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ASSESSING THE POSSIBILITIES OF FILLING THE GAP BETWEEN ROMANIA AND THE EU IN THE RDI FIELD[*]

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In the specialised literature there are several established models and methods for measuring the time required to fill the gap between various systems, by assessing the rate of development required to reach a certain reference level in a determined period of time. These models are known as "catching-up models".

The purpose of this study is the assessment, based on such models, of the pace required to fill the gap between Romania and the EU in the R&D field as well as of the factors that condition the pace required to achieve convergence with EU-25 average.

Key words: *catching-up models, gap filling, RDI public private funding.*

JEL*:* I28, F15, I21, H52

1. Introduction

Catching-up models have evolved from Veblen's (1915) and Gerschenkron's (1962) contributions, based on the assumption that countries using "technological imitation" grow economically faster, to more sophisticated models. Among them, we find those built by Nelson and Phelps (1966), who first introduced partial adjustment, the model proposed by Amable Bruno (1993), who explained the specific nature of convergence and divergence in the labour productivity field (applied to 59 countries, between 1960 and 1985), the model built by Benhabib and Spiegel (1994), who made further adaptation of the partial adjustment mechanism of catching-up models.

More recent and consistent contributions to defining and adjusting these models were made by Taskin and Zaim (1997), who empirically checked on a group of countries with more or less advanced law systems - by means of the Malmquist productivity index – the catching-up model hypotheses. Peri and Urban (2006) tried to demonstrate the impact of foreign direct investment on improving the technological level of developing countries; Bentzen (2005) tested the hypotheses of catching-up models for time series and periods characterized by different convergence rates (using real GDP per capita for leading OECD countries) and found a significant convergence of the American economy and the analysed economies; Lackenbauer (2004) tried to identify relevant factors (infrastructure, R&D, technology) for a few Hungarian regions in the process of

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convergence and cohesion with EU-15; Havlik (2005) tried to identify highly productive sectors that allow for a higher convergence whit EU-15; Sung and Carlsson (2003) tested a model for the case of Korea for identifying the role of the Government in promoting policies that favour technological development and ensure a high convergence with the development level of advanced countries.

Another model relevant for this study is Stehrer's model (2002), aimed at analysing, at one country's level, the impact of sectoral specialisation on production and of technological development on labour market, economic growth and productivity; also, Seidel's analysis (1997) found, in the case of OECD countries (by means of 1954 and 1992 data), that incomes in less developed countries grow at a rate of 2% a year, which takes 35 years for catching-up with developed countries (for European countries, he identified, as significant convergence factors, income homogeneity, strong trade relations and technological homogeneity).

These models are mostly applicable to measuring the convergence regarding labour productivity and technological advance of a group of countries or regions, economic integration of some countries or regions.

Specialized literature contains a large variety of models of this type – more or less complex – including different approaches to the dynamics of the analysed systems.

2. Methodological Issues

For measuring the convergence of the Romanian and EU (EU-15) R&D systems, we applied an adjusted form of the catching-up model proposed by Nelson and Phelps, which allows for the estimation of the number of years required to reach the EU level of certain indicators relevant for assessing the RDI development level as well as the necessary rate to reach this level as soon as possible.

We selected the following indicators, considered relevant for Romania's R&I system:

1. Share of total expenditures on research and development in GDP (GERD), which expresses total resources allotted for activities focused on developing a certain amount of knowledge in various fields, used later as a basis for developing applications in economy and society.

2. Share of expenditures on research and development allotted by industry in total expenditure on R&D (GERDI) expresses the contribution of the business sector to RDI funding as well as its importance as an engine of innovation in developed countries.

3. Share of expenditures on R&D from abroad in total expenditure on R&D (GERDA), which measures the R&D effort suported by foreign companies. This indicator is mainly relevant for small countries, as major importers of foreign capital, for which foreign investments in this field are significant incentives for RDI.

4. Graduates from technology and science field per 1000 people aged 20-29 (ABS). We considered graduates from both public and private higher education institutions or who are involved at present in post-graduation training programmes. The level and the domain of education and training for science and technology are based on the International Standard of Classification in Education (ISCED97) and the Eurostat Handbook of Education and Training (1999).

5. Patents registered with EPO per 1 million people (PATEPO). Patents are numbered in the year when the file was submitted to EPO for registration.

6. Education level of young people (PREG) is an indicator relevant for the quality of human factor in research; it is measured as percentage of the population aged between 20 and 24 years who graduated at least the secondary school.

7. Share of exports of high-tech products in all exports (HITECHX). The high-tech products included in this indicator pertain to the following branches: aeronautics, computers, office equipment, electronic products, pharmaceutical instruments, electrical equipment and weapons. Intra-EU trade was not considered.

In our opinion, this system of indicators properly reflect the quality of Romania's and EU countries' research and innovation systems and is relevant to the convergence analysis, since both the aspects concerning the resources used in innovation efforts (input) and the results of such efforts (output materialized in the number of patents and exports of high-tech products). For a synthetic picture of the convergence of the Romanian and EU RDI systems, we think it is useful to estimate also the convergence by the Synthetic Innovation Index, estimated within the European Innovation Scoreboard.

