	0.45%
20-EE	Estonia	2–4.91%	0.722	-	0.10%
21-SE	Sweden	2–4.54%	0.728	-	0.10%

Column (5) of Table A6 reads that Romania reaches 1% after 14 years, Portugal after 9, Poland after 8 and Spain after 7 years, right at the end of its Programme.

By contrast, the countries in Groups IIB and IIC do not reach 1%; column (6) shows that Italy, France, and Belgium after 5 years are at **0.54%**, **0.48%** and **0.45%** of GDP in 2029.

* * *

The resources in Table A3 are calculated (in 2024 euros) with Eq. (A16) for an annual increase in **GDP** equal to **(p-1) =3.0%** (of which **(g -1) = 2.0%** is assumed to be due to inflation) combined with a maximum annual increase in GBARD **(r-1) = 7%** but it is interesting to compute the effect a change in parameters would have.

Table A7 shows that if GDP increases by **(p-1) = 3.5%** per year (with inflation (**g -1) = 2.5%**),

- Slovakia passes from Group IIA to Group I,
- the total resources required are **144.6** bn (2024 euros), an amount that is identical to the **144.2 bn** of Table A4 (p.24) obtained with **(p-1) = 3.0%** and (**g -1) = 2.0%**.

This very interesting result is due to a cancellation: the resources needed for Group I countries **decrease by 5 bn** from 57.8 bn (= 0.7534 x 76.8, as shown in the first line of Table A2) to 52.7 bn (Group I in Table A7 without Slovakia) while the resources needed for the countries of Group II increase by the same amount.

Table A7. *With inflation factor* ***g = 1.025*** *and GDP growth rate (p-1) = 3.5% –the years* ***n*** *are in column (7) and the resources* $T_{25\text{-}(24+n)}$ *(**2024 euros**, Eq A10) are in column (8). Column (9):* $\mathbf{I_{24+n} = (r/p)^n\, I_{24}}$.

(1) **Country**	**(2)** $H_n(\frac{1}{g})$	**(3)** GBARD 2024 $\mathbf{G_{24}}$ (mn)	**(4)** PIL 2024 $\mathbf{PIL_{24}}$ (bn)	**(5)** R&D inten. 2024 $\mathbf{I_{24}}$ (%)	**(6)** Years **f** from E(A3)	**(7)** Years **n** – GBARD growth rate **(r-1)** from Eq. (5)	**(8)** **Resources 2024 euros** $\mathbf{T_{25\text{-}(24+n)}}$ Eq. A10 (mn)	**(9)** R&D Inten. final $\mathbf{I_{24+n}}$ (%)
Romania	15.98	397	284	0.140	50.4	20–7.00%	6508	0.272
Ireland	15.98	964	506	0.191	41.1	20–7.00%	15 800	0.371
Malta	15.98	37.1	17.4	0.213	37.9	20–7.00%	608	0.414
Bulgaria	15.98	187	85.8	0.218	37.2	20–7.00%	3065	0.424
Latvia	15.98	93.4	384	0.243	33.9	20–7.00%	1531	0.473
Hungary	15.98	518	1689	0.307	26.9	20–7.00%	8490	0.597
Lithuania	15.98	219	67.4	0.325	25.1	20–7.00%	3589	0.632
Portugal	15.98	802	242.3	0.331	24.6	20–7.00%	13 144	0.644
Slovakia	15.98	412	109.6	0.376	20.8	20–7.00%	6753	0.731
GROUP I (0.10% ≤ I_{24} < 0.385%)							**59 488**	
Cyprus	14.71	115.2	27.8	0.414	17.9	18–6.97%	2104	0.750
Poland	14.71	2768	654.6	0.423	17.2	18–6.85%	49 295	0.750
Slovenia	8.970	307	57.0	0.539	9.93	10–6.98%	1463	0.750
Luxemb.	8.970	430	77.5	0.555	9.05	10–6.66%	1936	0.750
Czechia	8.170	1567	276.3	0.567	8.41	9–677%	5747	0.750
Spain	6.508	8002	1346	0.595	6.96	7–6.98%	18 024	0.750
GROUP IIA (0.385% ≤ I_{24} < 0.60%)							**78 569**	
Croatia	4.762	445	68.0	0.654	4.12	5–6.37%	371	0.750
Italy	4.762	12 843	1963	0.654	4.12	5–6.37%	10 708	0.750
France	4.762	17 900	2639	0.678	3.03	5–5.61%	12 744	0.750
Belgium	4.762	3822	554	0.690	2.53	5–5.24%	2498	0.750
GROUP IIB (0.60% ≤ I_{24} < 0.70%)							**26 321**	
Estonia	1.976	260.3	36.0	0.722	1.14	2–5.49%	30	0.750
Sweden	1.976	4094	562	0.728	0.90	2–5.05%	406	0.750
GROUP IIC (0.70% ≤ I_{24} < 0.74%)							**436**	
TOTAL - 2024 euros		**61 242**	21 countries with I_{24} < 0.74%				**144 623**	
Subsidy with **F = 0.35** bn (2024 euros)							**50.6**	

