

The Resilience of the Romanian R&D System

Steliana SANDU¹

Abstract. *Based on the available literature on the concept “resilience”, the paper looks into the resistance capacity of the Romanian research and development (R&D) system confronted with the profound and frequent transformations after 1990, its ability to mitigate the consequences of the various shocks, and to surpass the aftermath of the more recent economic crisis. The national mechanisms and regulations that steered this system before 1990 were thoroughly replaced, in compliance with the requirements of the market economy, as well as the legislation and practice in the EU. The recurring interventions designed and implemented by very numerous policy-makers in the last 26 years have had a positive but also a negative impact on the R&D system institutions, employment, funding and sources. At the same time, they altered the speed and efficiency of the knowledge and technology transfer to the economy and the society. Yet, it is apparent that, despite multiple and various shocks and crisis, the Romanian R&D system has proven its resilience, its capacity to recover and adapt to new circumstances. This paper emphasizes the vulnerabilities of the R&D system, as well as the pillars that have ensured and will secure its resilience and endurance.*

Keywords: *resilience; the R&D system; resistance to changes; vulnerabilities; Romania*

JEL Classification: *B40; O32; O33; O38*

Introduction

Resilience is a concept that has been adopted recently in various scientific domains – from medicine, psychology, technical sciences to social, behavioral and economic areas (Pecitto, 2016). It has also drawn the attention of international organizations such as the

¹ Senior Scientific Researcher, PhD, Institute of National Economy, Romanian Academy, email: sandu.stelianan55@yahoo.com

UN, the World Bank or the European Commission which, for example, applies it in the context of the food security crisis (European Commission, 2012)

Nevertheless, as its popularity has lately increased, many experts have remarked on the operational constraints of the concept, especially when applied to socio-economic scientific field (Dagdeviren *et al.*, 2015). The social systems are complex and dynamic, further consisting of sub-systems with specific resilience capacity, frequently interacting and producing intricate synergetic effects.

Therefore, our attempt is particularly challenging, given the complexity of the Romanian R&D system, of its components with their own vulnerabilities and strengths, their own ability to react and recover, and their exposure to specific internal and external stressors.

Along the last 26 years, it has been subject to recurring systemic transformations induced either by external factors, or, even more often, by the 22 responsible ministerial teams employing frequently incongruent and contorting strategies. And yet, despite inherent long-term negative consequences, the Romanian research and development (R&D) system has proven its ability to constructively absorb shocks and to adapt its innovation capacity. The capacity to resurrect and reform itself, to reshape its systemic structure in accordance with each transformation stage, to adapt and to learn by doing, has so far prevailed and has, hopefully, ensured improved resilience for future distress and hazard.

This paper will highlight the weaknesses as well as the strengths that enabled the system to preserve its functions, its core structure and identity through learning and adapting.

Literature review

Mainly defined as the dynamic capacity of a system to respond to change and shock while preserving viability, core functions and structures (Adger *et al.*, 2005; Brikmann 2006), the concept of resilience, borrowed from the scientific fields of engineering and psychiatry, has been increasingly adopted and developed in various other empirical and theoretical research areas of ecological, social and economic sciences (Zaman Gh., Georgescu G., 2015 a; Zaman Gh., Georgescu G., 2015 b).

In the context of the goals of long-term sustainable social and economic development, of systematic and complex divergent processes related to the economic globalization, demographic ageing and climate change, developing and ensuring a high level of resilience of the social and economic systems has become an urgent need and a priority for policy-makers as well as for the society and local communities (Mitchell and

Harris, 2012, Jones *et al.*, 2010). It has been argued that a resilient socio-economic system is less susceptible to collapse, needs shorter time to return to the *ex-ante* state and is able to avoid long-term downturn.

In the literature, high resilience involves the capacity to absorb and accommodate to the stressors and to shock, the capacity to renew and recover through learning (Adger *et al.*, 2005; Mitchell, 2011). This entails successive or simultaneous learning, adapting and systemic restructuring, anticipation and improvement of core structure, conferring thus, a dynamic, processual character to resilience (Mitchell and Harris, 2012; Berkes 2007; Norris *et al.*, 2008; Bahadur *et al.*, 2010, etc). Further on, high resilience does not imply the obstinate return to a previous equilibrium state, but the openness to change, for undergoing necessary transformation in order to preserve vitality, roles and functions.

As a concept, resilience has also been closely related to *vulnerability*. While some authors address and assess resilience as the opposite to vulnerability (Berkes, 2007), other argue that resilience is far more than the positive facet of vulnerability, as it involves the systemic capacity to manage change, to prosper despite adversity, insecurity and constant change, to capitalize upon the unknown and to turn threats into opportunities. (Manyena *et al.*, 2011; Davies, 1993)

Recent studies draw the experts' attention on the need to acquire progress in clarifying the conceptual field of resilience (Zaman Gh., Vasile V., 2014). There is considerable ambiguity and confusion in approaching this concept, which bring forth difficulty in its operationalization, especially in the social and economic sciences where the systems involve sub-systems of different dynamics and behavior (Anghel, 2014; Davidson, 2016). The lack of consensus, the diversity of interpretation blur the notional boundaries and the conceptual translation from ecological/psychological science to the socio-economic area is frequently made by metaphors and a mix of positive and normative elements (Brown, 2014).

In the last few years, the literature reveals intense debate over the conceptual relevance of resilience versus sustainability, the possibility to effectively employ resilience in decision making in various policy areas. (Davidson, 2010).

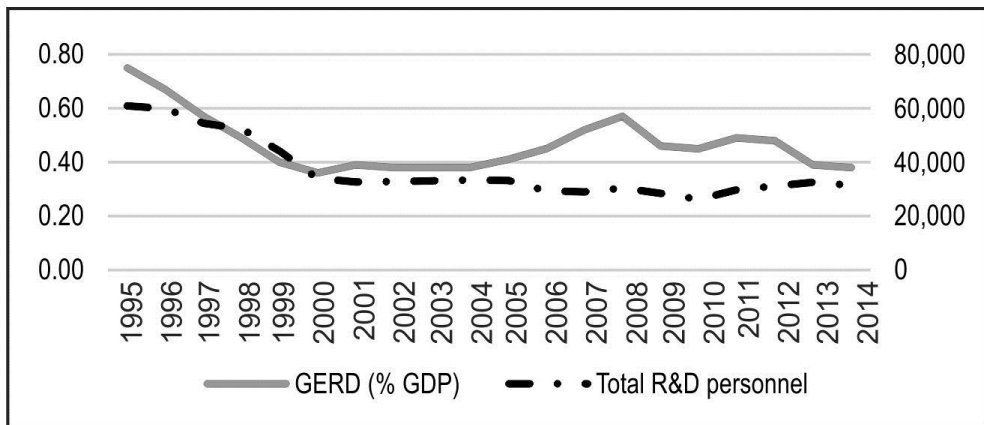
Nevertheless, an overview of the many definitions provided in the above-mentioned paper (Davidson, 2016) that stand out as milestones on the conceptual development road (from 1996 to 2013), highlights a shared core meaning, that is, "the capacity of a system to undergo shocks while preserving functions, structure, identity and developing its capacity to adapt, learn and transform".

