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«Η ΣΥΜΜΕΤΟΧΗ ΤΗΣ ΕΛΛΑΔΑΣ ΣΤΑ ΕΥΡΩΠΑΪΚΑ ΕΡΕΥΝΗΤΙΚΑ ΔΙΚΤΥΑ (1984-2018) ΚΑΙ Η ΕΠΙΔΡΑΣΗ ΤΗΣ ΣΤΗΝ ΠΑΡΑΓΩΓΗ ΚΑΙΝΟΤΟΜΙΑΣ ΚΑΙ ΣΤΗΝ ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ ΕΝΤΑΣΕΩΣ ΓΝΩΣΗΣ»

Deliverable D.1.1

"D.1.1: Conceptual and methodological framework – policy review"

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Αναθέτουσα Αρχή

Contents

Abstract

This deliverable presents the study's conceptual and methodological framework. It begins by highlighting the evolution of the Framework Programme through time and makes an overview of "additionality", a useful concept when organizing public support in research, technology, and innovation. Then it outlines the main characteristics of the Greek participation in the FP and provides the study's conceptual and methodological framework.

1. Literature Review and development of the theoretical framework

1.1. Introduction

Over the last three decades, the promotion of multinational collaborative activity between universities, research centers, firms and public agencies is at the core of European Union (EU) science and technology policy. Cooperative Programmes in the form of shared-cost consortia have become the most important source of EU funding and institutional support to innovation, international competitiveness, and contribute, through knowledge exchange and diffusion, to intra-European integration, and cohesion.

NETonKIE is aiming at exploring the participation and role of the Greek organizations (universities, research centers, other public organizations and businesses) in the collaborative research networks during a long period of more than 35 years. These networks are formed through the Research Joint Ventures (RJVs) funded -under competitive conditions- by the EU in the context of the seven Framework Programmes (1984-2013) and the eighth Horizon 2020 (2014-2020). Furthermore, NETonKIE will provide in-depth insight on the impact of the relevant research activity on innovation and the emergence of knowledge-intensive entrepreneurship in Greece. Research work up to now shows that Greece is exhibiting a stable and intense presence in the Framework Programme (FP) since its inception in 1984, while some actors, primarily universities and research centers, have acquired a significant role in the resulting research networks (e.g., Caloghirou and Protogerou, 2009; Protogerou et al., 2010; Protogerou et al., 2010; Siokas, 2014, Caloghirou et al., 2021).

A multilevel analysis, taking into consideration factors at the country level and organizational level will focus on the participation of Greece in these research networks. In addition, the analysis will seek to shed more light on the impact of EU-funded research networks on the diffusion of technological knowledge and the deployment of innovation at the national level as well as the promotion of knowledge-intensive innovative entrepreneurship.

In particular, by combining diverse but complementary research methods (social network analysis, survey work, case studies, experts views, secondary desk research) and mainly focusing on

Greece, NETonKIE aims at investigating: a) the nature, structure and evolution of the EU-funded collaborative research networks, b) the participation patterns, positions (central, peripheral actors) and different roles of participating organisations (e.g. research units, technology providers, technology users, project coordinators) as well as the intra-project structure and knowledge flows among partners, c) the participation determinants of Greek organizations and how they benefit from their presence in the networks, d) the impact of the particular research collaborative activity on the creation and diffusion of knowledge and the production of innovation outputs (e.g. research results, reports, publications, patents, new goods or services) and outcomes (valorization of research, creation of spin-offs and other new innovative firms, upgrading of existing industrial firms and improvement of the efficiency and effectiveness of the public sector) and the wider developmental impact (e.g. improving organizational capabilities and knowledge, strengthening the national/regional propensity to innovate or upgrading the national research in the European Research Area), e) the role of the young knowledge-intensive firms in these networks and the effect of their participation in their performance and evolution.

1.2 The evolution of European Framework Programmes through time

The Framework Programmes for Research and Technological Development, also called Framework Programmes (FPs) or abbreviated FP1 to FP9, are funding programmes created by the European Union (EU) to strengthen and nurture research in the European Research Area (ERA). The European Research Area is "a single borderless market for research innovation and technology across the EU, where countries come together and improve their research policies and systems and where there is free movement of researchers, knowledge and innovation"[1] (EU, 2021).

The FPs are the main EU research policy tools. They are agreed upon by the EU Member States and the European Parliament and they are executed over the period of several years. They fund research across a variety of technological fields such as information and communication technologies, biotechnology, advanced materials, health, energy, safety, space, transport, climate, and food. The supported projects must a have a minimum number of participants which cannot be fewer than three partners representing three different Member States or other associated countries. The thematic priorities of the Framework Programme are set top-down; however, within the specific thematic areas research teams can propose those subjects and partnerships that are likely to be proven mutually

[1] European Union 2021. The New European Research Area. Directorate-General for Research and Innovation. Available at https://op.europa.eu/en/publication-detail/-/publication/151f4fdc-2c97-11ec-bd8e-01aa75ed71a1 (last accessed 1/10/2021)

beneficial (bottom-up). Project funding is allocated on a competitive basis which practically means that research proposals are evaluated against a set of specific criteria such as relevance, scientific excellence, potential impact, quality of consortium, quality of management, etc.

The EU's involvement in R&D cooperation can be traced as far back as the Treaty of Rome (the Treaty Establishing the European Economic Community in 1957) through the establishment of the Joint Research Center and through research funding to organizations in Member States (Caloghirou et al., 2002). Nevertheless, it was not until the early 1980s that the current profile of EU research policy began to emerge. Back then the first concerns appeared that European firms were falling behind their American and Japanese counterparts in terms of innovation and market share in global markets and particularly in the IT industry. As a result, a major information technology and telecommunications programme, the European Strategic Programme of Research in Information Technologies I (ESPRIT I), was launched in 1984. This programme was originally based on a similar successful Japanese programme and in the very beginning the participating firms were major competitors (Peterson, 1991). ESPRIT I was subsequently used as a model for the creation of a more general "umbrella type" programme, which was referred to as the first Framework Programme. The framework was progressively being broadened to include various other programmes on R&D in diverse technological areas.

Since their introduction in 1984, the FPs have been basic pillars of European scientific and technological development, integration, and cohesion by supporting all kinds of R&D, mainly in high technology sectors (Muldur et al., 2006), favoring the participation in RJVs of various organizations from different European countries, and cultivating a sense-culture of a common European research policy in science and technology. The first three FPs constituted the response of EU to the deterioration of the innovation potential and market share of European firms in international markets. Their main aim was to promote the competitiveness of European industries by raising their technological level through the establishment of R&D collaborations among firms and public research institutes (supply- or technology-oriented) (Peterson and Sharp, 1998). However, the design of the next FPs has been influenced by the new theoretical conceptualization of the innovation process that emerged in the early nineties, and from FP4 onwards, stronger emphasis was given on knowledge diffusion and learning skills and capabilities (knowledge diffusion-oriented) (Protogerou et al., 2017). With FP4 and FP5 adopted in 1994 and 1998 respectively, the scope of the FP was enlarged and the focus on pre-competitive research was abandoned for an approach that would see the FP addressing societal challenges and supporting a wider range of activities in the innovation process.

Under this new perception, innovation is understood as a complex, non-linear system which involves interactive knowledge-sharing processes and feedback among a wide set of heterogeneous actors. Beyond accounting for inputs and outputs/outcomes, the systemic approach for public intervention is focused on the dynamics of R&D and innovation, i.e., the processes involved in producing innovation outcomes, providing additional rationales for publicly supporting R&D activities. The development of the European Research Area concept in 2000 marked a clear shift in the evolution of the FP. FP6 and FP7, adopted in 2002 and 2006 respectively, were designed to implement this EU research policy, which aimed to address the fragmentation of the European research landscape.