It is a positive fact that, by increasing the inflation factor from g = 1.02 to g = 1.025 (and the GDP growth factor from p = 1.03 to p = 1.035), the new **resources expressed in 2024 euros**, and thus the EU subsidies, **do not change**, but there are two negative consequences:

a) for **Group I countries**, the final values of the government R&D intensities, which are listed in column (9), **decrease by 10%** since $(r/p)^{20}$ passes from $(1.07/1.03)^{20} = 2.14$ to $(1.07/1.035)^{20} = 1.94$;

b) for Group IIA countries, Programme durations **f** increase by about **15%,** as can be verified by observing that Eq. (A4) becomes f = 30.07 ln(0.75/I24) and that 30.07/26.25 = 1.145.

A minor effect has already been mentioned: Slovakia drops from Group IIA to Group I and reaches 0.73% in 20 years instead than 0.75% in 19 years.

* * *

Thus, with a GBARD increase of 7% per year, the needed resources do not change when inflation increases from 2.0% to 2.5% and the annual increase in GDP increases so that p = 1.03 becomes p = 1.035. It is also interesting to analyse what happens when **r decreases from 1.07 to 1.065** while maintaining g = 1.02 and p = 1.03.

Since in the two cases r/p = 1.065/1.03 = **1.0340** and r/p = 1.07/1.035 = **1.0338**, it follows that the two exponentials 1.0340^{20} = 1.952 and 1.0338^{20} = 1.944 are practically identical, as are the logarithms ln(r/p) of Eq. (A3). This implies that the above-mentioned properties a**) and b) also apply in the case r = 1.065.**

In the case r = 1.065, however, the resources required are approximately **10% less than the 62 million** (current prices) in the case r = 1.07, as can be seen by calculating - from the data in Table A5 (p. 24) - some typical ratios between the two quantities that are proportional to the resources required for r = 1.07 and r = 1.065:

$\{H_j(1{,}07) - j) / \{H_j(1{,}065) - j)$ = **1.084** (5 a); **1.094** (10 a); **1.106** (15 a); **1.118** (20 a). (A19)

APPENDIX 2

20-year Plan with the GRARD-2023 used for GBARD-2025 and 2025 as reference year

As mentioned at the beginning of Section 2 (p. 6), in this Appendix, **data on GBARDs and GDPs for 2023 are used for 2025**, taken as the reference year. The purpose is to compare them with the results described in the main text and in Appendix 1, which are obtained by using the **GBARDs and GDPs of 2022** and applying them to 2024, chosen as the reference year.