The strategy for enhancing resilience, while stemming from a systemic and long-term approach, should focus on the two dimensions of resilience – the inner strength to resist shocks, on one hand, and the capacity to recover from the impact, on the other. The policy instruments and measures should, therefore, aim at lowering exposure to risks and shocks while improving the capacity to cope with and adapt of the system as well as of its components, at local, national and regional level (Zaman Gh., Vasile V., 2014).

The Romanian R&D System's resistance to shocks after 1990

Beside the shattering shock of the transition from a hyper-centralized to a market-based, liberal model, the other most important constraints the Romanian R&D system was compelled to accommodate to are related to the persistent shortage of human and financial resources, inconsistent strategies and policies for research and innovation, uncorrelated with the economic developments or with other related sectoral policies, as well as to external shocks such as the last economic downturn, that took its toll on the R&D resources. The historical evolution of the availability of the necessary critical input for the R&D system - either financial or human – provides a relevant perspective over the level of systemic resilience and its dynamics along the years (Figure 1).

Figure 1. The evolution of the financial and human resources availability in the Romanian R&D system



Source: Eurostat database.

Moreover, along successive fundamental transformation processes, it has been haunted by the deeply embedded mentalities stemming from prolonged decades of communism.

The historical memory of the old model has perpetuated institutional patterns, behaviors and attitudes that caused even a stronger resistance to change and restrained the ability to effectively and optimally adapt to new requirements and constraints.

A short overview on the Romanian R&D system prior to the shock of transition to market economy

Since the early 1980s, the Romanian system of science and technology (S&T) has faced various and numerous encumbrances. The expanded function of the former National Council for S&T, a political and bureaucratic supervisory body, failed to successfully coordinate the R&D system towards increasing performance.

The entire research field was thoroughly invaded by politics and ideology, void of organizational autonomy and freedom of scientific creativity. The S&T system had a pyramidal structure, based on over-sized Central Research Institutes.

Therefore, when the reform began, the Romanian R&D and innovation system was presenting unique, specific features (Radosevic S., Lauriol L., 1998) even within the East European context: the industrial research was organizationally separated from industry itself, being concentrated on large specialized institutes; the criteria and mechanisms for priorities setting were autarchy and not competition-based; the internal evaluation system was distorted by political and ideological factors; the R&D infrastructure was not updated due to an autarchic policy; the previously almost complete isolation of Romanian science was difficult to overcome on short term, with low financial resources; the cycle of research-development-production became more of a slogan than a really functioning policy, etc.

The R&D system in Romania before 1990 was based on centralized planned funding from public sources, distributed according to the policy goals of that period and the research activity was formally guided by the slogan of “the link between education, research and production”. Most of industrial research was performed in the large industrial research institutes affiliated to the so-called “industrial centrals” (Sandu S., 2004). These institutes were mainly running an outdated, but “multilaterally developed” industry, due to an autarchic development of the country, to the isolation of the Romanian research community from the developed countries’ scientific environment, and, at the same time, due to the suppression of the import of equipment and spare parts. The ambitions of the state leadership before 1990, to have 95% new products at the worldwide level and 5% above the world average, compelled researchers to report results that were mostly non-consistent with reality. Meanwhile, in universities, scientific research was almost nonexistent and the network of institutes of the Romanian Academy was abolished in 1974.

The first steps to a new role and institutional structure, while overcoming the shock of adaptation to a market economy

After 1990, in merely two years, the Romanian research and development system plunged from an excessively centralized system into an excessively liberal mould. The stunt was done through numerous, mostly non-correlated and even unjustified reforms. *Laissez faire* became the prevailing principle throughout the Romanian economy, and in R&D, as elsewhere. Strictly regarding the R&D system, the reform gradually designed a new institutional and legal framework that was meant to encourage competition for access to funding, as well as to develop the RDI capacities and the investment in the industrial sector, that itself was undergoing a tough process of privatization and transformation

To this end, the National Council for S&T and the Central Research Institutes were dissolved. The Romanian Academy of Sciences (AoS) was acknowledged as the highest scientific forum in Romania and as an autonomous scientific entity; its network of research institutes was reconstructed. The reorganized Ministry of the Education and Science was responsible for the domestic and international scientific activity. The second step consisted in the elimination of all hindrances specific to a super-centralized system, by granting the research units autonomy in the decision-making and organization processes. The third step, concurrent with the creation of a new enterprise structure - commercial companies with state-owned capital - was that of granting all economic units and R&D institutes, large operational autonomy.

Yet, despite political rhetoric, the role of S&T was marginalized by the policies implemented between 1990 and 1993. Consequently, its involvement in solving Romania's social and economic problems has been marginal. The policy-makers adopted very liberal measures, which were insufficiently grounded, disorganizing the activities and affecting the quality of the research potential in the long run. On its side, the scientific community, resistant to change and hardly flexible, was mostly unprepared to meet the challenge, hanging on the old routine of accessing public funding on a non-competing base. Thus, through some procedural drawbacks, public money was still considerably scattered to numerous research projects, which were unfortunately not correlated with the economic and social priorities and needs of the country.

The infrastructure of public R&D, higher education and the network of the Romanian Academy's institutes was insufficient and outdated and the research staff became oversized as compared to the scarcity of financial resources (Zaman et al., 1995).

The industrial R&D institutes underwent a brutal process of achieving autonomy, most of them being forced to become commercial companies, while others were assimilated by some industrial companies. The fall in demand for domestic and foreign R&D, coupled

with the slow pace of privatization and the passive attitude of investors towards need for the modernization of production processes, inhibited radical reform in industrial research. Most of the R&D institutes were threatened with liquidation. The researchers formed a trade union which put pressure on policy makers to find ways of saving the R&D system in Romania. A Special Fund was set up, financed by one percent of the turnover of the state and private companies, aiming to finance priority research programs and, thus, to eliminate subsidies, addressing public budget pressures and constraints. Running all the risks of penalty payments imposed by the legislation, the companies refused to pay the 1%, for supporting the Special Fund, and, consequently, it was abolished (Sandu, 2004).

Following this transitional period of serious crisis and uncertainties, the RDI system in Romania came eventually to be based on institutions and funding mechanisms inspired by the models of the developed countries.

The policies for recovery

With the aim of stopping the “uncontrolled restructuring” of R&D between 1990 and 1992 when 40% of personnel left this sector, and in order to preserve technological development, the Ministry of Research and Technology (MRT) was established at the end of 1992 to coordinate R&D activities, as the main decisional and strategy responsible organism. It elaborated and partially implemented development strategies based on innovation, periodically reviewed after very numerous replacements of ministers of research. Thus, the process of recovery started in 1993-1994, at a slow pace.