The data series used in the model for the 1999–2005 period were taken from Eurostat and shown in Annex 1.

Considering the small number of indicators (they are annual indicators), we decided to use the linear trend alternative.

In the catching-up model, we denote by R_{UE} the average annual growth rate of indicator I_{UE} and by R_{ROM} the average annual growth rate of the related indicator I_{ROM} for Romania. The level of the two indicators in year t will be:

$$I_t^{UE-25} = I_0 \times (1 + R_{UE})^t \qquad (1)$$

and, similarly:

$$I_t^{ROM} = I_0 \times (1 + R_{ROM})^t \qquad (2)$$

On the basis of the present value of indicator I_0 (different for Romania and EU-25 average) and the estimated growth rates for Romania and EU-25 (per each indicator and per a synthetic index of innovation), we first determined the t value (that is the number of years necessary for Romania to reach the EU average, taking into account its present performance, analysed in comparsion with EU countries' performance. The value of t can be estimated by equalizing the two indicators in year t and then defining the logarithms of the terms in the following equation:

$$I_t^{ROM} = I_0 \times (1 + R_{ROM})^t = I_t^{UE} = I_0 \times (1 + R_{UE})^t \tag{3}$$

that is:

$$\frac{I_{ROM}}{I_{UE}} = \left[\frac{1 + R_{UE}}{1 + R_{ROM}}\right]^t \tag{4}$$

By means of logarithms, we get:

$$Log\left[\frac{I_{ROM}}{I_{UE}}\right] = t \times Log\left[\frac{1 + R_{UE}}{1 + R_{ROM}}\right] \tag{5}$$

that is:

$$t = \frac{Log\left[\frac{I_{ROM}}{I_{UE}}\right]}{Log\left[\frac{1 + R_{UE}}{1 + R_{ROM}}\right]} \tag{6}$$

where:

- t – the time necessary for Romania to reach EU average;
- I_{ROM}, I_{UE} – current values of the indicator relevant to the RDI system;
- R_{ROM}, R_{UE} – values of average annual rates estimated by means of temporal data series.

Estimates were made with different scenarios (optimistic, realistic and pesimistic), in accordance with possible growth rates of the indicators analysed in Romania and EU-25 in the next period. The average annual growth rate in the period 1999–2005, concerning both Romania's and EU-25 R&D indicators, was used to work out the realistic scenario, the highest rate in the above-mentioned period was used for the optimistic scenario, and the lowest rate for the pessimistic scenario.

To compute the average annual growth rate for Romania in a certain period of time we use the following relations:

$$\frac{I_{ROM}}{I_{UE}} = \left[\frac{1 + R_{UE}}{1 + R_{ROM}}\right]^t \tag{7}$$

from where:

$$\left[\frac{1 + R_{UE}}{1 + R_{ROM}}\right] = \sqrt[t]{\frac{I_{ROM}}{I_{UE}}} \tag{8}$$

that is:

$$R_{ROM} = \left([1 + R_{UE}] / \sqrt[t]{\frac{I_{ROM}}{I_{UE}}} \right) - 1 \quad (9)$$

Using the last formula, we get different values, depending on the scenarios dealing with *t*, on the growth rate of RDI indicators in the European Union and on the minimum average annual rate, which various R&D indicators should take on in Romania, so that the convergence of the two systems should be feasible.

3. Estimates and Results

To determine the time required for Romania to reach the EU average and the minimum growth rate required for the Romanian RDI system to reach the EU average within a fifteen-year horizon we initially computed the annual growth rates (on a chian basis) and the average annual rate between 2000 and 2005 of the selected indicators both for Romania and EU 25 (Annexes 3, 4 and 5).

On this basis, we established later the growth rates of each indicator relevant for Romanian and EU RDI systems (Annex 6) for various scenarios: optimistic (maximum growth rate), pessimistic (minimum growth rate) and realistic (average annual growth rate in the above-mentioned period). Considering the average annual growth rate in European countries and the value of individual indicators for 2005, we computed the time necessary for Romania to reach EU25 average, assuming future developments in accordance with the rates established for the three scenarios (Table 1).

Table 1

The time necessary for Romania to reach the EU25 average of significant indicators of the RDI system

years

Romania (years)	Pessimistic scenario	Realistic scenario	Optimistic scenario
GERD	25.0	19.4	17.6
GERDI	14.6	14.7	12.9
GERDA	22.6	13.2	8.5
ABS	13.2	10.6	8.9
PATEPO	38.1	31.1	25.2
PREG	3.3	2.2	2.0
HITECHX	38.3	34.8	32.0
Average	22.1	18.0	14.6

According to results presented in Table 1, the widest gap between Romania and the EU average occurs in high-tech products, patents registered with EPO (over 38 years for the pessimistic scenario) and total expenditure on RDI (25 years for the pessimistic scenario) and the fastest recovery can be achieved for R&D specialists (13.2 years for the pessimistic scenario) and higher education graduates (3.3 years for the pessimistic scecnario). According to the pessimistic scenario, over 22 years are required to fill the gap, while, according to the optimistic scenario, the gap could be filled in about 14 years.