Table 3bis. *Duration n, growth rate of GBARD and Resources (current prices) with GDP at +3%/year.* ***In each box, the first row shows the data from Table 3 for the 2025-2044 period (p. 7) and the second row refers to the 2026-2045 period.***

(1)	**(2)** Country	**(3)** Debt/ GDP 2025 **D_{25}** (%)	**(4)** GBARD 2025 **G_{25}** (Mio)	**(5)** GDP 2025 **GDP_{25}** (Mrd)	**(6)** R&D Inten. 2025 **I_{25}** (%)	**(7)** Years **f** from Eq (5) wth **r = 1,07**	**(8)** Years **n** and GBARD rate **(r-1)** from Eq. (5)	**(9)** **New resources** **$R_{26\text{-}(25+n)}$** Eq. (7) (Mio)
UE	Union Eur.	83,5 -	**117 425**		**0,74** -			
1-RO	(Romania)	47.2 48.9	397 493	284 324.4	0.140 0.152	44.1 41.9	20–7.00% 20–7.00%	9471 11 768
2-IE	Irlanda	44.4 43.3	964 1051	506 510	0.191 0.206	35.9 33.9	20–7.00% 20–7.00%	23 003 25 087
3-BG	(Bulgaria)	22.6 22.9	187 213	85.8 94.7	0.218 0.225	32.5 31.6	20–7.00% 20–7.00%	4463 4957
4-MT	Malta	52.3 47.4	37.1 52.5	17.4 20.5	0.213 0.256	33.1 28.2	20–7.00% 20–7.00%	886 1253
5-LT	Lettonia	41.0 45.0	93.4 118	38.4 39.4	0.243 0.299	29.6 24.1	20–7.00% 20–7.00%	2231 2817
6-PT	Portogallo	112,4 97.9	802 802	242.3 267.9	0.331 0.299	21.5 24.1	20–7.00% 20–7.00%	19 137 19 143
7-HU	(Ungheria)	73.9 73.4	518 616	168.9 198.0	0.307 0.311	23.5 23.1	20–7.00% 20–7.00%	12 363 14 766
GRUPPO I: 7 Paesi (0,10% ≤ I_{25} < 0,35%)								**71 554** **79 791**
8-SK	Slovacchia	57.8 56.1	412 453	109.6 122.9	0.376 0.368	18.1 18.7	19–6.81% 19–6.93%	8303 9370
9-LT	Lituania	38.1 37.3	219 278	67.4 71.8	0.325 0.387	22.0 17.36	20–7.00% 18-6.86%	5226 4961
10-CY	Cipro	85.6 73.6	115.2 138.3	27.8 31.3	0.414 0.442	15.6 13.9	16–6.89% 14-6.96%	1563 1389
11-PL	(Polonia)	49.3 49.7	2768 3817	654.6 749.0	0.423 0.510	15.1 10.1	16–6.75% 11-6.67%	36 421 21 164
12-CZ	(Cechia)	44.2 42.4	1567 1626	276.3 317.4	0.567 0.512	7.35 10.0	8–6.67% 10-7.00%	4409 7778
13-EL	Grecia	172.6 163.9	1537 1281	206.6 225.2	0.744 0.569	- 7.25	- 8-6.62%	- 3574
GRUPPO IIA: 6 Paesi (0,35% ≤ I_{25} < 0,60%)								**55 922** **48 236**