This ministry elaborated short-term strategies for R&D in each field of scientific research. The existing institutes underwent reorganization and restructuring, and new institutes were established. The privatization process had already begun in 1993, with the privatization of approximately 5% of all existing R&D units and the establishment of new private companies oriented towards R&D. This process of R&D restructuring continued in 1994 with assistance from the World Bank and the European Union's organizations, through special programs (e.g. PHARE).

They guided several strategies inspired by Western European models. The Romanian authorities endeavored to adapt the R&D infrastructure and to introduce policies similar to those of the OECD countries. The Industrial Liaison Offices (ILO's) and related local organizations, which support innovation and technology transfer, were developed in Romania since 1992, through a combination of bottom-up initiative and top-down strategy. Unfortunately, when the support from the state budget stopped, most of these new organizations for the transfer of technology from research to industry collapsed. A major shortcoming of the reform in Romania was the absence of the specific bodies and

of the mechanisms to elaborate the S&T strategy and policy at the national level according to the needs of industry and society and to coordinate activities and the institutes involved (Sandu, 2004).

The emphasis was mainly placed on the commercialization of researchers' results rather than on the identification of, and the response to, the needs of the companies for technology and technical improvement.

After 1994, the National Council of University Research and the Grant Council of the Romanian Academy were created, with the aim of stimulating the quality of research activity, through selective competitive funding and encouraging young researchers. Moreover, the Consultative College for R&D was established to determine the thematic priorities for the 22 main areas, covering Romania's whole range of scientific research. The financial resources were supposed to be allotted within competition-based systems, granting equal and free access to all researchers from every institution, regardless of ownership and structure.

A wide open access to competition was considered an important step in making the Romanian R&D system compatible with the European model. Yet, the disparity between the size of R&D providers – numerous researchers (11443 in 1999) and research institutes (626 in 1999) and the low level of financial resources (0.41% in 1999), on one hand, and the funds allotment disregarding the national socio-economic priorities, on the other hand, caused the erosion of the budgetary allocations and, consequently, inefficient use of funds.

The political instability and inconsistency was, to a great extent, responsible for the high fragility of the Romanian R&D system. In 26 years, the central governmental body in charge with the RDI management was led by 22 ministers—each of them following different perspectives and approaches regarding the organization and management of this field.

For policy makers along the transitional years, a critical issue was the transformation of the technological structure of economy and industry, so that it could ensure compatibility with the production systems in the European Union. To this end, increasing the national capacity to absorb and produce new technology stood out as a prerequisite which, unfortunately, was not successfully met.

The effects of all attempts of creating and consolidating an effective innovation system were not visible because they were not based on an institutional support for the stimulation of demand for innovation, by the rational selection of privatization models of the industrial companies, correlated with the privatization of research institutes. The institutional changes of the science and technology system, without achieving an

informal, systemic and coherent framework, able to provide the prerequisites for the application of the non-linear pattern of innovation, did not produce the expected results.

Considerable political attention was also paid to the need of strengthened and consolidated linkages between the two poles of the scientific research market: the research results providers and the users of these results. Attempts to that end were also hardly successful, as the interaction between the two poles works as long as the innovative behavior of the enterprises is stimulated, and along with it, the potential demand for new technologies. It works, in other words, as long as innovation turns into an accessible instrument of market competition.

On the other hand, due to the lack of cooperation and strategic coordination between the main managing institutions of science and education, the links between the basic and applied research units and the beneficiaries were in consistency and short-term oriented. At the same time, the extremely simplistic approach to the innovation process, which remained restricted to the mere application of scientific research results, as well as the tendency of ignoring the fundamental role of innovation in modernizing economic structures in Romania, especially in the early years, belittled the necessity and possibility of considering and capitalizing on innovation as a key economic development factor.

The year 1995 can be considered as a first turning point for R&D system recovery after so many attempts and errors. The governmental initiatives were designed to pursue the following specific objectives:

- turning the public R&D funding into a competitive system of resources allocation, following well designed evaluation and selection procedures. In 1995, 25% of the total R&D funds were allotted this way. The first evaluation report on research institutes was issued in 1995. In addition to such *ex post* evaluation, the auditing of some institutes under the PHARE program was undertaken, along with the prior evaluation of projects in order to select them for grants and, also, to select programs to be funded from the core budget;
- Allocation of funds via priority national programs
- Co-financing of the technology transfer projects; about 11% of overall R&D budget was to be provided by the users of the R&D results
- Creating and developing an experimental structure for the transfer and implementation of the research results together with the logistical support for the dissemination of scientific and technological information on a regional level through newly established regional invention centers and a new experimental innovation network.

The non-existent coherent regulatory framework for autonomy and effectiveness, the inherited models of micro-management for R&D, the lack of a comprehensive strategy for industry reformation were the main problems that challenged the reform of industrial R&D. The revival of the industrial R&D institutes was supposed to be addressed in an integrative approach, involving not only interventions on the supply side of R&D services, but also on the demand side.

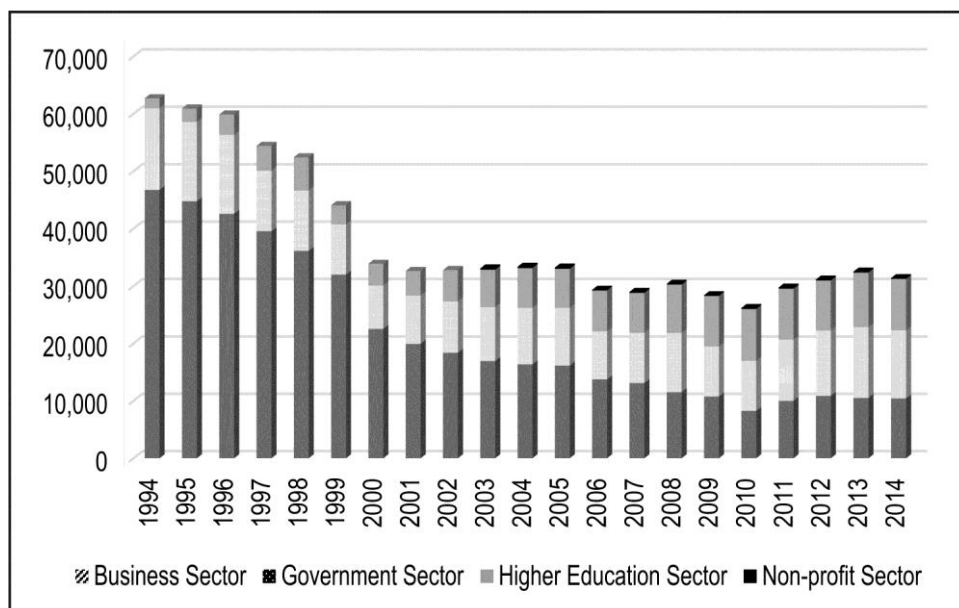
Until 1995, the RDI public policy had been focused on the supply-side actors – the R&D institutes – which, while being financially supported with private money secured through a special tax levied on enterprises, were nevertheless institutionally and functionally dissociated and isolated from the business sector that they were supposed to serve. Their activity was planned and organised according to the undertaken public contracts for research products previously designed within the Ministry of Research and Technology offices. Their research results – specification sheets for new products and processes - would be afterwards classified and disseminated to the industry sector. Unfortunately, the potential buyers were rather scarce, as this offer on the RDI market rarely proved enough relevance for industry. Even if, after 1995, these RDI units largely displayed an inertial behaviour, from 1996-1997 onward, the MRT attempted to close the gap between supply and demand, and to improve the relevance and responsiveness of the public RDI activities to the private sector. One significant measure was to increase the participation of the business sector representatives to the policy-making entities responsible of the funding provided through priority programs.