In this vein, FP6 was oriented towards the integration of fragmented research efforts more than any of the previous FPs by fostering the creation of crucial 'centers of excellence' that would act as catalysts for marginal actors restructuring the way research is undertaken and nurturing the development of an overall more collaborative attitude among private and public organizations that would represent the backbone of a truly representative European Research Area (ERA) (Breshci and Malerba, 2009). FP7 was largely focused on maximizing the FP's macro-economic impacts, overcoming the fragmentation of European basic research (through the establishment of a European Research Council and Joint Technology Initiatives), and raising the competitiveness of European industry (Muldur et al., 2006).

The adoption of the Europe 2020 strategy and the Innovation Union flagship initiative in 2010 influenced the structure of FP8, which was adopted in 2013 and named Horizon 2020. Horizon2020, was the larger programme in terms of budget compared to its predecessors. It involved and networked a wide range of stakeholders with three main priorities: a) to reinforce and extend the excellence of EU's science base and to consolidate the European Research Area, b) to promote industrial leadership by speeding up the development of future technologies and innovations and assist small and medium-sized innovative enterprises to grow into world-leading firms, and c) stimulate a critical mass of research and innovation efforts to directly address grand societal challenges. (European Commission, 2017a).

Currently, FP9, named Horizon Europe, is under way with an increased budget of 95.5 billion euros. Mission-oriented policy has been identified as the key instrument to reframe Europe's approach to tackling grand societal challenges, in other words to make them more practical and systemic so that R&I investments can help attain specific, targeted, and concrete goals so that society itself can reap the greatest possible benefits (Mazzucato, 2019; Mazzucato, 2018). The mission-oriented policy approach has had a great influence on the structure of Horizon Europe. Five major European research and innovation "missions" to tackle challenges such as cancer, climate change, polluted oceans and soil, and the development of carbon-neutral cities have been included in the programme. It has also adopted a new approach to partnerships facilitating objective-driven and more ambitious partnerships with industry in support of EU policy objectives. By setting up research and innovation "missions" that require the cooperation of different industries, it is possible to create measures that will reward companies that are willing and able to invest in parallel with public investment. In other words, this is not about static R & D subsidies but about dynamic co-investment throughout the innovation chain (Mazzucato, 2019).

Not only the rationale but also the content of the FPs has evolved. New priorities (research areas) along with new instruments have been introduced. Furthermore, the FPs budget has grown substantially since the launch of these programmes (1984) until today (see Table 1). More specifically, the budget raised from €3.8 billion to €77 billion between FP1 and Horizon 2020, while Horizon Europe is the biggest EU Research and Innovation programme ever with nearly €100 billion of funding available over 7 years (2021 to 2027). In this context, over the last three decades, the collaboration intensity among businesses, universities, research centers and other entities aiming at research and development of innovations (innovation production), has been increased rapidly. These collaborative activities typically take the form of Research Joint Ventures and can be defined as the organisational schemes that consist of two or more organisations, whose main goal is to participate in collaborative Research and Development (R&D) (Caloghirou et al., 2003a; Caloghirou et al., 2003b; Caloghirou et al., 2004). Each partner transfers its own technological knowledge to the consortium and the pursuit is that this combination of knowledge and skills will lead to benefits and added value for all the involved actors (Revilla et al., 2005).

Table 1: Framework Programmes: Evolution of rationale, priorities and budget

	Periods - budget (billion of €)	Emphasis of rationale	Main priorities	New actions
Before	1975-1983	Ad hoc basis	Fragmented	-
FP1	1984-1987 3.8	Supply or technology oriented: main aim to promote industrial competitiveness (technological catch up with global competitors)	Energy and ICT oriented	Environment, international cooperation human capital and mobility
FP2	1987-1991 5.4	Information Society	ICT oriented	Biotechnologies, marine resources, dissemination
FP3	1991-1994	Industrial competitiveness	Multiple	

	6.6		priorities	
FP4	1994-1998 13.2	Diffusion-oriented, increase of learning skills and knowledge	Multiple priorities	Transport and social sciences
FP5	1998-2002 13.7	Shift towards the needs of the community and its citizens	Multiple priorities	Nanotechnologies
FP6	2002-2006 17.9	Integration of research efforts by creating European Research Area (ERA)	Multiple priorities	New instruments
FP7	2007-2013 50.5	Extension of the scope of the FP towards exploratory research and innovation activities	Multiple priorities	Security
Horizon 2020 (FP8)	2014-2020 77	Focus on excellence, industrial competitiveness and addressing societal challenges	Multiple priorities	Social challenges: health, food security, energy, transport, climate and environment, inclusive and secured societies
Horizon Europe (FP9)	2021-2027 95.5	Strengthen ERA, tackle policy priorities and sustainable development goals, boost innovation uptake, competitiveness and jobs	Multiple priorities	Research and innovation "missions" to tackle cancer, climate change, polluted oceans, and soil

1.3 Policy evaluation and the concept of additionality

In the economics literature, public support for RTI has traditionally been justified on the rationale of market failures. The market failure approach is founded on the difference between the benefits to society and the benefits to the individuals/organisations (private returns) undertaking the RTD investment. The larger this difference, the larger the spillovers from the private sector to the society and the lesser the motivation and willingness of the private party to invest at the socially optimum level (Breschi and Malerba, 2009).

Even though the market failure argument has been considered as the main motivating factor for the implementation or the first FPs, the gradual changes in the EU RTI policy as depicted in the FPs evolution in the previous section (section 1.2) seem to reflect new theoretical conceptualizations of the innovation process. Innovation process is conceptualized as a complex non-linear system that involves interactive learning and feedback inputs among various organisations. Beyond taking into consideration inputs and outputs/outcomes, the systemic perspective puts emphasis on the dynamics of research, technology, development, and innovation, i.e., the processes involved in creating innovation outcomes, providing additional rationales for public intervention. In this vein, public support for research, technology and development activities can be found in 'system failures' arising from issues such as technological lock-ins, timing of investments, institutional constraints, coordination failures (e.g., technology standards), complexity of knowledge bases and inefficient mechanisms for facilitating knowledge flows (Edquist, 2005). Rather than just providing additional resources, government policy measures should therefore give emphasis on advancing collaborative learning, bolstering the linkages among different organization types engaged in the innovation process and facilitating a wide diffusion of knowledge. However, policy should also consider the major differences that occur across national, sectoral, and regional innovation systems (Edquist, 2005; Malerba, 2002). The consideration of such differences has highlighted the concept of 'additionality', a highly relevant and useful concept when organising public support for RTI. Additionality is a key concept of research, technology, and innovation (RTI) policy evaluation and refers to the question of what difference is made by a public intervention and whether the difference justifies the intervention (Gök and Edler, 2012; Hyvärinen and Rautiainen, 2007).

In general, the concept of additionality has been developed around three dimensions: input, output/outcome and behavioural additionality (Breschi and Malerba, 2009).