(1)	(2) Country	(3) Debt/ GDP 2025 D_{25} (%)	(4) GBARD 2025 G_{25} (Mio)	(5) GDP 2025 GDP_{25} (Mrd)	(6) R&D Inten. 2025 I_{25} (%)	(7) Years **f** from Eq (5) wth **r = 1,07**	(8) Years **n** and GBARD rate **(r-1)** from Eq. (5)	(9) **New resources** $R_{26-(25+n)}$ Eq. (7) (Mio)
14-ES	Spagna	111.6 105.1	8002 8997	1346 1498	0.595 0.601	6.08 5.81	7–6.47% 6-6.88%	16 503 14 596
15-LU	Lussemb.	24.7 25.5	430 507	77.5 81.0	0.555 0.626	7.91 4.74	8–6.95% 5-6.79%	1269 565
16-IT	Italia	141.7 134.8	12 843 13 461	1963 2131	0.654 0,632	3.60 4.49	5–5.86% 5-6.59%	12 210 14 535
17-Fr	Francia	111.8 109.9	17 900 18 266	2639 2822	0.678 0.647	2.65 3.88	5–5.10% 5-6.09%	14 661 18 104
18-BE	Belgio	104.3 103.1	3822 3865	554 596	0.690 0.648	2.19 3.84	5–4.73% 5-6.06%	2889 3810
19-HR	Croazia	68.2 61.8	445 533	68.0 78.0	0.654 0.683	3.76 2.46	5–5.86% 5-4.95%	423 422
GRUPPO IIB: 6 Paesi (0,60% ≤ I_{25} < 0,70%)								**47 955** **52 032**
20-SE	(Svezia)	32.9 31.5	4094 3908	562 541	0.728 0.722	0.78 1.00	2–4.54% 1-7.00	566 273
GRUPPO IIC: 1Paese (0,70% ≤ I_{25} < 0,74%)								**566** **273**
21-NL	Olanda	50.1 45.1	7533 8532	959 1066	0.786 0.800	-	-	-
22-SI	Slovenia	72.3 68.4	307 518	57.0 64.0	0.539 0.809	8.68 -	9–6.86% -	1142
23-FI	Finlandia	73.3 77.1	2402 2349	268 273	0.896 0.860	-	-	-
24-AT	Austria	78.4 78.6	3606 4095	447 473	0.807 0.866	-	-	-
25-DK	(Danimar.)	29.8 33.6	3108 3277	381 376	0.816 0.871	-	-	-
26-EE	Estonia	18.5 20.2	260.3 337	36.0 38.2	0.722 0.882	1.00 -	2–4.91% --	41 -
27-DE	Germania	66.1 62.9	43055 44090	3876 4185	1.110 1.053	-	-	-
GRUPPO III: 7 Paesi (0,74% ≤ I_{25})								**1183** **0**
TOTALI				**Paesi con I_{25} < 0,74%**				**177 180** **180 332**

The last line shows that the **20-year Plan 2026-2045 requires a total investment of 180 billion**, in current currency.

Since the countries in the Table are sorted in the ascending order of I_{25}, the composition of the groups in the 2026-2045 period is different from that in the 2025-2045 period. However,

the last row shows that the **total investment only increases by 2%,** which is the annual inflation rate. So, the **model is robust** to changes in parameters.

Looking at the numbers in the last column of Table 3bis, it appears that the largest beneficiaries of the Programme are Ireland (25 billion), Poland (21 billion), Portugal (19 billion), France (18 billion), Hungary (14.8 billion), Spain (14.5) and Italy (14.5). But the argument is not correct because the EU contribution must be compared with the GBARD of the reference year 2025. This is why Fig. 5bis – which is like Fig. 5 on p. 13 – shows the ratio of EU funding (in current currency) to the GBARD of 2025.