The transition to the market economy – Weaknesses of the Romanian R&D system

The transition to a functional open market economy required a thorough fundamental transformation of the Romanian R&D system which very soon produced visible effects. While the number of research units increased by almost 70% in the first decade after the 1989 (from 369 in 1990 to 626 in 1999), following the re-establishment of the Academy institutions network, the division of previous research institutes and their conversion into commercial companies etc., the number of R&D personnel followed a steadily declining trend (Table 1). Between 1990 and 1999 it dropped by 50%, mainly due to discouraging income prospects, career insecurity, the openness of foreign human resources markets and poor recruitment strategies. While the number of employed researchers increased in several social sciences, in technological research, critical for innovation and technological progress, the employment level dropped drastically. Also, between 1995 and 1999, the share of employment in the public sector fell by 12%, at the advantage of the private sector. (Figure 1) The average age reflected

an alarming aging process (61.8% of researchers were older than 40 in 1999) (NIS 2000, p. 238).

Figure 2. Total R&D personnel (FTE), Romania, 1994-2014



Source: Eurostat Database.

In terms of R&D expenditure, its share in GDP dropped from 2.6% in 1989, down to 0.82% in 1993 and, further on, to 0.41% in 1999 (Table 1).

Table 1. Total R&D personnel and expenditure in Romania, 1995-2000

Ind. / Year	1995	1996	1997	1998	1999	2000
GERD (% GDP)	0.75	0.67	0.57	0.49	0.41	0.36
Total R&D personnel (FTE)	60,939	59,907	54,436	52,454	44,091	33,892

Source: Eurostat database.

During the economic transition, the demand for domestic and foreign R&D decreased. The financial problems of state-owned industrial enterprises, along with ineffective incentives for investments in updating production processes, inhibited the radical reform of industrial research. At the same time, the fiscal stimuli for private enterprises to invest in R&D were also barely significant. Within the framework of autonomy and decentralization landmarks, and given poorly managed and scant public funds, the role of the public institutions was restricted to providing inadequate funding.

The consequences were contradictory and the industrial R&D did not recover. Many of the privatised R&D units experienced financial distress. Altogether, they couldn't develop into a system able to efficiently and effectively support the industrial innovation, to answer to technical challenges which were economically important.

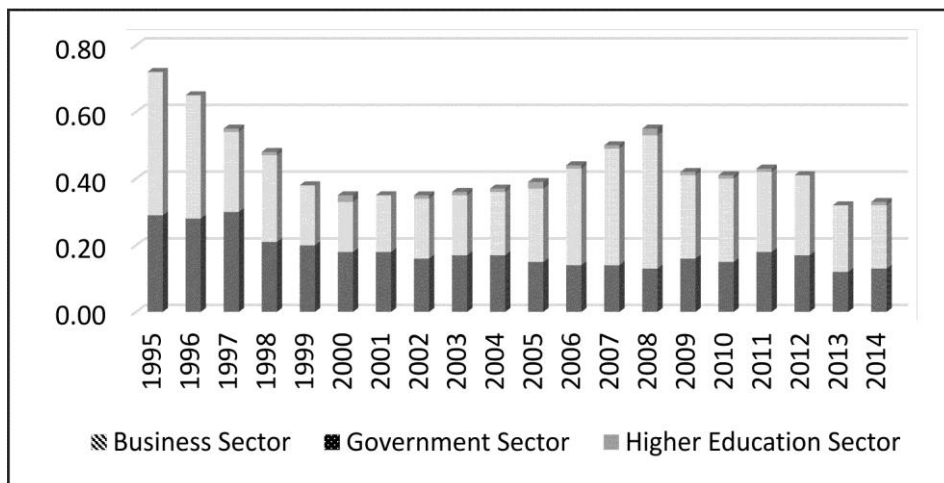
Although most financing was institutional, the R&D units attracted additional financial resources from other economic actors (10% to 25% of their funds). They also tapped on various available national and foreign grants, such as the Academy Grants Fund, set up in 1995. The Academy developed a long-term research strategy up to 2010, as an instrument to coordinate the activities of the research institutes and encourage the efficient use of resources.

Many industrial research institutes, supported until 1989 by industrial funds, abandoned research activities altogether and started commercial activities, stimulated by the very permissive legal framework for entrepreneurial activity within R&D institutes. Turned into business firms overnight, the industrial research institutes plunged into competition with other businesses from the production and service sectors and, with no strategies to stimulate excellence, prestigious research institutes implemented the most unusual measures in order to ensure survival.

Following the privatization of some R&D units through the MEBO (Management and Employee Buy Out) privatization approach, a small nevertheless important number of R&D units successfully attracted private resources in consulting and small-scale production activities. As against the state-owned entities, the viable private R&D units presented low levels of debt, valuable real estate property, as well as significantly depreciated physical assets. Their main challenges sprang from the lack of capital, poor management abilities regarding technological investments and underdeveloped marketing skills.

As a consequence of decentralization, privatization and policy instruments directed towards increasing the participation of the private sector to R&D funding, the R&D expenditure changed considerably, as the share of private funding increased at the expense of public financing (Figure 3).

Figure 3. Total intramural R&D expenditure (GERD) by funding sector (% of GDP)



Source: Eurostat Database.

As in-house R&D is still limited, most of the business sector resources for research were spent on a contractual base in different branches of industrial research. Many small private firms declaring an interest in doing R&D emerged spontaneously. In many cases R&D was not their main activity. Rather, they were involved mainly in the consulting and services sector.

The lack of priorities and the low R&D financing – Barriers to consolidating resilience

The issue of prioritization was particularly significant for the configuration of the R&D system, since priorities are emphatic and reflect the essence of the strategies and policies for research and innovation. They represent the reference points for the allocation of funds to RDI and their determination had to be closely linked to the priorities of the economy and social development, which are, in turn, directly connected to the level of scientific and technologic progress.