The same computation was used for the synthetical innovation index. Considering the rates estimated for EU25 and Romania for the 2000–2006 period (on which there are data available), we estimated future developments identical with the previous ones (at the average annual rate for 2002–2006) or at the minimum rate of the period, for the pessimistic scenario, or at the maximum rate of the period, for the optimistic scenario (Annex 6).

Table 2

The time (in years) necessary for Romania to reach the EU25 average

	Pessimistic	Realistic	Optimistic
The time (in years) for achieving the convergence of synthetical innovation indexes	24.3 years	19.7 years	16.6 years

According to the results obtained in the pessimistic scenario, the time for filling the gap in innovation in all aspects concerning the size of the Synthetical Innovation Index is over 24 years, while in the optimistic scenario, this period could be reduced to about 16 years (according to Table 2).

The determination of the minimum growth rate required for Romania to reach, within a fifteen-year horizon, the EU25 average values of the indicators used in this paper are based on 2005 values of this set of indicators for Romania and EU25 and growth rates used for different scenarios (see Table 3).

Table 3

Minimum growth rates of certain RDI indicators required for Romania to reach the EU25 average within a 15 - year horizon

- per cent -

Romania	Pessimistic	Realistic	Optimistic
GERD	11.05	11.10	11.26
GERDI	11.46	11.47	11.49
GERDA	3.03	3.06	3.08
ABS	1.76	1.77	1.77
PATEPO	37.86	38.42	38.60
PREG	0.13	0.13	0.13
HITECHX	10.53	10.74	10.94
Average	9.40	9.53	9.61

If Romania intends to reach the EU25 average within a 15-year time horizon, then the average growth rate of individual indicators ranges between 9.40% (pessimistic scenario) and 9.61% (optimistic scenario). The highest growth rate should include over 10% EPO-registered patents (over 35% per year) and expenditures on R&D (GERD and GERDI).

For chatching up with the EU25 as regards Synthetic Innovation Index within a 15-year time horizon, it is necessary to maintain a steady growth rate (between 6.56% for the pessimistic scenario and 6.68% for the optimistic scenario).

Table 4

The minimum growth rate of the Synthetic Innovation Index for reaching the EU25 average in the next 15 years

- per cent -

	Pessimistic	Realistic	Optimistic
Synthetic Innovation Index	6.56	6.62	6.68

Of course, the above-mentioned results are based on the extrapolation of the previous results, when the Romanian RDI system was confronted with major problems.

By economic policy measures, it is possible to change the trend indicators and speed up the convergence of the Romanian and EU RDI systems. Anyhow, in the last years – on which no Eurostat data are yet available – the GERD level rose significantly between 2005 and 2008, owing to increasing expenditures on RDI made through the National Plan for Development and Research for 2007–2013 – NP II.

If we also consider the provisions of the National RDI Strategy for the 2007–2013 time horizon, we estimate a diminution in the time required to reach the EU-25 level of specific RDI indicators. We base our assertion on the possible impact of increasing public funding on the private one and, consequently, on the indicators showing the widest gap between Romania and the EU.

4. The Relation between Public and Private RDI Funding. Effects on Speeding Up the Convergence of the Romanian and EU RDI Systems

The most sensible aspect concerning the convergence of the Romanian and EU RDI systems is the stimulation of the private sector to increase its contribution to total expenditures on R&D, taking into account an increase in this contribution up to 75% and the significant diminution of the business sector between 2000 and 2005 (expecially after 2003).

While the public sector almost doubled its contribution to R&D in Romania (measured by the weight of expenditures on R&D in GDP) between 2000 and 2007 (Table 9), the weight of expenditures on R&D made by the private sector in the GDP diminished from 0.18 to 0.14% in the same period.

The question concerning the extent to which public support is complementary or replaces private R&D is fundamental for formulating consistent R&D policies. There are theoretical arguments to support both assumptions. Public support could stimulate companies to develop or increase resources for R&D, since public subsidies diminish marginal costs and increase the profitability of R&D projects. On the other hand, public support could diminish private effort in the R&D field, so that the company can replace own funding with public funding of certain projects (substitution effect).

The failure to provide clear answers and the contradicting results of certain empirical studies or contradicting opinions of some experts[1] are caused by the absence of a properly defined conceptual framework.

The questions we try to answer are the following: Is there an effect of substitution or complementarity of public funds on R&D private funding in Romania? How can an increase in public funding produce positive effects on increasing expenditures on R&D made by the private sector ? As the private sector had access to funding through various sub-programmes of the National Plan for Research and Development, will it also receive public funds for R&D in the next years?

In the last decades, the specialized literature[2] was enriched with several studies which deal – from different angles and by specific methodologies – with the relation between public funding and private funding of R&D and the impact of subsidies on the dynamics of investments of the private sector in this field.