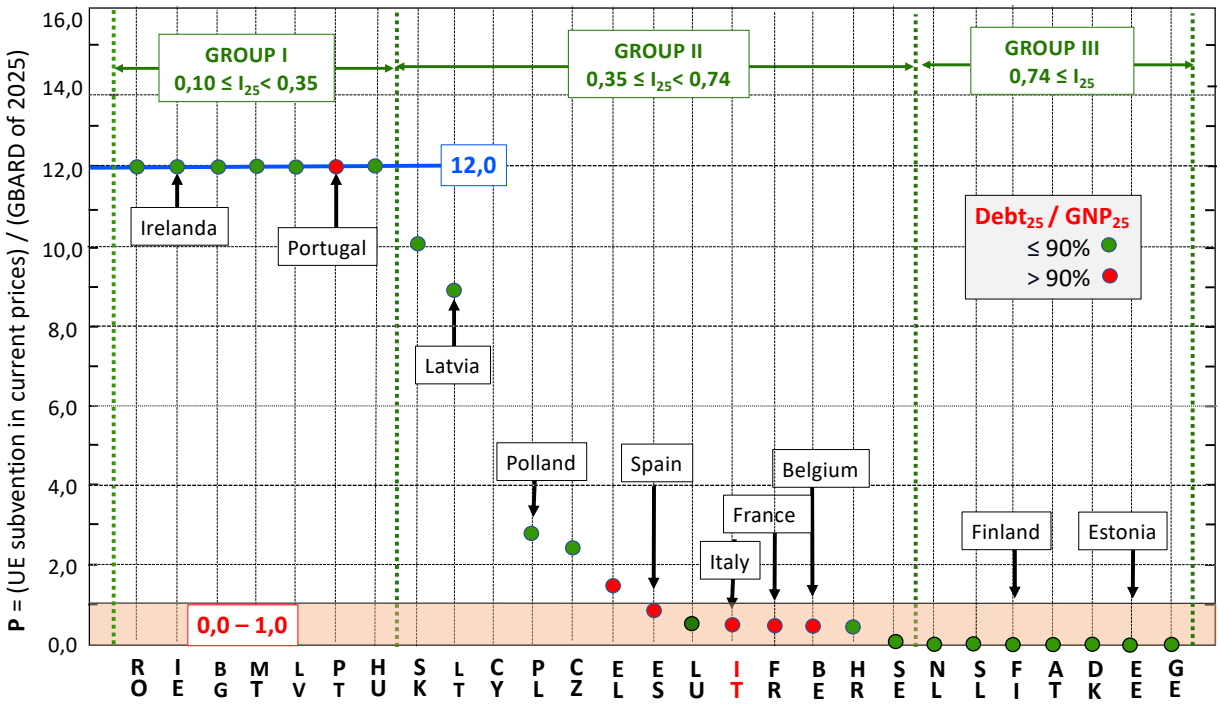

Figure 5bis. *The ratio of the total EU contribution to the GBARD of the reference year (2025) is a measure of the equity of the 20-year Programme.*

The figure shows that the largest beneficiaries of the 20-year programme are the **Group I countries**, which receive **12 times** the investment of 2025.

For Slovakia and Lithuania, the ratio drops to 9 and Poland is at 2.5. Rich and indebted countries (red points), on the other hand, are all about **half of the 0-1 band**, almost **25 times** less than the countries that invest poco in public research.

This argument leads to the conclusion that the 20-year programme is fair.

It should be noted that in Fig. 5 (p. 13), **F = 0.35** is taken and the numerator is the inflation-adjusted funding, whereas in Fig. 5bis, **F = 0.50** is taken and the numerator is the funding expressed in current currency. Corrected for inflation, the ratio **P = 12** of the Group I countries becomes **Q = 9**, with Q defined by Eq. (11) on p.13.

Table 5bis gives essentially the same information as Table 5 on p. 14.

***Table 5bis**. Public R&D intensity at the beginning and at the end of the **2026-2045 Programme**, which has different durations for each (column 4) and EU reimbursements (column 6) with F = 0.50 (Eq. 8 and Eq. 9 of p. 10).*

	(1)	(2) Country	(3) Initial R&D Intensity I_{25} (%)	(4) Duration **n** years - GBARD rate (r-1)	(5) **UE refunds on n years** (with F = 50%)	(6) **Final R&D intensity** I_{25+n} (%)
GRUPPO I	1-RO	(Romania)	0.152	20–7,00%	**5884**	**0,325**
	2-IE	Irlanda	0.206	20–7,00%	**12543**	**0,441**
	3-BG	(Bulgaria)	0.225	20–7,00%	**2478**	**0,481**
	4-MT	Malta	0.256	20–7,00%	**627**	**0,548**
	5-LV	Lettonia	0.299	20–7,00%	**1408**	**0,640**
	6-PT	Portogallo	0.299	20–7,00%	**9571**	**0,640**
	7-HU	(Ungheria)	0.311	20–7,00%	**7383**	**0,665**
II A	8-SK	Slovacchia	0.368	19–6.93%	**4685**	**0,750**
	9-LT	Lituania	0.387	18-6.86%	**2481**	**0,750**
	10-CY	Cipro	0.442	14-6.96%	**695**	**0,750**
	11-PL	(Polonia)	0.510	11-6.67%	**10 582**	**0,750**
	12-CZ	(Cechia)	0.512	10-7.00%	**3889**	**0,750**
	13-EL	Grecia	0.569	8-6.62%	**1787**	**0,750**
II B	14-ES	Spagna	0.601	6-6.88%	**7298**	**0,750**
	15-LU	Lussemburgo	0.626	5-6.79%	**283**	**0,750**
	16-IT	Italia	0,632	5-6.59%	**7267**	**0,750**
	17-Fr	Francia	0.647	5-6.09%	**9052**	**0,750**
	18-BE	Belgio	0.648	5-6.06%	**1906**	**0,750**
	19-HR	Croazia	0.683	6-6.88%	**211**	**0,750**
II C	20-SE	(Svezia)	0,722	1–7.00%	**137**	**0,750**
				TOTALE	**90 167**	**-**

The sum of the repayments is 90 billion, obviously half of the 180 billion in Table 3bis.