- 'Input additionality' deals with the issue of whether public expenditure has created additional funds to be spent and on what thematic areas are they spent.
- 'Output/outcome additionality' deals with the question of whether public expenditure generated additional private and social returns.
- 'Behavioral additionality' addresses the issue of whether public expenditure created sustainable effects beyond the infusion of resources and outputs such as improving the knowledge base, capabilities, organization and firm strategies

Input additionality deals with the question of whether public R&D support lead to the increase of R&D investments of the private firms that receive them[2] or, alternatively, whether these public funds just introduce inefficiencies (e.g. higher salaries for researchers[3]) or are substitutes for R&D that would have taken place anyhow. In the latter case, there is a crowding-out effect (Georghiou, 2002; Clarysse et al., 2009). This is typically the rationale behind the requirements of industry involvement in some

[2] And if so whether this increase is larger than the amount of taxpayer's money used for funding the R&D programme.
[3] Although the salary issue has its own importance in countries suffering from "brain drain" such as Greece.

publicly funded projects or the requirements of co-funding from private actors (Borrás and Edquist, 2019). This type of additionality is more commonly examined through econometric methods as there are a number of databases that can be easily used for estimation (Hyvärinen and Rautiainen, 2007). Several studies have shown either that public R&D funding has a genuine input additionality on corporate R&D investment (e.g., Falk, 2006; Lööf and Hesmati, 2005; Ebersberger and Lehtoranta, 2006) or converge on the conclusion that there is no crowding-out effect (Duguet, 2003; Czarnitzki and Licht, 2006; Gonzalez and Pazo, 2008). However, there is also evidence of substitution effects (e.g., David et al., 2000; Marino et al., 2016).

The main problem with using input additionality as a dependent variable is that there is not a clear direct link between R&D input and innovation output, and even more between R&D input and productivity and economic performance improvements (Clarysse et al., 2009; Hyvärinen and Rautiainen, 2007). Given the non-linear character of innovation processes, it is questionable whether input additionality is always translated into innovative output and economic welfare. Therefore, econometric scholars have also paid attention to the so-called "**output additionality**" of public funds (Clarysse et al., 2009). Georghiou (2002) defines the concept of output additionality as the proportion of outputs from the R&D process which would not have been achieved without public support. Outputs include direct results of the research function such as publications, patents, prototypes, and licenses as well as more indirect results such as new products, services and processes. The latter in turn affect variables of economic performance such as turnover, productivity, profitability, exports and growth that refer more to outcome additionalities (Klette et al., 2000; Hyvärinen and Rautiainen, 2007). In addition, the creation of start-ups and new business areas is also included in this dimension of additionality (Hyvärinen and Rautiainen, 2007). While input additionality is rather straightforward to measure in relation to specific R&D projects, output additionality raises several operationalisation issues. Clarysse et al. (2009) underline that these problems relate to the fact that R&D projects are rarely individual projects that are not part of a larger R&D portfolio within the firm, particularly concerning large firms. Due to inter- and intra-firm spill-overs, it is not easy to identify a one-on-one relationship between the project and the outputs that result from that project, especially pertaining to more indirect outputs (e.g. innovative products) and economic outcomes that need much more time to be realized (in some cases even around 10 years) [Clarysse et al., 2009; Hyvärinen and Rautiainen, 2007]. For this reason, Hyvärinen and Rautiainen (2007) stress the need of using long-term data and suitable research methods in order to distinguish the impact of public funding from other effects.

Gök and Edler (2012) highlight that "the concepts of input and output additionality are widely considered as the hallmark of the neoclassical policy rationale which ultimately seeks to remedy market failures. If a government action designed to address market failures does not create more inputs and/or outputs that would not have been created without it (e.g., input and/or output additionality), then it is unsuccessful."

The concept of **behavioural additionality** was firstly introduced by Buisseret et al. (1995) as a reaction to the mainstream input-output based logic of evaluation of technology and innovation policies that approach the firm as a black-box. The authors argued that the information regarding input and output additionality are not sufficient to assess the success of a policy (Gök, 2010). They proposed to study what happens inside the firm and how the firm's behaviour changes as a result of the government intervention. More recently, Autio et al. (2008) introduced the term of "second-order additionalities" to refer to the learning outcomes of collaborative R&D programmes while the input and output additionalities are labelled "first-order additionalities". Therefore, we could say that the concept of behavioural additionality (either explicitly referred or implicitly implied) goes beyond the market failure rationale and it is based on the evolutionary view that focus on policy actions aiming to increase cognitive capacities of organisations to overcome other types of failures such as system and knowledge processing failures (Gök and Edler, 2012). However, behavioural additionality aims to complement and not to replace the traditional input and output additionality concepts (Clarysse et al., 2009).

Although the concept of behavioural additionality has gathered considerable attention from a range of scholars, there is no consensus as to what it means and it lacks a comprehensive theoretical basis and a sound, accepted operationalization (Gök and Edler, 2012). As a consequence, there is also variation in the manner it has been put into practice for evaluation and policy making purposes. Gök and Edler (2012) by making an interesting review regarding both the academic literature and policy evaluation studies, identified a wide variety of approaches ranging from those with quite narrow character to those with quite broad character in terms of the content, the scope, the depth and the persistence of change. For instance, the category of the most "narrow" approaches that Gök and Edler (2012) has identified, views behavioural additionality as an extension and/or complement of input additionality focusing on specific projects and time periods [e.g. "whether the R&D would not have been carried out at all without public support, or alternatively whether the public funding changed the scale and scope of the R&D or whether R&D would have been done differently" (Luukkonen, 2000)]. At the other end of the spectrum, behavioural additionality is considered as the induced change in the general conduct of the firm i.e., not confined to R&D or even innovation related activities, that endures long time after the relevant public support. A characteristic example is that of Georghiou and Clarysse (2006) who connects this concept with changes in firm's dynamic capabilities. In addition, Clarysse et al. (2009) utilised the theory of organisational learning and more specifically three dimensions of learning i.e., experiential learning, interorganisational and congenital learning (the latter closely related to the absorptive capacity), to explain the mechanisms whereby behavioural additionality is obtained. In the same vein, Bach and Matt (2005) defined a new category of cognitive capacity additionality that Hyvärinen and Rautiainen (2007) integrated it into a broader concept of behavioural additionality by defining the latter as "how public R&D funding affects the firm's behaviour, cognitive capacity and learning". In addition, Hyvärinen and Rautiainen (2007) via their review of relevant evaluation studies, proposed that behavioural additionality refer to the dimension of R&D projects (scale, risk, time and quality) as well as to the dimension of organisational capabilities and competences (innovation management, networking, collaboration, project management, human capital, strategic choices, technology).

Regarding the issue of behavioural additionality measurement, Gök supports that in general all conceptual approaches of behavioural additionality share two common problems (Gök, 2011; Gök,2010). Firstly, the building blocks of behaviour are analysed and measured mainly through an input-output logic. For example, collaboration behaviour is evaluated in terms of the money spent on collaboration (input to collaboration behaviour) or the amount of collaboration (output of collaboration behaviour) but not in terms of its qualitative characteristics. Considering this, the authors propose to operationalize and measure behavioural additionality by focusing on organisational routines at three different levels: i) micro (within a particular firm), ii) meso (within a population of firms), and iii) macro (within the economy). Secondly, the compatibility of the concept with evolutionary thinking demands a dynamic framework of analysis, namely, to investigate the entire process of behavioural change and not just to compare the building blocks of behaviour after policy support with the building blocks of behaviour prior policy support, as it is used hitherto.

Finally, Hyvärinen and Rautiainen (2007) suggest a fourth dimension of additionality that can be viewed as an extension of output additionality. This is the impact of public R&D financing at the macro level i.e., on the whole economy (in terms of productivity, economic growth, exports etc.) and through which or directly as well on society and well-being (in terms of environment and health, security and safety, employment etc.).