As a consequence of the general positive opinion on the role of R&D in economic growth, all developed countries promote public support for this field. Governments stimulate in various ways the R&D activity in their own laboratories and institutes, provide funds for academic research and non-profit organisations' research activity, offer contracts to public and private institutions and even grant subsidies to private companies for R&D, directly or by tax incentives. Also, governments concern for technology dissemination and promotion of innovative companies, based on new technologies or products.

Economic theory contributed to reaching a consensus on providing public support for private R&D, maintaining that R&D activities generally cannot be easily funded in a competitive market. Beginning with Nelsons' classical article (1959), later supported by Arrow *et al.* it has been argued that the profit from investments in R&D should not be given only to the investor, since the most important outcome of R&D investments, i.e., scientific knowledge, could be used by other companies for producing new goods and services, as long as they are not classified information.

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[1] David P., B. Hall, A. Toole, 2000, "Is public R&D a complement or substitute for private R&D? A review of the econometric evidence", *Research Policy*, 29, p. 497-529.

[2] OECD, 2001, *Changing Patterns of Public and Private Financing of R&D*; TIP, 2004, *Input Additionality Effects of R&D Subsidies in Austria*; Klette J., J. Moen, Z. Griliches, 2000, "Do subsidies to commercial R&D reduce market failures? Microeconomic evaluation studies", *Research Policy*, 29, p. 471-495.

This “non-rivalry” feature of scientific discoveries – determined by the fact that their utilisation by a company does not exclude their utilisation by other companies – causes the private investors’ reticence about R&D.

The need to correct market failures that affect this field, the distinction between private benefits from R&D activities (smaller and difficult to fully get them) and the social ones, caused by the character of public goods of R&D results, the occurrence of multiplication effects, as well as the sub-optimal social level of private investment in R&D are strong, both theoretical and practical, reasons for granting public subsidies in order to supplement private resources provided for R&D.

Even if market failures are accepted as reasons for public support to R&D, including the private sector, it is necessary to demonstrate that public R&D programmes and other types of direct and indirect subsidies are effective, that the principle of additionality is observed, i.e. public subsidies are turned into increases in companies’ own resources provided for R&D and that they do not replace private expenditure, which companies still have to make.

The public support given to the business sector should comply with the requirement for economic and social effectiveness, i.e., research made by companies and receiving public funding should have results with a technological, economic, social and environmental impact.

Of course, there are many problems in assessing the impact of public funding on private investments, in all above-mentioned respects, caused mainly by the lack of required information, quantitative and qualitative methods and suitable assessment methods.

The possible effects of public support to corporate R&D are considered additionality effects of different types:

- **input additionality** – occurs when companies provide an amount larger than tax deduction for their own R&D;
- **output additionality** – occurs when there are effects on turnover or profit increase;
- **behavioural additionality** – occurs when public funding alters corporate decisions.

A subsidy is granted in order that the number of additional projects supported by a private investor should be higher than in case of not granting such subsidies, i.e. the government should not hinder but stimulate private investment in R&D. If public funding is directed towards projects which the company would have completed anyhow, it is a wrong allocation of public R&D resources. Only a **complementarity** relation between public funding and private funding would justify public intervention.

A major problem regarding the additionality is caused by asymmetric information circulating between the company receiving a subsidy and the government, which cannot know *ex ante* what the effects of a subsidy are. Moreover, we should consider that the level of R&D private funding is the result of an internal process of making decisions, which is dependent on several internal and external circumstances. This process is only indirectly influenced through subsidies, by the size of the marginal profit resulted from the allocation of additional funds.

The effects of a subsidy on the private R&D allocation dynamics can be classified as follows:

- **the substitution effect** of a subsidy occurs when a company uses the subsidy for diminishing its own expenditures;
- **the partial substitution effect** occurs when a company increases its total expenditure on R&D, but less than the subsidy;
- **the multiplication effect** occurs when the company allots more than the subsidy.

In early 1990's, the governments of the EU countries financed about 12% of total R&D activity of the business sector as against to less than 8% in 2005 (in the 27 EU member countries). A gradual diminution in direct subsidies granted to the private R&D sector was accompanied by a higher utilisation of tax incentives for R&D in this sector.

Generally, tax incentives have gradually evolved since 1990, although individual experiences show a great diversity in combining the two public funding mechanisms: by subsidies and by tax incentives. In Romania, there is no convincing experience in tax incentives for RDI, as it is understood at the EU level. There still are exemptions from taxes for IT researchers: according to the Fiscal Code in force, when determining the taxable profit, the expenditures on R&D are deducted, and the incomes earned by natural persons by patent application or concession are included among non-taxable incomes.

While the 1990's witnessed a change in favour of increasing tax incentives for R&D and diminishing subsidies, after 2000, the subsidies were not diminished, but only maintained or even consolidated through a policy mix. Most of the member states decided to focus on consolidating a portofolio of mechanisms for maintaining the level of direct funding, and extending and improving tax incentives at the same time. In certain countries, such as Spain, Portugal and the United Kingdom, the extension of tax incentives was combined with an increase in direct subsidies.