To transform the 90 billion in current prices into 2026 prices, one can use the factor calculated for the 2025-2044 period from the data in the last row of Table 4 on page 11: 50.5/62 = 0.815. This yields 0.815 x 90 = **73 billion of the year 2025**.

Fig. 4bis, equivalent to Fig. 4 on p. 9, gives a global and qualitative impression of the effects of the 2026-2045 20-year plan: **the thirteen countries in Group II reach 0.75%,** but with timescales varying between 1 year and 19 years. In Group I, **six countries** reach the Intensity range **0.50% - 0.70%**. Romania, however, lags.

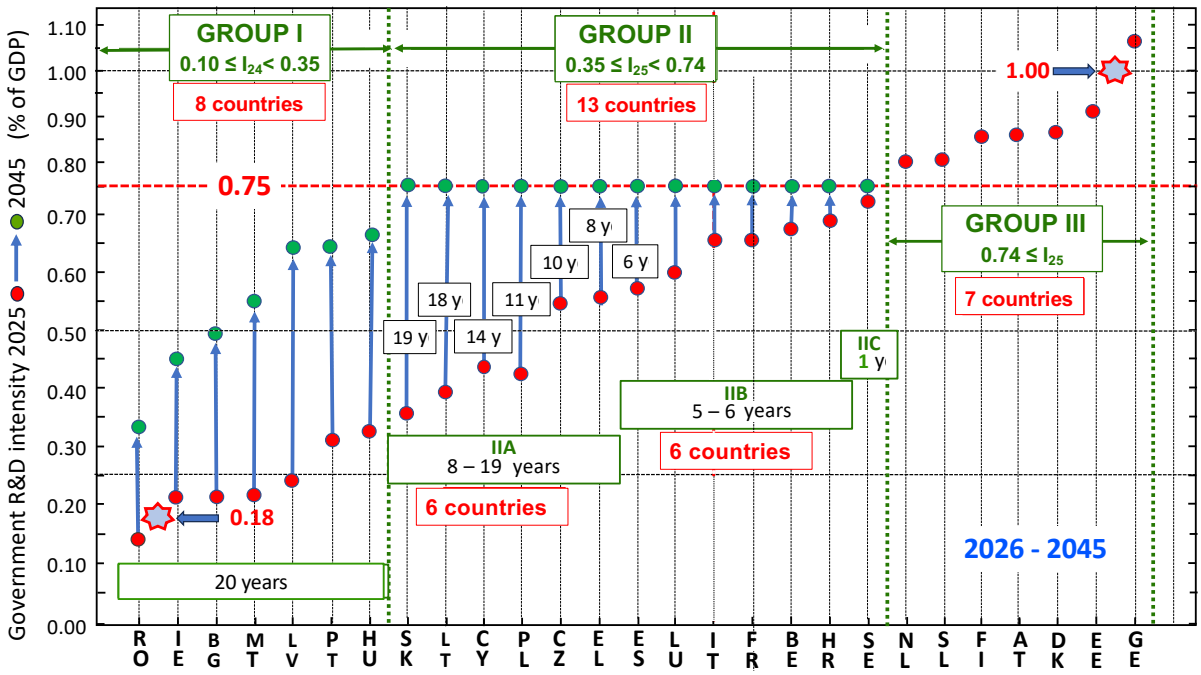

Figure 4bis. *The figure shows that, in the reference year 2025, the R&D intensities of the 27 countries are evenly distributed betweenat0.18% and 1.0% and illustrates the fact that the 13 Group II countries reach 0.75% at very different times.*

Fig. 6 bis was obtained by scaling Fig. 6 on page 17. It shows that in the four five-year periods, the **73 million** are distributed in the sequence **23.1 - 15.4 - 17.7 - 16.8**.