1.4 The participation of Greece in EU FPs

Greece appears to be part of a group of countries that exhibit a medium to high presence in FPs, maintaining its participation intensity rate over time. Specifically, it can be characterized as an experienced FP country with long standing and recurring participation since its inception in 1984 (EC, 2019, while some actors, primarily universities and research centers, have acquired a significant role in the resulting research networks (Caloghirou and Protogerou, 2009; Protogerou et al., 2010; Protogerou et al., 2010; Siokas, 2014; Caloghirou et al., 2021).

With the increasing significance of EU research funding, national policy makers have put domestic participation in EU research at the center stage of the research policy agenda (Enger and Castellacci, 2016). For Greek policy makers, the need to understand the determinants and impact of EU research programmes should rank even higher in the agenda. This is because the share of EU FP funding in total research expenditure is much larger for countries like Greece -where for many years one of the main substantial national funding mechanisms for research projects mainly referred to the coverage of the required Community co-funding- compared to other large and research advanced EU countries (Mitsos, 2007). Over time, the Greek participation in the programmes and the networks that are formed through these programmes is particularly high, not only in comparison with corresponding European partners, but also in relation to the GDP and the R&D expenditures of the country itself.

Specifically, from the beginning of the FPs in 1984 and up to 2020, Greece ranges between the 7th and 10th place among EU28 countries in terms of participations, and between the 8th and 11th position in terms of participating organizations (please see more details in Deliverable 2.5), attracting, in total, about 2.3% of the funding for these programmes, despite the fact that the share of Greek expenditure in the total R&D expenditure of the EU-28 does not exceed 0.7%, and the country's GDP is 1.1% of EU GDP for 2019. Most importantly, during the last seven years competitive EU FP funding accounted for 10-12% of the total R&D expenditure in the country (Caloghirou et al., 2021)

The participation rate per organization is of particular interest, as it shows the highest value among EU countries with 5.31 research projects per participating organization across FPs (1984 - 2020) (Caloghirou et al., 2021). This fact suggests that the increased Greek participation cannot be solely attributed to the high number of participating organizations in these programmes and networks but should be explored considering the repeated participation of a more limited set of organizations. These organizations are mainly the major universities and research centers of the country, which have the resources for such a wide and repeated participation. It is characteristic that seven Greek Universities and research centers are ranked among the top 100 European organizations on the basis of their central position in the research networks, their total participations and their participations as coordinators of the research projects, in terms of the total FP (1984-2020) (Caloghirou and Protogerou, 2019, please also see Deliverable 2.5)

Greek organizations not only show a very strong presence in all the FPs, but their presence seems to be important in all the technology areas that are funded, following in general the trend of the overall European participation per thematic area. The multidimensional nature of this participation can be attributed to the heterogeneity of research fields covered by the central Greek organizations that are mainly Universities and research institutes with a wide range of activities (Siokas, 2014).

Although the FPs are of critical importance to research and the opportunity to participate in the FPs has had a positive overall impact on the development of national research and innovation systems there are also other EU policies and programmes with a significant influence as well. Perceptions as to the extent of the FPs impact on the national research and innovation systems are closely related to the degree of country participation and the FP funding as percentage of the total R&D funding. Due to the long standing and solid presence of Greece in the European FPs, and the large share of FP funding as a percentage of the country's R&D funding, they have affected the national research and innovation system to a large extent, shaping the priorities of basic research in Greek academic and research institutions (Caloghirou and Protogerou, 2009; Protogerou et al., 2010b; EC, 2019). In this vein, it should be noted that the financial crisis and adverse economic environment in Greece since 2010 signified severe cuts in the national funding. Under these conditions, FP funding has been a major source for high level research and the number of proposals submitted by Greek research teams has significantly increased.

Furthermore, the FPs appear to be the main tool for international cooperation in science and technology. In this respect, given the limited size of Greece's research and innovation system, the FPs provided an opportunity for motived researchers in Greek academic and research institutions to get engaged in state-of-art research and acquire funding for this purpose. This was particularly important for top Greek scientists, many of whom had relocated to Greece in the 1990s' after prominent careers abroad to pursue high-profile research and at the same time build very competitive research teams. The FPs have had also a substantial, positive effect in Greece in developing a highly trained research force. FP participation allowed Greek research teams to recruit and train a large number of PhD and postdoctoral students and to provide them with technical/technological skills and networking opportunities with EU partners that could be directly exploited in follow-up academic or private sector positions. Moreover, FP participation had a positive influence on teaching methods in Greek universities, in the sense that they have provided illustrative examples from FP research projects to explain theoretical developments in formal courses and supplied material for different student projects as part of their curriculum (EC, 2019).

FP participation has improved the role of some Greek private companies in EU RTD projects and has also strengthened their links with leading universities and research institutes. One important weakness comes from the very limited success in Greece in implementing policy measures to promote different forms of technology transfer. The limited connection between the country's productive and business system and its research, technological and innovative activity is a significant missing link within the national (domestic)innovation system and constitutes a serious systemic weakness which is reflected in the relatively low innovative performance of the business sector and, in the limited commercial and developmental use/exploitation of the remarkable research activity carried out in Greek academic institutions (RAND, 2011; Caloghirou and Protogerou, 2009; Caloghirou, 2017). Thus, the main benefits from FP participation are linked to knowledge creation and training that have contributed to an improved R&D quality in Greek public and private sector organizations.

In addition, prominent Greek actors in EU-funded research networks could facilitate the development and diffusion of innovation at the regional and national level. However, it appears that there is an absence of links for knowledge diffusion and innovation deployment among organizations holding prominent positions in EU-funded research networks and regional institutions (Protogerou, 2010b). The dissemination of innovative results and knowledge gained through the participation of Greek organizations in EU-funded research networks should be further strengthened by national and regional innovation policies focusing on improving demand, strengthening knowledge-intensive industries and supporting institutions and interactions between the various national and regional elements of the innovation system (Caloghirou et al, 2021).

Furthermore, it seems that participation in the FPs has grown over time through a bottom-up approach to EU research. Greek participation has been sparked by specific initiatives of individual public and private sector organizations. At the same time there was no underlying strategy (at least in FP5, FP6 and FP7) for promoting participation at a national or regional levels with associated thematic goals. In this vein, funding has been available for research fields of specific interest to researchers, but there has been no interconnection with national priorities (EC, 2019). In a sense, FPs have contributed to expanding the gap between public research and the priorities of the public and private sector stakeholders dealing with economic development. In this vein, there is a need for a clear national research agenda with specific priorities, focusing on large and long-term strategic objectives with specific mission-oriented policies, rather than fragmented small interventions with limited impact on the economy. In this way it can be decided which areas of research can be aligned with EU activities and which should be developed at national level.

1.5 Overall Conceptual Framework

Research, technology and innovation strategies at EU and national levels are evolving rapidly depicting the broadening concept of innovation and its relation to research (see also sections 1.2 and 1.3 for an overview of the evolving rationale underpinning EU FPs and the concept of behavioral additionality). These developments contribute to a much more complex picture than the recent past when innovation and research were less closely integrated at a policy and strategic level. This increasing complexity in the research and innovation environment induces a transition away from over-dependence on a linear innovation generation and diffusion towards a more open, dynamic, and networked systems-based conceptualization. Furthermore, there has been pressure on policy makers and policy shapers to make interventions more transparent and cost-effective and to assume an evidence-based perspective to new policy developments. In parallel with the changes in the understanding of innovation process and in the orientation in policymaking, there have also been significant developments in the evaluation methodology which exert an increasing pressure for a clearer identification of the policy interventions effects through better data collection and quantification tools and techniques. Therefore, emphasis is put on two significant factors, the context or the environment in which policy is designed and implemented and the mechanisms or processes by which policy instruments are applied.