Even if at present there is no convergence towards an optimum level of R&D taxes in the European countries, governments recognize the importance of tax incentives, as a compementary mechanism for direct allotment to RDI.

Following the analysis of the types of policy for combining the R&D direct and indirect public funding mechanisms, we get four categories of countries, grouped by the extent of the shift between 1991 and 2006 from a policy based on strong direct funding to a policy favouring tax incentives.

Table 5

Types of RDI policy by the degree of correlation of RDI direct and indirect funding mechanisms

Type of policy	1991	2000	2006
Strong direct founding and unfavourable fiscal treatment	4 countries: Germany, Italy, Sweden, UK, and EU-17	3 countries: Czech R., Italy, Poland	Italy
Low direct funding and unfavourable fiscal treatment	Belgium, Denmark, Ireland, Greece, Hungary, Netherlands, Portugal, Finland	Belgium, Germany, Greece, Finland, Sweden, UK	Germany, Greece, Finland, Sweden
Low direct funding and favourable fiscal treatment	Austria	Denmark, Ireland, Spain, France, Hungary, Netherlands, Austria, Portugal	Belgium, Denmark, Ireland, France, Hungary, Netherlands, Austria, Portugal and EU-17
Strong direct funding and favourable fiscal treatment	Spain and France	None	Czech R., Spain, Poland, UK

Source: Warda J., "An evolution of EU direct subsidies – Fiscal Incentives Policy Mix 1991-2006", Report prepared for EC, DG Research, January 2007.

Governments use tax incentives as a direct means of determining the companies to invest in R&D. Companies prefer to invest in projects ensuring a higher level of assimilation of the research outcome and a faster recovery of the investment, which makes the crowding-out be smaller than the spill-over.

In November 2006, the European Commission, in *Towards a more effective use of tax incentives in favour of R&D*, pointed out the necessity to provide new tax incentives for investments in RDI, as well as to substantially improve the existing ones. It defined the guidelines for a more effective and stable system of tax incentives, focused mostly on European R&D.

These orientations are more important for Romania since the experience in granting tax incentives to companies to increase investment in R&D is shorter.

Tax incentives are considered an important part of the general public effort for supporting R&D in the business sector in the EU countries.

Defining and implementing tax incentives, which are in charge of the member states, reflect the national concerns for increasing investments in R&D and, consequently, the European fiscal perspective on RDI is fragmented, excessively complex and, sometimes, discriminating against foreign RDI organisations and multinational RDI partners.

The identification and the dissemination of good practices could improve the effectiveness of fiscal systems in Europe and could ensure their compliance with the Community legislation. Common approaches shall be consistent especially with regard to the following: the cross-border use of RDI resources, the transnational expansion of new innovative companies, the correlation of the national eforts within European scale research projects, etc.

For this purpose, the Commission adopted, on the basis of a dialogue with member states and an open method of coordination, a guide for: establishing, implementing and assessing tax incentives for RDI; the compliance of national tax incentives for RDI with Community laws; establishing and imposing taxes for the following target groups: companies participating in large research programmes of the EU, i.e., Technology Initiatives and EUREKA, in order to provide, in due time and on a synchronized basis, financial support for industry involvement; new R&D-intensive companies, in order to support the growth of new R&D-intensive companies, through risk capital. Since tax incentives are considered a way to stimulate private investments in R&D, a common approach to the two problems is required.

The European Commission clarifies that the tax incentives which confine benefits to internal activities are incompatible with the EU Treaty. It also mentions that the tax incentives directed to a specific group or sector represent state aid, which should be compatible with the regulations on state aid. The new framework adopted for RDI state aid could have a direct effect on tax incentives for R&D.

In reviewing the tax incentive policies, the European Commission recommends:

– tax incentives should be easily accessible to a large number of R&D companies;
– they should include simplifying elements and low administrative costs;
– principles and methods for assessing the effects of tax incentives should be considered;
– they should be granted in due time, efficient and predictable.

As regards tax incentives, the member states should approach on a common basis the problems of common interest, such as the funding of transnational R&D projects, the increase in number of new innovative enterprises, the external mobility of researchers and the treatment of philanthropic funding of research.

Some member states have already provided tax incentives for reducing the employment cost of R&D personnel. They are used when strategical objectives refer to increasing the number of researchers. The good effect of these incentives is the stimulation of the companies considered to make their own research. These incentives generally imply a lower tax on wage or a lower social contribution of the personnel directly involved in research. Other incentives could ensure fiscal advantages for individuals or companies; for example, individual or corporate donations to foundations which fund or make R&D are deductible from taxes.

As regards tax incentives, the European Commission maintains explicitly that territorial constraints are incompatible with the EU Treaty. Examples of such constraints are the legal provisions that limit tax incentives for R&D to internal activities and the freedom to manage or to sub-contract R&D activities anywhere in the EU.