In Romania, due to the historical inheritance as well as to the transition specific particularities, the problem of priorities setting was not considered a major concern for the policy-makers.

At the same time, one must note that institutions that were supposed to play a major part in determining science policy on the basis of economic and social priorities, such as the Inter-Ministry Council for Science and Technology, while formally existent, was not operational (European Commission, 2015).

Moreover, the instability of the legislative framework and the absence of effective institutions and financing mechanisms designed to stimulate competition and scientific performance brought about a waste of considerable funds as they were allotted, to a significant extent, to projects selected not on a priority basis, but on institutional, political and client-based criteria.

The problem of setting priorities in research and innovation could have been and still could be satisfactorily addressed not by administrative decisions, but by applying methods aiming to correlate the economic and social objective with R&D potential.

Anyhow, probably the biggest hindrance to effectively setting and pursuing priorities for research is the chronically obturated communication between research and industry. This situation is due, on one hand, to differences in technological capacity and know-how, and, on the other hand, to the incongruence of the research results with the needs of the business sector. Also, the reticence and diminishing interest among potential beneficiaries in applying research results also hindered the information and knowledge flows between R&D outcome providers and users.

Due to the inappropriate, ineffective, incomplete or non-integrated national R&D strategy, priorities, institutional and legal framework, the importance of the mechanisms of research funding gradually decreased in favour of grants or other competition-based forms of funding. As mentioned above, the allocation of increasingly scarce resources was not always based on scientific or economic performance, or according to priorities in science. The peer review system of project evaluation proved, also, to be frequently dysfunctional.

During 1992-1994, in order to preserve and develop the technological research potential, the Special Fund for R&D was created and based on mandatory fiscal contribution from the private sector. In this circumstances, quite a large number of applicants from an extremely wide thematic range were financed. Yet, each year, from over 4 000 financed projects, many were irrelevant to the needs of the financing business sector and industrial companies.

Starting in 1994/1995, the allocation of research funds in accordance with targets and priority programs was declared as a core guiding principle of the first National Plan of Research-Development-Innovation 'Horizon 2000' (R-D-I Plan). The purpose of the RDI Plan was to finance "programs of an interdisciplinary and inter-sectoral character

intended to promote the partnership for the solution of complex problems” (MRT, 1997). Unfortunately, beyond the declarative level, according to the former president of the National Agency for Science, Development and Innovation, this program eventually financed “everything that Romanian science could provide” (ANSTI, 1998).

Thus, through the 22 specialized commissions, funding was provided in 1998, for instance, to 8,286 themes, operational programs, regional and interdisciplinary programs, carried out within hundreds of national institutes, institutes of the Romanian Academy, units within higher education, non-governmental organizations, as well as public and private commercial companies.

One step ahead in the course of defining priorities in accordance with the major targets of economic and social development was accomplished in 1997, when the priority national projects RELANSIN, CALIST, INFRAS and CORINT were launched as part of the R-D-I plan. The aims of these programs were

- to increase the impact of R&D on the economy and society, with a view to re-launching the sustainable economic development;
- to intensify innovation processes and their transfer to direct support to increase the quality and competitiveness of the products and services that Romanian enterprises provide to domestic and international markets;
- to direct the S&T competence and resources to the extension of the national scientific, technological and innovation base;
- to achieve legislative, institutional and procedural compliance with the EU rules, for a quick and efficient partnership implementation.

The fragmentation of the R&D system obstructed the establishment of priorities at the national level, so every institutional entity fought to sat their own priorities and to ensure the necessary resources for their implementation as much as possible from public funds. The deep thematic and institutional dispersion, the disengagement of policy makers at ministerial level, the disinterest of the potential beneficiaries of the research results were, together, important barriers to shaping proper priorities in areas of major national socio-economic and technical-scientific interest.

Non-prioritisation of the research activity and weak linkages between research and industry adversely affected the industry structure, dominated by low and medium-level technology, which stands as a token of the Romanian innovative performance, ranking Romania the last among the EU countries.

Regarding innovation, Romania is specialized in low innovative sectors (apparel, leather) and in medium-high innovative sectors (textiles, basic metals). Nevertheless,

some technology and innovation sectors (such as accounting and computing machinery and motor vehicles, and, to a lesser extent electrical machinery and apparatus) have increasingly recorded added value, while, in the case of other knowledge-intensive sectors (such as medical precision and optical instruments and even chemical products), the share of added value decreased.

The 2014-2020 RDI Strategy made significant progress in choosing priorities for the Romanian scientific research. The areas with the highest potential for a smart growth and smart specialisation were selected. Through a foresight exercise, the priorities for the smart specialisation, that involve potential or existent comparative advantages, and which may contribute to the acceleration of the economic growth, together with the alternatives that may provide answers to pressing social needs were thoroughly identified.

Romania still stands out in important sectors, in the European economic context, such as the automobile industry, TIC, nanoscience and nanotechnologies, security. In these fields Romania holds, also, a certain potential for developing regional clusters. Unfortunately, the level of specialisation in agriculture, forestry and fishery does not match the existing potential. Even if the scientific papers related to these sectors are not so numerous as in other areas, they are acknowledged and appreciated in terms of quality and impact (comparable to international levels) by EU experts. Yet, not only that research in these sectors hasn't been encouraged, but large research centres have been dissolved (European Commission, 2013).

Could the Romanian R&D system consolidate its resilience?

The developed countries' success stories confirm that there is no sustainable economic development nor high resistance and resilience to shocks of the RDI system without a critical level of innovativeness at the firm level as well as at the economic sector level. According to Eurostat data, to European Commission reports as well as to other national research papers (Zaman et al., 2016), Romania hasn't been able to escape the "modest innovator" status in the last 16 years. Despite the fact that in all the strategic documents lately elaborated by the Romanian policy makers, "innovation " has been formally acknowledged as a key factor for the socio-economic development, Romania currently ranks the last in the EU28, with respect to the Summary Innovation Index (European Commission, 2016).

The last European Innovation Scoreboard (European Commission, 2016) assesses the innovative performance of Romania in 2015 at a lower level than the previous year and the lowest within the EU. Compared to 2008, the indicator value dropped by -4.38%, from 0.246 down to 0.180 in 2015, while the average value for EU 28 increased by

0.74% (Table 2). Even Bulgaria, the other country in "modest innovators" cluster, recorded positive growth rates (+1.4%) and an upward trend.

Romania ranks the last among the EU countries with respect to many of the indicators that composed the Summary Innovation Index, such as "Finance and Support", "Firm investments", "Linkages and Entrepreneurship", "Intellectual Assets", and the last but one regarding the "Human Resources" and the "Open, excellent and effective research system" dimensions.