Drawing on the above observations, in the context of this study it was deemed necessary to consider the institutional context in which policy processes take place in Greece which would also help us understand the mechanisms whereby policy objectives are implemented, and outcomes are produced. The following sections set out some of the defining elements of this approach that have guided the more detailed exploration undertaken in the present study. They relate to a) the country's national and policy context where the FPs have operated, and b) the impacts induced by the country's participation in the FPs, and they will ultimately underlie the methodological approach adopted to investigate the main research questions of this study in line with the main research objectives outlined in section 1.1.

1.5.1 The national research and innovation system

An important part of the formation and implementation of RTI policy is an explanation of the institutional arrangements and the way that a country's research and innovation system is structured. Our theoretical framework employs the national innovation systems approach which highlights the interactions between the different constituent parts of the system as a baseline for the analysis and quantification of factors influencing participation in FPs and as well as the impacts resulting from Greece's participation it these programmes.

The main components of the innovation system are the organizations (the actors) that are considered the "players", and the institutional arrangements that make up the rules of the game. Organizations include companies (often considered the most important players in innovation development), universities, research centers, institutions, and non-profit organizations, financial, consulting and support organizations as well as public bodies / organizations for the formulation, design and implementation of public policies related to research, innovation, education, competition, etc. Organizations can also be stakeholders for the development and dissemination of innovations. In the context of an innovation system, it is of particular importance to highlight the interactions and networks that emerge and can be cultivated, as well as the processes of learning, knowledge absorption and development of the corresponding competencies and skills at organizational and individual level, which take place and can be supported.

Institutional arrangements (consisting of a set of rules and laws, established practices, operational routines / procedures, unwritten rules, common customs, etc.) include laws / rules that protect intellectual property, laws and practices that affect the operation of universities and research centers, the university-business relations, the academic community-industry networks, etc.

Although in general there seems to be an agreement on the main components of an innovation system, the specific configuration of organizations and institutional arrangements varies from system to system and from country to country and even between countries with common social economic characteristics.

In Figure 1 we propose a model for the innovation system of Greece, based on previous work by Kuhlmann and Arnold (2001) and Warnke et al. (2016). This model emphasizes two main subsystems: a) The productive / business System which includes large enterprises, mature small and medium enterprises and new knowledge / technology intensive enterprises, and b) the education and research System that includes universities, public research organizations and vocational education and training bodies. These two systems are connected both directly and indirectly through intermediaries [consultants, technology providers, innovation brokers, new intermediaries (communities of practice, clubs, associations)].

In addition, they are affected by: a) the demand system consisting of public and private sector demand as well as innovative users or user groups, b) the socio-economic environment (macroeconomic conditions, tax system, culture for innovation and entrepreneurship, etc.), as well as c) by the entities that constitute the supporting infrastructure of these two subsystems, such as intellectual / industrial property and standardization organizations, financial institutions (banks, venture capitals, business angels, etc.), the support mechanisms for innovative entrepreneurship (incubators, accelerators, coaching, mentoring), chambers of commerce and other stakeholders. Finally, the political and administrative system, i.e. government at all levels, various governing institutions (national research / innovation councils, regulating authorities, etc.), as well as the policies of research, technological development, innovation and entrepreneurship (RTDIE policies), plays an important role in shaping the above-mentioned factors.

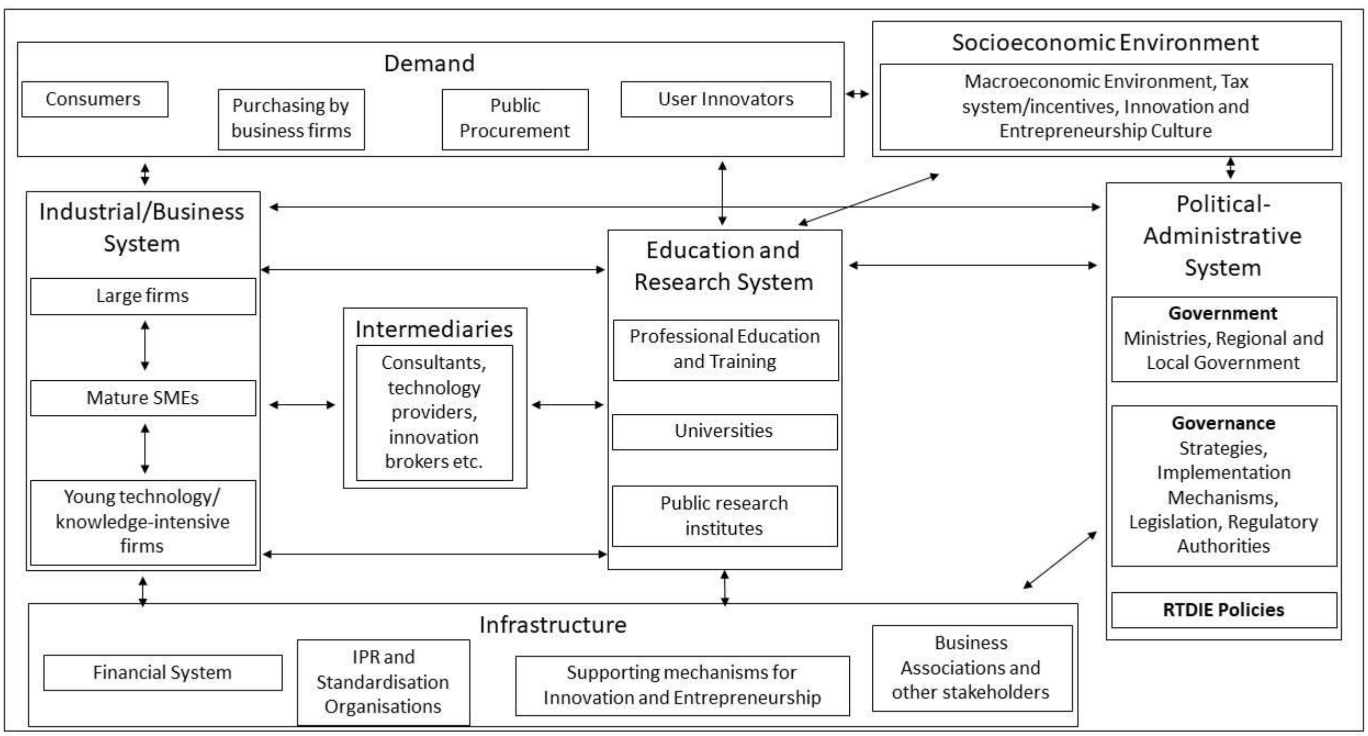

Figure 1. The National Innovation System

Whereas all the various components in an innovation system have the potential to strengthen one another, they may also risk blocking one another and have an opposite, rather than the desired, effect. This latter point is important, as in the last decade or so the RTI policy has become much more complex. Efforts are being made, both at a national and international level, to develop RTI capacity and align research and innovation activity with wider societal needs and challenges. The literature also suggests that RTI policy is becoming wider and more intertwined with other policy areas (e.g., environmental, social, entrepreneurship, industrial policy etc.) leading to a system of policies. It is therefore important to understand how the different parts of the innovation system can operate as a common structure. Furthermore, as the innovation process is largely multifaceted it is also becoming increasingly essential to mobilize the entire system to address social and economic challenges.