Tax incentives for R&D could constitute a state aid if they distort the market by favouring certain actions or the production of certain goods, and affect the trade between member states. One of the distinguishing criteria is the selectivity of tax incentives for R&D. A tax incentive for R&D is considered selective if potential beneficiaries are restricted in terms of size (e.g. SME), location or sector, in which case it is considered state aid.

The direct fiscal measures pursuing objectives of general economic policy by reducing the tax burden on certain production costs (including R&D costs) do not normally constitute an aid if they are applied to all companies and to the production of all goods and services. In principle, the utility, the purpose and the level of tax incentives may vary in accordance with the specific conditions of the member states, that is, existing industrial structure, level of corporate R&D, macroeconomic situation, and general fiscal environment.

The analysis of good practices in the European countries in the field of R&D tax incentives show that they work for simplification, low administrative costs, and they are reliable and stable.

In Romania, most of the R&D organisations (about 63% in 2006, according to INSEE) work in the "business sector", characterized by a varied structure, as regards both the form of organisation and the form of property. By size, most of them pertain to the SME class, consisting of joint-stock companies, commercial companies and limited-liability companies, many of them stemming from former technological research institutes, specialized in various industrial fields.

Receiving funds on a centralized basis before 1989 but no funds after 1990 and remaining at the mercy of a quasi-inexistent R&D market, large institutes – constrained by an uncertain legislation – chose to take varied forms of organisation, some of them quite strange. Because of the concerted pressure exerted by trade unions from the R&D area and researchers' associations, it was possible to ensure in 1994 and 1995 survival funding through a special fund, constitued by mandatory payment (by law) of 1% of the public and private companies' turnover, on the assumption that research outcome was addressed to these companies. Actually, the propensity for investment in research was inexistent at that time of profound restructuring, which brought about the companies' unwillingness to supply the special fund and, consequently, the fund was dissolved.

The dependence of the institutes from the business sector on public funding continued, although competitive funding, based on programmes, had a relatively minor effect of "behavioural additionality". The first programme, initiated in 1995 for competitive funding from R&D public funds, called Horizon 2000, introduced a system for the assessment of funding applications by expert evaluators. Unfortunately, the composition of the assessment commissions, including even managers of the institutes that were applying for funding (most of them institutes from the industrial sector), often turned assessment into negotiation by vague criteria, thus causing the dissipation of public funds, granted in small amounts to many users. The chronic sub-funding produced proportional results, unattractive to industrial users.

The gradual improvement of competitive funding based on national programmes within the National Plan for Research, Development and Innovation 1999–2006, and of the assessment system, based on clear criteria oriented towards the scientific value of a project, its applicability and the competence of the teams forming the research consortium eliminated many shortcomings of the R&D public funding system. Nevertheless, because of the way the fifteen programmes included in the National Plan for Research, Development and Innovation for 1999–2006 was drawn up (by a Consultative Board, mostly composed of representatives of the technological institutes from the business sector), most of the public funds went to such institutes, i.e. 60% in 2001 and 42% in 2006 (INSEE, 2006).

Another important barrier to investments in research and development made by the private sector was the low level of its innovative culture, which was not supported by a system of operational technological transfer or adequate forms of necessary risk capital.

The Programme for Excellence Research, started in 2005 to stimulate private expenditure on R&D, had no visible effects. Also, until recently, the lack of important tax incentives for investors in this field and of financial services and instruments for risk diminution, as well as the inability to assume financial and commercial risks was the reason of the low level of corporate research. The risk capital (in an early stage in Romania) did not visibly stimulate R&D.

All the above-mentioned determined a contradictory evolution of R&D expenditures in GDP made by the Romanian public and private sectors (see Table 6). Along with increasing public expenditure on R&D there was a diminution in the weight of the business sector, especially after 2005, when total expenditure on R&D amounted to 0.46% of GDP in 2006, as against 0.39% in 2001.

Table 6

The share of total expenditure on R&D in GDP by funding sources

- per cent -

	2000	2001	2002	2003	2004	2005	2006	2007
Economic agents	0.18	0.19	0.16	0.18	0.17	0.15	0.14	0.14
Public funds	0.15	0.17	0.18	0.18	0.19	0.22	0.29	0.36
Higher education units	0.02	under 0.01	0.01	0.01	0.01	0.02	0.01	0.01
Foreign funds	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Total	0.37	0.39	0.38	0.39	0.391	0.41	0.46	0.53

Source: Romanian Statistical Yearbook, 2008, p. 494.

The above arguments and data support the assumption that there is an effect of substitution rather than an effect of complementarity in funding R&D in Romania. At the end of 2006, experts from the National Authority for Scientific and Technological Research (NASTR) said that it was necessary to achieve at least a ten-times increase in the contribution of the private business sector to general expenditure on R&D in order to attain the objective regarding the allocation of 2% of GDP to R&D by this sector between 2013 and 2015.

5. Conclusions

The measurement of convergence is an urgent need; in practice, several more or less complex models have been built to make such an estimate. The results of the implementation of catching-up models for assessing the convergence of the Romanian RDI and EU RDI brought us to the following conclusions:

1. These models could help us to assess the time required for reaching the performance of a reference system, taking into account the average annual rates of the two systems and the present value of the analysed indicators.