Table 2. The Summary Innovation Index

Year	EU 28	Romania
2008	0.495	0.246
2009	0.502	0.255
2010	0.511	0.264
2011	0.514	0.263
2012	0.519	0.261
2013	0.521	0.228
2014	0.523	0.223
2015	0.521	0.180

Source: European Commission, *European Innovation Scoreboard 2016*, p.94

With respect to the dimension of "Economic Effects" (including indicators such as the employment in knowledge-intensive activities, the medium and high-tech product exports, sales of new-to-market and new-to-firm products, etc.), Romania ranks the fifth to last, after a negative growth rate of – 0.10% between 2008 and 2015 (Table 3).

Table 3. The Summary Innovation Index by main dimensions

Innovation performance dimensions	Romania	UE 28	Growth rates (%), 2008-2015
Human Resources	0.392	0.575	0.183
Research systems	0.111	0.466	0.355
Finance and support	0.070	0.490	0.420
Firm investments	0.084	0.426	0.342
Linkages and entrepreneurship	0.045	0.473	0.428
Intellectual Assets	0.149	0.556	0.407
Innovators	0.193	0.526	0.333
Economic Effects	0.273	0.573	0.300

Source: European Commission, *European Innovation Scoreboard 2016*, p.95

The table below depicts substantial gaps between Romania and the EU28 average performance, especially regarding the “Linkages and Entrepreneurship”, which refers to the SMEs collaboration with other companies and to public-private co-publications. Also, the “Finance and support”, the “Intellectual Assets” and the “Open, excellent research systems” present considerable lags.

The constant deterioration, in the last eight years, of the Romanian innovative performance, measured through the Summary Innovation Index, is not only the result of the economic crisis but, to a great extent, it is the direct result of the partially operationalized policy measures, of the lack of coordination between the various institutions with key roles in supporting the RDI activity, of the weak and marginal cooperation between the private and public sectors, as well of the extremely low level of EU funds absorption within the Framework Programmes for Research and Development and within other SOP s programs (European Commission, 2015).

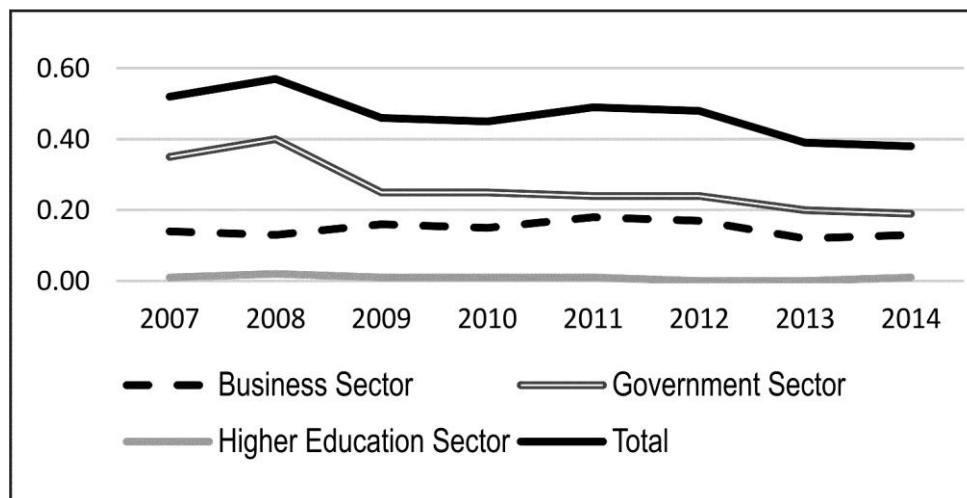
The greatest challenge that Romania has to face for higher competitiveness and productivity, for a better place on the European and international markets is to eventually break the vicious circle where low innovation negatively affects sustainable development through weakening the intensive growth factors. On the other hand, a low economic development level and an industry structure dominated by sectors with low and medium technologies inhibits the propensity of the business sector to invest in R&D and innovate, with negative consequences on sectoral and overall economic efficiency (Goschin, 2014).

Following the last economic crisis, a shock that shattered the Romanian system of R&D and innovation, the intensity of RDI investment has had a new turning point. After a significant and consistent growth between 2005 and 2008, the share of R&D expenditure in GDP started a sharp continuous downward trend, dropping from 0.58% in 2008 to 0.38% in 2014, under the 2013 level. From the fifth to the last position, in 2008, Romania fell to the last position among the EU countries in 2013 and 2014, regarding the intensity of R&D. The sector with the lowest contribution to the R&D funding is the private sector. Yet, while the private sector investment in R&D followed a sinusoidal trend, the highest decrease occurred in the public sector expenditure for R&D, which fell from 0.40% in 2008, down to 0.19% in 2014 (Figure 4).

These developments suggest divergent after-shock behaviour among the various components of the R&D system which confirm, therefore, the intricate and complex pattern that determines the systemic level of resilience. While the private sector attempted a boost in RDI investment after 2008 when the international financial crisis hit the Romanian business sector (Figure 4) and has strived to keep the level as high as

possible, the public sector investment in research and innovation has remained constantly on a downward trend.

Figure 4. The gross expenditure for R&D by funding sector in Romania, 2007 – 2014 (%)



Source: Eurostat database.

The chronically underfinanced R&D sector has achieved low performance levels, with negative consequences in multiple other areas, with a long-term impact on social and economic equilibrium and development prospects. For example, the available human resources for research have deteriorated in quantity and quality, given the higher brain drain and lower competences of the R&D personnel.

Having in view all the negative recent trends briefly described above, the achievement of the assumed targets regarding R&D within the Europe 2020 Strategy (2% of GDP by 2020, equally shared between the public and the private sectors) represents an even greater challenge, considered by experts an unrealistic and unreasonable goal (Zaman et al., 2016)).

Looking back to the history of dramatic transformations of the Romanian RDI system in the last 26 years, to the challenges it faced while adapting to the requirements and constraints of the transition to a market economy, of the integration process in the European Research Area, one cannot but acknowledge a certain level of systemic

resilience to shocks and hazards. In the context of often inappropriate and poorly substantiated strategies and policies, of increasingly insufficient financial resources, the current level of the resilience of R&D system, though important, is critically low. After seven years since it was hit by the last economic crisis, it hasn't yet bounced back in terms of input as well as output indicators.

Nevertheless, the R&D system survived and made progress in the management at central and local level, in the approach and procedures of evaluation of the science and scientists. The number of internationally acknowledged scientific journals, of co-publications and the share of the national scientific publications in the most cited scientific reviews worldwide have increased along with the number of new S&T and PhD. graduates, etc.