In this study we opted to use an innovation system approach than employ for example the more simplified linear model of innovation. The system perspective does not only allow for a better understanding of the interplay between actors and activities at national level but also of the interplay between national and EU actors and activities.

In this context it is clear that the largest part of publicly-funded research in the EU has been undertaken at national level. In 2011, national funding accounted for 85% of total R&D expenditure, while European funding, including the FP, accounted for just 15%. Yet, the pooling of resources in research and innovation seems to be an effective way of generating impact. For example, it has been estimated that the implementation of ERA has the potential to lead to efficiency gains of at least 1 billion euros a year for over a period of 15 years suggesting that FPs can have leveraging effects in the EU Member States[4].

Furthermore, the percentage of national funding varies across countries and, therefore, FPs can be an important source of research funding for countries with lower national funding capacity. The table below shows that for Greece EC funding accounts for 20.4% of the country's public funding and 11.2% of the total country's R&D funding in 2019 highlighting the critical significance of this type of research funding.

[4] Deighton Ben, 26 January 2016. Funding Programme analysis reveals 'substantial' impact on EU competitiveness. Horizon. The EU Research and Innovation Magazine. Available at: https://ec.europa.eu/research-and-innovation/en/horizon-magazine/funding-programme-analysis-reveals-substantial-impact-eu-competitiveness (last accessed 15/10/2021).

Table 2. European Commission funds as % of total and public R&D funds (2019)

Country	% of Total R&D funds	% of Public R&D funds
Latvia	32.2%	46.3%
Lithuania	24.1%	38.9%
Cyprus	19.9%	33.4%
Bulgaria	6.4%	21.1%
Greece	11.2%	20.4%
Slovenia	5.3%	17.1%
Croatia	8.9%	16.9%
Czechia	6.9%	16.5%
Estonia	7.2%	15.7%
Romania	6.1%	14.7%
Belgium	3.0%	12.5%
Malta	4.6%	12.0%
Ireland	3.0%	11.8%
Finland	3.8%	11.7%
Spain	5.2%	11.0%
Poland	4.7%	10.1%
Iceland	3.4%	9.5%
Portugal	4.5%	9.3%
Bosnia and Herzegovina	5.5%	9.1%
United Kingdom	2.7%	9.1%
Italy	2.9%	7.9%
Denmark	2.3%	7.3%
Hungary	2.5%	7.0%
Austria	2.0%	6.6%
Sweden	1.6%	5.9%
Germany	1.6%	5.4%
Montenegro	3.2%	5.3%
France	1.9%	5.1%
Slovakia	2.0%	4.4%
Luxembourg	2.0%	4.2%
Norway	2.0%	3.9%
Netherlands	1.2%	3.5%
Serbia	1.8%	2.4%
North Macedonia	0.9%	1.2%
Turkey	0.3%	0.6%

Source: Eurostat

1.5.2 Typology of the impacts of FP participation

1.5.2.1 A definition of impact

A central concept of our theoretical framework is that of impact resulting from FP participation. We have conducted an extensive literature review of relevant studies, evaluations, and impact assessments of FPs, mainly focusing on FP7 and Horizon2020, to prepare a comprehensive typology of impact and its components. Impact was first included as a selection and award criterion for research in the 7th FP (2007-2013) and gained importance in Horizon 2020 (2014-2020) and in Horizon Europe as a core evaluation standard. This development in the evaluation procedures of research proposals reflects the increasing demand for demonstrating impact and highlights the need for a sophisticated approach to impact going beyond the dichotomy of science-for-science's sake and a utilitarian concept of science. In addition, it points out the need that researchers and other FP beneficiaries carefully consider how their activities impact society, the environment, the economy, policy development etc. (LERU, 2018).

Impact is a complex and multi-faceted phenomenon and as such it should be understood as a non-linear, network-oriented process where academic knowledge is a dynamic part of wider knowledge production in which stakeholders bring their own expertise, knowledge and insight. Hence, measuring impact requires sophistication in a diversity of approaches (LERU, 2018; LERU,2017).

Following the EC's guidelines on impact assessment, impact refers to all changes which are expected to happen due to the implementation and application of a given policy option/intervention. *Such impacts may occur over different timescales, affect different actors and be relevant at different scales (local, regional, national and EU). In an evaluation context, impact refers to the changes associated with a particular intervention which occur over the longer term (EC, 2017b, p.90).*

A collaborative FP programme should not therefore focus just on short-term results, but also on achieving longer-term unexpected and unpredictable impacts by funding and stimulating research independently from its development level. In this vein a distinction between basic and applied research is not useful. In order to achieve impact, the interactions among researchers from various disciplines and other stakeholders and societal actors are crucial and these interconnections should be further stimulated by policy makers. In this sense, the interaction process among various stakeholders such as researchers, industry, public organizations, the government, and the general public to generate impact can be understood as "productive interactions" (Saapen and van Droge, 2011). Productive interactions can be defined as "exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant. These exchanges are mediated through various 'tracks', for instance, a research publication, an exhibition, a design, people or financial support.

The interaction is productive when it leads to efforts by stakeholders to somehow use or apply research results or practical information or experiences. Social impacts of knowledge are behavioural changes that happen because of this knowledge" (Saapen and van Droge, 2011:212).

Therefore, impact should be approached as a dynamic, open, and networked process in a culture of sustained engagement and co-production of knowledge. There are no linear pathways to impact. Research and innovation are taking place in a network in which different partners with diverse expertise and knowledge collaborate based on a joint agenda. It is this type of interactions that should be captured by an impact assessment of parts of the FP, e.g., societal challenges. Measuring impact needs to happen both at the level of the FP and at the level of projects. This will require different methods and indicators.

This type of assessment should be developed and started when the programmes that address societal challenges are still 'ongoing' but it should continue considerably after the programme has finished. The impact assessment should only be concluded 10, preferably 15 years after the end of the programme.

1.5.2.2 Typology of impacts

An important element to consider in our theoretical framework is how to identify and categorize the impacts of FPs participation. Based on extensive literature review, this section will first describe the different types of impact resulting from participation in the Framework Programmes and then present the approach adopted by NETonKIE project to measure them. This typology was designed to cover the main categories of impact resulting from the participation in FPs and also cover the main elements of the national research and innovation system as presented in section 1.5.1.

A distinction is made between different impact categories:

- Scientific impacts
- Economic impacts and impacts on innovation
- Networking impacts
- (Wider) Societal impacts
- Policy impacts

Among the different impact categories outlined above **scientific impacts** tend to be the most immediate and is the type of impact most documented in the context of national and EU evaluations. For example, in 2016 it was estimated that FP7 had generated over 170000 scientific papers, even though the more than half of the projects were still running.[5] These impacts are centered primarily around the generation processes of scientific and research knowledge, involving primarily higher education institutes, research organizations, public agencies and to smaller extent private organizations. Scientific impacts also address the application of high-quality new knowledge as this impact type equally influences the training and mobility activities of researchers.

Economic impacts and impacts on innovation are impacts which support wealth creation and economic prosperity especially through the commercialization of scientific results. However, such effects also foster all forms of innovation, including breakthrough innovation. Although economic impacts and impacts on innovation are typically related with industry FP participants, the role of universities and research institutes is also crucial as they are actors that may create spin-offs and produce other relevant outcomes/impacts.

Networking impacts are concerned with capturing interaction effects among several actors of the research and innovation systems and the changes in the effectiveness of cooperation among universities, research centres, and other private and public actors.