1. The convergence of Romania and EU-25 is weak, especially with regard to the outcome indicators specific to the RDI system (patents registered with EPO, exports of high-tech products).

2. According to our calculations, the highest convergence occurs in relation to the graduates employed in R&D and their education level (but it is not enough for Romania to have an R&D system with highly educated personnel, unless it is not ready to produce significant results to be capitalized on the market).

3. The low convergence of the RDI system directly affects economic growth and labour productivity.

4. Convergence is a little higher (measured in years) as regards the synthetical index of innovation.

5. Since the number of years necessary to fill the gap between Romania and the EU is large, the strategies and the policies for the development of the Romanian RDI system shall provide all possible tools for speeding up the growth rates of various indicators pertaining to the RDI system, especially tax incentives.

6. The business sector is not sufficiently consolidated in order to contribute to general expenditures on R&D to the desired extent for 2013-2015. Strongly dependent on public funding, it is characterized by the "substitution effect", and not by the "complementarity effect". Considering the strategic objective of the Government for increasing the public expenditures on R&D to 1% of GDP by 2010 and the private ones to 2% of GDP by 2013-2015, it is very important to observe the additionality principle, that is, for one leu of public investment in private R&D sector, there should be an additional amount of private investment. We take into account the fact that, at present, a large amount from public funding goes to the private sector.

Annex 1

Data series used in the model

General expenditure on R&D in GDP, % (GERD)

	1999	2000	2001	2002	2003	2004	2005
Romania	0.4	0.37	0.39	0.38	0.39	0.39	0.39
EU-25	1.86	1.87	1.88	1.89	1.88	1.85	1.85

The share of expenditures on R&D in industry in total expenditure on R&D, % (GERDI)

	1999	2000	2001	2002	2003	2004	2005
EU-25	56.1	56.3	55.9	54.6	54.2	54.9	54.5
Romania	50.2	49	47.6	41.6	45.4	44	44

The share of expenditures on R&D from abroad in total expenditure on R&D, % (GERDA)

	1999	2000	2001	2002	2003	2004	2005
EU-25	7.2	7.3	8	8.9	8.6	8.2	8.5
Romania	2.5	4.9	8.2	7	5.5	5.5	5.5

Graduates from technology and science fields per 1000 people aged between 20 and 29 as number of graduates per 1000 people (ABS)

	1999	2000	2001	2002	2003	2004	2005
EU-25	9.8	10.2	11	11.4	12.3	12.6	12.6
Romania	4.4	4.9	5.3	5.8	9.4	9.8	9.8

Patents registered with EPO per one million people, number of patents per one million people (PATEPO)

	1999	2000	2001	2002	2003	2004	2005
EU-25	126.329	135.309	135.199	132.548	136.114	136.114	136.114
Romania	1.055	0.848	1.411	1.306	1.172	1.172	1.172

The education level of young people, % (PREG)

	1999	2000	2001	2002	2003	2004	2005
EU-25	76.6	76.6	76.5	76.7	76.9	77.2	77.5
Romania	77.8	76.1	77.3	76.3	75	75.3	76

The share of exports of high-tech products in total exports, % (HITECHX)

	1999	2000	2001	2002	2003	2004	2005
EU-25	19.5	20.6	20.4	18.2	17.7	17.7	17.7
Romania	3	8	6	6	4	4	4

Annex 1 (continued)

ISI evolution in Romania and EU-25, in the period 2003-2005

Scoreboard Innovation Index	2002	2003	2004	2005	2006
EU-25	0.34	0.42	0.41	0.42	0.46
RomAnia	0.04	0.08	0.15	0.16	0.19

Source: Eurostat, http://epp.eurostat.ec.europa.eu.

Annex 2

Components of the Innovation Synthetical Index

1. Input:
1.1. Determinant factors of innovation
1.1.1. New graduates employed in research per 1000 people aged between 20 and 29
1.1.2. Persons who earned a full doctor's degree per 100 people aged between 25 and 64
1.1.3. Broad-band Internet lines (broad-band Internet links per 100 people)
1.1.4. Participants in continuous training programmes per 100 people aged between 25 and 64
1.1.5. Education level of the young people (number of young people aged between 20 and 24 who are higher education graduates)
1.2. **Factors contributing to knowledge creation**
1.2.1. Expenditures on R&D – GERD (% of GDP)
1.2.2. Expenditures on research made by the private sector - GERDI (% of GDP)
1.2.3. Share of expenditures on R&D made by the high-tech sector (as share of expenditures on R&D for the sector of manufactured products)
1.2.4. Share of private companies receiving public funds for research
1.2.5. Proportion of academic R&D funding by the private sector
1.3. Innovation and entrepreneurs
1.3.1. Innovative SMEs (% of all SMEs)
1.3.2. Innovative SMEs cooperating with other entities (% of the total)
1.3.3. Expenditures on innovation made by private companies (% of turnover)
1.3.4. Risk capital for new SMEs (% of GDP)
1.3.5. Expenditures for purchasing IT (% of GDP)
1.3.6. SMEs which do not make technological changes (% of SMEs)
2. Output
2.1. Practical use of the research outcome
2.1.1. Employees in the high-tech products sector (% of the total workforce)
2.1.2. Employees in high-tech services (% of the total workforce)
2.1.3. Share of exports of high-tech products and services in total export
2.1.4. Sales of new products on the market (% of the turnover)
2.1.5. Sales to new companies - not necessarily new products (% of the turnover)
2.1.6. Employees in the high-tech sector (% of the total workforce)
2.2. Intellectual property
2.2.1. New EPO patents per one million people
2.2.2. New USPTO patents per one million people
2.2.3. New patents to the Triad per one million people
2.2.4. Newly registered trademarks per one million people
2.2.5. New industrial designs per one million people