The shift of the funding mechanism from an institution-based to a competitive based approach, within the framework of the National RDI Plan 2007-2013 and the Horizon 2020 Plan, the assessment procedures regarding projects proposals which involved mix teams of Romanian and foreign experts, enhanced the international visibility and relevance of the Romanian scientific community, facilitating its integration within the European and international networks of the R&D. In this respect, the multiplication of the Romanian scientific reviews indexed in international databases, the increase in number of scientific papers, books and other prestigious publications are important tokens of progress (European Commission, 2013).

Conclusions and recommendations

After 1990, the Romanian scientific research sector hardly managed to surpass the difficulties of the fundamental restructuring processes, of the re-organising imposed by the transition from a hyper-centralized system to one market driven structure, by the privatisation processes of large research institutes, by the necessity to identify and attract alternative funding sources for industrial research. Yet, the RDI system stayed viable and functional, with its ups and downs, proving that that model of "trial and error" or "learning by doing" cannot ensure long-term stability or high performances.

The restructuring process brought forth a new research sector – the high education sector – which has undergone steady consolidation, as the input (number of researchers) and output (number of scientific papers, participation in international scientific events and in national and international research programs). In this sector, indicators of research performance have constantly improved. An important stimulus to this outcome was the extremely high criteria of university career advancement, imposed both, to universities and research institutes.

It is worth mentioning that, despite being hardly hit by the economic crisis, the main actors of the R&D system have been able to ensure survival and recovery through identifying and attracting extra budgetary funds, from alternative funding sources. Yet, the current weaknesses of the Romanian R&D system, that undermine its resilience to future hazards converge mainly to: the weak and superficial linkages between research, education and business; the underfunding and dysfunction in resources allotment; the low capacity of attracting and capitalizing on available European funds that turns Romania into a net contributor to the European funds for science and technology; the brain-drain phenomenon; the lack of systematic and consistent political perspective over the research and development system, which should involve inter-dependent components of smart specialisation etc.

The existent Romanian RDI system is still fragmented, with scarce linkages between applied and fundamental research performed in the Romanian Academy institutes, in the industry research institutes or within universities. The fragmentation is also apparent with respect to the performant research entities which, assuming their own uncorrelated – and often overlapping – thematic portfolios, favour the waste of resources or prove irrelevant to the market economy requirements.

Building a stronger and more resilient RDI system, supported by adequate investment in research and innovation, by efficient fund allotment requires a comprehensive and thorough analysis of the causal relationships among the systemic components, within the complex network of internal and external factors which, interdependently and synergetically, influence the national RDI system. In this context, it becomes increasingly important to clarify the intricate dynamic of the either complementarity or substitutional relationship between the private and public contribution to increasing the RDI investment.

Given the particularities of the Romanian economy, especially in the context of the recent economic crisis which considerably diminished the private funding resources for research and innovation, the public support provided through various instruments for effectively stimulate the interest for research and innovation of the private sector becomes critical and vital.

Therefore, the objective of higher investment towards research and innovation needs to be joined by consistent efforts for ensuring the social and economic efficiency of the public financial resources allotted to research and development programs.

These should be seriously analysed in terms of quality and impact of research results under different aspects: technologic, economic, social and environmental.

Achieving higher levels of private sector investment in research and innovation, which stands out as a first priority for reaching the Europe 2020 targets, requires tighter correlations among the various sectoral policies (industry, fiscal, financial, competition etc.) which may to germinate a wider array of indirect but complementary policy instruments that have been way under-utilised. The fiscal incentives, facilitated access to venture capital, increased state aid for innovation in the private sector are some of the most frequent recommendations in order to achieve higher private investment in RDI.

Most of the European Union member states have acknowledged the growing importance of the fiscal instruments as a complementary tool to direct public R&D funding. The national strategies and policies for RDI include some fiscal and financial instruments intended to encourage higher intensity in RDI activity and expenditure at industry and business sector. Yet, so far, their impact is hardly evident.

The interest for RDI investment at firm level may also be stimulated through facilitating the access of private company to the results of the R&D activity performed in the public sector that may become valuable input in the in-house research and innovation activities, at company level, provided that these results might prove to be relevant to the potential user.

Yet, in Romania, to a considerable extent, the results of the research projects funded with public financial resources are not sufficiently monitored in order to ensure the achievement of the assumed objectives and the results transfer to industry. The inadequate infrastructures of knowledge and technology transfer from research towards potential beneficiaries, the irrelevance of these results for the business sector, or the low capacity of absorbance of research results at firm level are some of the factors that hinder cooperation between academy and industry.

The exploitability of the R&D results provided within the National Programs for Research-Development and Innovation is still at low levels, as they often prove unmarketable. An important responsible factor is poor of the ex-post qualitative assessment of the funded R&D project, which directly affected the motivation and determination of researchers to achieve high-quality results, with applicability in the Romanian economy and society.

The infrastructure of innovation and technologic transfer, through its organisations specialised in the dissemination, the transfer and valorisation of RD results – such as technologic platforms, transfer networks, and clusters – is still in an early stage. The centres of excellence in universities, the scientific parks may become natural environments for educational and research activities, that could be capitalized upon as

strategic levers towards higher technologic concentration around universities. Designing and implementing programs specifically oriented towards to this end may be able to provide the necessary framework favourable to strengthening partnerships and linkages between business, universities and R&D institutes.

Other highly innovative countries, such as the Netherlands, Germany or France, that may serve as examples of best-practice for Romania, have achieved the economic revival of those regions where the scientific research results were being transferred towards firms through spin-offs.

Nevertheless, the first prerequisite is to ensure that the scientific research provides viable answers to the needs and requirements of the industry and of the business sector. This entails systematic efforts oriented towards constantly improving the quality of the human resources employed in research and of the research results, through public policies and measures.

At company level, on the other hand, successful improvement of the absorptive capacity depends on micro as well as macroeconomic factors. The design of a stable and consistent legislative framework, able to stimulate the firms' interest for research and for acquiring the RDI results provided by the public and higher education sectors (through fiscal and financial instruments) has to be realized by joint and congruent efforts for creating a pro-innovation culture in the business sector, having in view that the economic agent remains the final decisional factor.

Bibliography

- Adger W.N., Hughes T.P., Folke S, Carpenter SR, Rockstrom J, 2005, "Social-ecological resilience to coastal disasters." *Science* 309:1036-1039.
- Anghel I., 2014, "Resilience and Social Risks Management. Concepts and Policies", communication presented at The Second World Congress on Resilience: From Person to Society, Timișoara, 8-10 May, 2014.
- Bahadur A.V., Ibrahim M., Tanner T., 2010, "The resilience renaissance? Un packing of resilience for tackling climate change and disasters". Institute of Development Studies (for the Strengthening Climate Resilience (SCR) consortium): Brighton, UK.
- Berkes F., 2007, "Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking", *Natural Hazards* (2007) 41: 283-295.
- Birkmann J., 2006, "Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions", in J. Birkmann (Ed.): *Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies*. Tokyo: United Nations University Press, pp. 9-54.