Societal impacts are related to strengthening the effect of research and innovation in formulating and implementing EU policies (increased use of evidence in policymaking or evidence-based policy) and advocate the uptake of innovative solutions in industry and society to address global challenges. These impacts can range from improved environmental legislation/protection to an improved public awareness of science and understanding of the usefulness of certain technological solutions.

Policy impacts refer to effects within governance and management, effects on legislation regulating research and innovation at national level and to the application of evidence-based policy making not only as regards RTI policy but also other public policy areas e.g., health, environment, safety.

In terms of assigning the observed effects to participation in FPs, scientific impacts, networking impacts and policy impacts are easier to provide strong evidence for (are more straightforward and easier to measure) and can be more easily attributed, at least partly, to FP involvement. On the other hand, the remaining impact types (economic impacts and impacts on innovation, societal impacts) are more challenging to collect data on and measure effectively, partly because of the extended time lag between the activities undertaken and the wider impacts resulting from these. This is especially

[5] Deighton Ben, 26 January 2016. Funding Programme analysis reveals 'substantial' impact on EU competitiveness. Horizon. The EU Research and Innovation Magazine. Available at: https://ec.europa.eu/research-and-innovation/en/horizon-magazine/funding-programme-analysis-reveals-substantial-impact-eu-competitiveness (last accessed 15/10/2021).

important for FP funding of research activities or a mixture of innovation and research activities. For example, a study carried out by Cancer Research UK[6] clearly shows that on average it takes 17 years for the research they have funded to have an impact.

Nevertheless, another important factor is that innovation and economic impacts along with societal impacts are relatively more complex impact types that require a combination of activities, various actors and funding to take place. For example, to address challenges related to specific health problems or climate change, academic research from a wide range of disciplines is required, but solutions also call for a wider societal impact for which researchers need to collaborate with other experts and technology users and actually co-produce knowledge. Therefore, the prevalence of uniform, linear models of knowledge generation and impact assessment, putting emphasis on easily measurable output and direct economic benefit have started to retreat (LERU, 2017).

Furthermore, the funding mix over time plays a critical role in advancing challenging issues in specific fields. For instance, national regulation promoting environmental protection cannot be expected to change because of one or even multiple FP projects. Yet, the technical know-how and evidence accumulated from FP participation can over time contribute to legislative changes at a national level. This does not suggest that FPs do not contribute directly to these types of impact, they can indeed be an important source of funding and lead directly to innovation outputs such as patents, prototypes, new products and processes, etc. However, the research and innovation system actors also benefit from other funding streams and state funding may be needed to strengthen national participation internationally and particularly in the FPs (EC, 2019).

[6] https://www.cancerresearchuk.org/sites/default/files/policy_june2014_medical_research_whats_it_worth_briefing_document.pdf

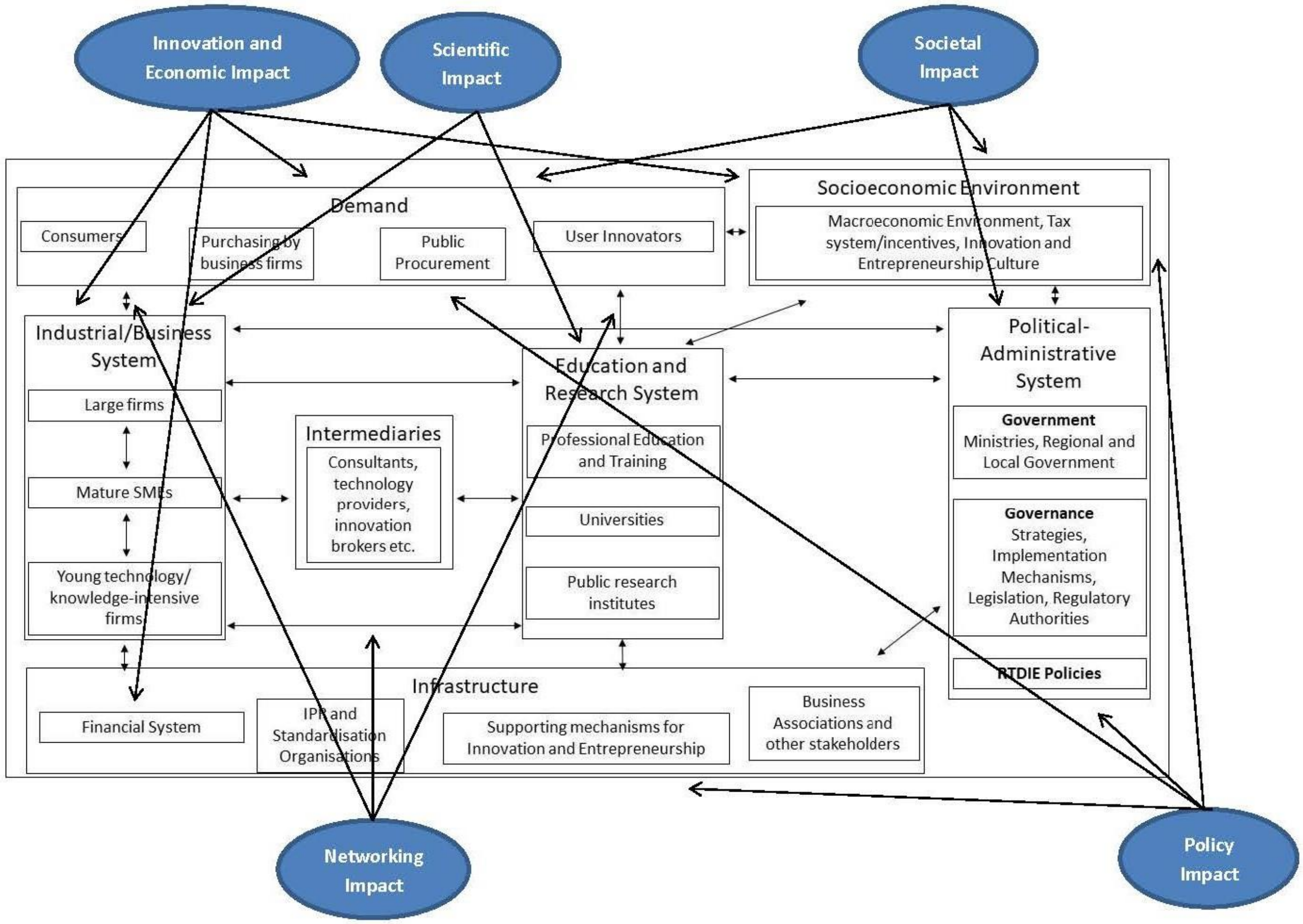

Figure 2. The impacts of FPs participation on the National Innovation System

2. Overview of the methodological framework

In this section we will provide a brief overview of the study methodology that we will followed to address our specific research objectives. In this respect, our methodological steps to acquire a comprehensive picture of the impact of Greece's participation in EU FPs will include:

- an analysis of Greece's participation patterns and trends over a period of 35 years,
- an analysis of the networking activity of Greek actors participating across FPs (FP1 to Horizon2020),
- an assessment of the added value of FP participation, presenting a taxonomy of impacts and the inhibiting or facilitating factors which are conducive to generating impact,
- the organization of a validation workshop

2.1 Participation patterns and evolution across FPs

The provision of an adequate picture of the FP and its evolution over time has been hindered by a relative lack of data. This is mainly due to the fact that the primary goal of databases (developed by the European Commission services) covering information on FP applicants and participants was to assist proper FP contract and financial management and not to offer detailed statistics on FP participation and application patterns (Muldur et al., 2006).