Annex 3

Growth Rates (on a Chain Basis) and the Average Rate of Indicators of the Romanian and EU RDI Systems, 2000-2005

Growth Rates (on a Chain Basis) of Indicators for Romania

(%)

	2000	2001	2002	2003	2004	2005	R. mediu
GERD	–7.50	5.41	–2.56	2.63	0.00	0.00	–0.34
GERDI	–2.39	–2.86	–12.61	9.13	–3.08	0.00	–1.97
GERDA	96.00	67.35	–14.63	–21.43	0.00	0.00	21.21
ABS	11.36	8.16	9.43	62.07	4.26	0.00	15.88
PATEPO	–19.62	66.39	–7.44	–10.26	0.00	0.00	4.84
PREG	–2.19	1.58	–1.29	–1.70	0.40	0.93	–0.38
HITECHX	166.67	–25.00	0.00	–33.33	0.00	0.00	18.06

The Annual Growth Rates of Individual Indicators in EU-25

(%)

	2000	2001	2002	2003	2004	2005	R. mediu
GERD	0.54	0.53	0.53	–0.53	–1.60	0.00	–0.09
GERDI	0.36	–0.71	–2.33	–0.73	1.29	–0.73	–0.47
GERDA	1.39	9.59	11.25	–3.37	–4.65	3.66	2.98
ABS	4.08	7.84	3.64	7.89	2.44	0.00	4.32
PATEPO	7.11	–0.08	–1.96	2.69	0.00	0.00	1.29
PREG	0.00	–0.13	0.26	0.26	0.39	0.39	0.20
HITECHX	5.64	–0.97	–10.78	–2.75	0.00	0.00	–1.48

Source: Processed after Eurostat, http://epp.eurostat.ec.europa.eu.

Annex 4

Annual Growth Rates and the Average Rate of ISI, GDP per Capita

The Annual Growth Rate of ISI (%)

	2003	2004	2005	2006	R. mediu
EU-25	23.53	-2.38	2.44	9.52	8.28
Romania	100.00	87.50	6.67	18.75	53.23

Source: Processed after Eurostat, http://epp.eurostat.ec.europa.eu.

Annex 5

Scenarios for Growth Rates of the Indicators Describing the Romanian and EU RDI Systems

The Growth Rates of RDI Indicators in Romania

	The value of the indicators in 2005	Maximum rate (%)	Average rate (%)	Pessimistic scenario (%)	Realistic scenario (%)	Optimistic scenario (%)
GERD	0.39	5.41	–0.34	7.5	10.0	12.5
GERDI	44	9.13	–1.97	3.0	4.0	5.0
GERDA	5.5	96.00	21.21	5.0	7.5	10.0
ABS	9.8	4.26	15.88	6.0	7.0	8.0
PATEPO	1.172	66.39	4.84	15.0	20.0	25.0
PREG	76	1.58	–0.38	1.0	1.5	2.0
HITECHX	4	166.67	18.06	5.0	7.5	10.0

The Growth Rates of RDI Indicators in EU-25

EU-25	The value of the indicators in 2005	Maximum rate (%)	Average rate (%)	Pessimistic scenario (%)	Realistic scenario (%)	Optimistic scenario (%)
GERD	1.85	0.54	–0.09	1	1.5	3.0
GERDI	54.5	1.29	–0.47	1.5	2.5	3.5
GERDA	8.5	11.25	2.98	3.0	4.0	4.5
ABS	12.6	7.89	4.32	4.0	4.5	5.0
PATEPO	136.1	7.11	1.29	1.5	3.0	3.5
PREG	77.5	0.39	0.20	0.4	0.6	1.0
HITECHX	17.7	5.64	–1.48	1.0	3.0	5.0

ISI Growth Rates (Romania and EU)

	The value of the indicators in 2006	Maximum rate (%)	Average rate (%)	Pessimistic scenario (%)	Realistic scenario (%)	Optimistic scenario (%)
UE-25	0.46	23.53	8.28	8	9	10
Romania	0.19	87.50	53.23	12	14	16

Source: Processed after Eurostat, http://epp.eurostat.ec.europa.eu and the European Innovation Scoreboard 2007.

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