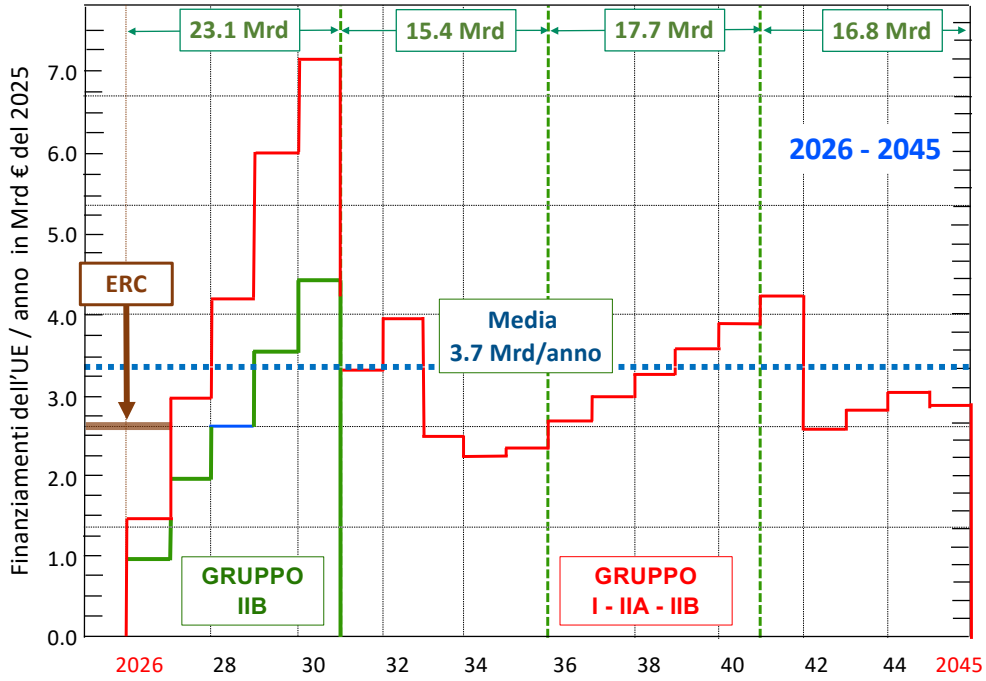

Figure 6bis. *The annual development of EU investment,* ***expressed in 2025 currency****, is compared with the annual investment of the E*uropean Research Council *(violet segment).*

The red histogram gives the trend of the EU contributions year by year. The green one refers to Group I countries and has, of course, a peak at the end of the 5-year period. Because of this peak, the expenditure, expressed in 2025 Euros, is not constant over time.

It is interesting to calculate the average over the 20-year period, which - as indicated by the blue dotted line - is **3.7 billion/year**, and to observe that it is only in the years 2029 and 2030 that the UE reimbursements will be very different from the average.

The purple segment represents the entirety of the grants awarded by the *European Research Council* to European researchers on the sole basis of the quality of their research: **2.5 billion/year**. In the 20-year Plan 2026-2045, therefore, the EU should invest 50% more per year than it invests today in the *best European researchers*. **This is a more than reasonable sum** because it will make it possible to *put all researchers in all European countries* on an equal footing and remedy the disparity between the 27 EU states, which is unacceptable because, as mentioned on p. 6, implies that many countries

- do not have the *means* and *research facilities* to contribute to Europe's development;
- cannot train their *young researchers* by preparing them to compete, among equals, for *European Research Council* (ECR) grants, awarded on the basis of scientific quality alone;
- are unable to offer their *teams of researchers* the minimum conditions to do good basic science and to be able to participate in European calls for proposals with a chance of success.

Besides being an injustice, it is a waste.

A final observation: over the 2026-2045 period, the average is *3.7 billion per year,* **a small correction to the 750-800 billio**n that, according to the Draghi Report, Europe will have to invest each year to improve productivity, support the ecological transition and maintain sovereignty.