- Brown K., 2014, "Global environmental change: a social turn for resilience?" in *Progress in Human Geography* 38:107-117.
- Dagdeviren H., Donoghue M., Promberger M., 2015, "Resilience, Hardship and Social Conditions", *Journal of Social Policy* <http://www.rescueproject.eu/download/JSP%20article%20-2015.pdf>
- Davidson D., 2010, "The applicability of the concept of resilience to social system. Some sources of optimism and maging doubts," in *Society Nature Resources*, vol. 23(12): 1135-1149.
- Davidson J., Jacobson C., Lyth A., Dedekorkut-Howes A. et al., 2016, "Interrogating resilience: toward a typology to improve its operationalization" in *Ecology and Society*, vol. 21(2):27.
- Davies S., 1993, "Are coping strategies a cop out?" Institute of Development Studies Bulletin, 24 (4): 60-72. Institute of Development Studies: Brighton, UK.
- European Commission, 2012, "The EU approach to resilience: learning from food security crises." COM (2012) 586, Brussels, 2012.
- European Commission, 2013, "Research and Innovation performance in EU Member States and Associated countries. Innovation Union progress at country level". Directorate General for Research and Innovation.
- European Commission, 2016, "European Innovation Scoreboard 2016", Directorate General for Internal Market, Industry, Entrepreneurship and SMEs.
- Goschin Z., 2014, "R&D as an Engine of Regional Economic Growth in Romania" in *Romanian Journal of Regional Science*, Romanian Regional Science Association, vol. 8(1), pages 24-37, June.
- Jones L., Ludi E., Levine S., 2010, "Towards a characterisation of adaptive capacity: a framework for analyzing adaptive capacity at the local level", ODI Background note, December 2010.
- Manyena S.B., O'Brien G., O'Keefe P., Rose J., 2011, "Disaster resilience: a bounce back or bounce forward ability", *Local Environment*, 16(5): 417-424.
- Ministry of Research and Technology (MRT), 1997, "The Annual Report on National Program "Horizon 2000" Evaluation".
- Mitchell F., 2011, "Resilience: concept, factors and models for practice", Briefing, SCCPN.
- Mitchell T., Harris K., 2012, "Resilience: A risk management approach", ODI Background note, January 2012.
- Mitruț C., Zaman Gh., Goschin Z., Constantin D.L., 2010, "A Composite Index of R&D Absorption Capacity. Spatial Configuration in Romania", in *Economic Computation and Economic Cybernetics Studies and Research*, vol. 44, 1, p 4-20, Academia de Studii Economice.
- National Institute of Statistics (NIS).2000, "Romanian Statistical Yearbook: Bucharest: *National Institute of Statistics (NIS)*, p. 238.
- Norris F.H., Stevens S.P., Pfefferbaum B., Wyche K.F., Pfefferbaum R.L., 2008, "Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness", *American Journal of Community Psychology* 41: 127-150.

- Pecitto M., 2016, "The concept of resilience in OSH management: a review of approaches" in *International Journal of Occupational Safety and Ergonomics*, vol. 22(2): 291-300.
- Radosevic, S., and Lauriol L. (1998) "Measuring S&T activities in the former socialist economies of Central and Eastern Europe: Conceptual and Methodological issues in linking past with present." *Scientometrics* 42, No. 3: 273-297.
- ANSTII, 1998, "Annual Report on National Program "Horizon 2000" Evaluation" *Romanian Government – the National Agency for Science, Technology and Innovation 1998*.
- Sandu S., 1996, Innovation Potential and Research-Industry Relations in Romania, chapter six in the book: *Building New Bases for Innovations* (Andrew Webster ed.), Cambridge, Politechnic University, UK.
- Sandu S., 1998, "Industrial R&D in Romania", in: *Transforming S&T Systems – the Endless Transition?*, Nato Series, IOS Press, ISBN 90-5199 370 6, p.244-252.
- Sandu S., 2002, "Innovation, Technological Capability and Economic Growth". Bucharest: Expert Publishing House.
- Sandu S., 2004, "Romania: Transformation of the S&T system", in *From System Transformation to European Integration. Science and technology in Central and Eastern Europe at the beginning of the 21st century*, LIT Verlag Munster, p. 259-281.
- Sandu S., 2010, "Main Issues of R&D Financing in Romania", in *Romanian Journal of Economics*, Anul XX, volumul 30, nr.1, p. 127-145.
- Sandu S., Anghel I., 2015, "The Road to Higher Performance of Two EU Modest Innovators" in *Annals of the Constantin Brâncuși Univ. of Tg. Jiu*, Economy Series, Special Issue.
- Sandu S., Anghel, I., 2011, "Evaluation of National Capacity of scientific knowledge absorbtion in Romania and some European countries", in *Quality Access to Success Journal*, Supplement, year 12, No.121.
- Sandu S., Paven I., 2012, "University - Industry Collaboration - an instrument for increasing R&D investment", in *Annals of the Constantin Brâncuși Univ. of Tg. Jiu*, nr. 4, 2012.
- Sandu S., 2012, "Smart specialisation concept and the status of its implementation in Romania", in *Emerging Markets Queries in Finance and Business*, in Elsevier Journal.
- Sandu S., 2014, "The market of R&D and Innovation in Romania: Elsevier Proceedia Economics and Finance, volume 8, 2014,p 649-657.
- Zaman Gh., Sandu S., Dachin A., Ionescu Sistesti I., Toia A., 1995, Romanian Case. In the book: *Transformation mittel - und ost – europaischer Wissenschafts systeme, Landerberichte, Leske + Budrich*; p. 977-1044.
- Zaman Gh., Sandu S., 2005, "European Research Area :Challenge for Romanian R&D and Innovation System", in *Science and Technology Policy, Lessons for CEE countries*, editori: Annamaria Inzelt, Gh.Zaman, Steliana Sandu, Expert Publishing House.

- Zaman Gh., Georgescu G, 2015 (a), "Resilience to crisis and GDP recovery at county level in Romania", MPRA Paper 63246, University Library of Munich, Germany.
- Zaman Gh., Vasile V., 2014, "Conceptual framework of economic resilience and vulnerability, at national and regional levels," in *Romanian Journal of Economics*, Institute of National Economy, vol. 39(2(48)), pages 5-18, December.
- Zaman Gh., Georgescu G., 2015 (b), "Regional aspects of economic resilience in Romania, during the post-accession period," in *Romanian Journal of Economics*, Institute of National Economy, vol. 40(1(49)), pages 5-32, June.
- Zaman Gh., (coord.), Vasile V., Georgescu G., Sandu S., 2016, "Aspecte metodologice introductive referitoare la analiza pe baza de scenariu" , in *Strategia de dezvoltare a Romaniei in urmatorii 20 de ani*, coordinator Ionel Valentin Vlad, Editura Academiei Romane, volumul III, partea I-a, p. 324-360.