LIEE/NTUA has developed and maintains the STEP to RJVs database which currently includes detailed information on all collaborative cross-national research projects funded by the European Commission from FP1 to H2020 (up to December 2020), i.e., it includes information on 41,965 research projects and 94,585 different (unique) participating organizations with 375,500 participations covering a period of almost 35 years. The primary information source for the database construction is CORDIS, the official information service of the European Commission which comprises information on research projects and their participants. However, the processing of this sources' raw data into a usable standardized form is a complicated and laborious endeavor/undertaking. This unique and extremely rich database constitutes a valuable tool for providing a more complete and, at least to our knowledge, the most up-to-date picture of networking activity attained through EU-funded research projects as it will refer to a 35-year period covering eight consecutive programmes (FP1 to Horizon2020). In this vein, it will also offer a comprehensive picture of the Greek participation and its evolution over time. Our findings on participation patterns and trends will be set it the wider context of national research and innovation capabilities and national research orientations and policies.

2.2 Analysis of research networking activity across FPs

The research partnerships and networks that are developed through time in the FP, allowing for knowledge exchange and technology transfer, are considered key elements for the creation and diffusion of innovation (European Commission, 2017). The analysis of networks and Social Network Analysis (SNA) in particular, provides a way to aggregate micro level data and capture meso level trends and developments. While there is wide agreement on the usefulness of empirical methods of SNA for innovation and futures research, however, studies implementing SNA is these fields are still missing (Kolleck, 2013). Moreover, as concluded from prior research, stimulating network formation and development is often an under-utilized opportunity in innovation policy (Kaufmann and Schwartz, 2008;

Larruscain et al., 2017). However, to devise policy to enhance the efficiency and effectiveness of networks, their monitoring and evaluation is necessary.

Using the extensive STEP to RJVs database, social network analysis (SNA) will be employed to provide insights for a longitudinal view of the EU-funded research networks regarding the structure of network relationships, the position of individual organizations as well as the assessment of their function as structures promoting knowledge creation and diffusion, technology transfer and hence enhancing the production and diffusion of innovation. SNA tools will also be used to study the role of Greek organizations in the networks between 1984 and 2020 as well as the evolution and structure of the subnetworks established by research projects with at least one Greek partner during the same period. In this way, this research project will provide a new prism to examine important aspects of the longer lasting and more sustainable contribution of EU research public policy beyond the infusion or resources, the so-called 'behavioral additionality' (Clarysse et al, 2009), i.e., the creation of outcomes/impact such as improving the knowledge, capabilities, and strategies of organizations and impacting the national/regional capabilities to innovate.

2.3 An assessment of the overall value and impact of FPs participation

The European Commission systematically carries out ex-ante, mid-term and ex-post evaluations of the FPs at a global level (i.e., these evaluations cover participant countries across EU Member States, associated countries and third countries), but there is no requirement that FP evaluations should be undertaken at national (or regional) level. To the best of our knowledge there is only one study that focuses on a comparative study of FPs at a country level across EU Member States (EU, 2019).

Multi-method analysis increases the possibilities of getting varied and extensive results, and thus better understands a complex phenomenon. In addition to SNA, a mixture of qualitative and quantitative research methods will be used to assess the overall value and impact of FPs participation.

In this respect, a survey among Greek FP participants (i.e., universities, research centers and business firms) will aim at capturing the determinants behind Greek participation and the potential benefits arising from their involvement in FPs in terms of scientific impact, economic and innovation impact (including the potential of EU-funded research collaborative networks in fostering knowledge-intensive entrepreneurship-KIE), as well as networking and social impact. KIE can be considered as a transformative mechanism converting useful knowledge into economic activities and innovative new ventures and a key driving force for an innovation-led and high-growth potential growth path (Malerba and McKelvey, 2018).

Moreover, several in-depth case studies in selected organizations and secondary information sources will be used a) to support and complement network analysis and survey results, b) to better grasp the impact of links and connections established in the context of EU-funded networks and c) unveil the factors that inhibit or facilitate potential impacts.

In conducting the assessment of FPs participation impact our emphasis will not only be on the outcomes of the FP projects, but also (when possible) on the processes leading to these outcomes. This approach may help us to unveil the mechanisms generating the outcomes and throw some light on intermediary outcomes, such as the changes in research and innovation capacities and capabilities, that can influence the country's future research and innovation performance. This analysis will also refer to the important institutional and other contextual factors of research, technology, and innovation activities at the national level.

A validation workshop will be organized as an exercise of validation of the findings and the conclusions derived from the empirical work undertaken during the study as presented above. The workshop will involve experts from universities, research institutes, and industry with long experience in FPs, as well as RTI policy experts, who along with the study team, will discuss the main results and preliminary conclusions of the study. Furthermore, the workshop will assist in validating and formulating emerging policy recommendations.

In the next few pages of this section, we present in detail the framework we have developed for measuring the added value and impact of Greek participation operationalized per type of impact. In particular, different types of impacts as addressed in section 1.5.2.2. are presented - scientific, economic (including on innovation), as well as the impacts on national research and innovation policies, policy-related impacts, and wider societal impacts including social and environmental impacts – indicating the research methods mix that will be used to capture each impact type. In the context of WP1 and in parallel with the theoretical framework building we have developed specific research instruments (case study protocols and survey structured questionnaires) that along with extensive literature review have helped us to build up specific indicators to measure each impact type (please see Deliverable 1.2 for details).

TABLE 3. TYPES OF IMPACTS AND METHODS FOR THEIR ASSESSMENT		
SCIENTIFIC IMPACTS		
Types of Impacts	**Indicators**	**Research Methods to be used**
Promoting knowledge and scientific advancement	• Publications in refereed journals, books, conferences etc. (Output) • Enrichment of research teams' knowledge in scientific fields that are already active (Output/Outcome) • Engagement of research teams in scientific fields that were not active before (Output/Outcome)	• Survey • Case Studies
Development and utilisation of new and innovative methodologies, equipment, techniques, technologies, and cross-disciplinary approaches	• Creation or significant improvement of research instruments / facilities / infrastructure (Output) • Improving business R&D capabilities (Outcome) • Business R&D activity of higher risk (Output/Outcome)	• Survey • Case Studies
Promoting international and interdisciplinary scientific collaboration	• Publications in cooperation with other partners of the FP projects (Output) • Enhancing international research networking (Outcome) • Increasing collaborations between research teams from different disciplines (Outcome)	• Survey • Case Studies • Social Network Analysis
Delivering and training highly-skilled researchers	• Improving the research experience of researchers (Outcome) • Improving the leadership, collaboration and project management skills of researchers (Outcome) • Attracting PhD candidates, postdoctoral and senior researchers from home country or other countries (Output/Outcome)	• Survey • Case Studies

Promoting the mobility and career advancement of researchers	• Level of researchers mobility
	  ○ Internationally (Output/Outcome)
	  ○ In Industry and Public Organisations (Output/Outcome)
		• Survey
		• Case Studies

Improving teaching and learning	• (Measuring Directly) Improving teaching and learning (Outcome) • Creation or significant improvement of research	• Survey • Case Studies

	instruments / facilities / infrastructure (Output/Outcome) • Improving the research experience and collaboration skills of researchers (Outcome) • Attracting PhD candidates and postdoctoral researchers (Output/Outcome)	
INNOVATION & ECONOMIC IMPACTS		
Types of Impacts	**Indicators**	**Research Methods to be used**

Enhancing innovation and economic performance of private firms	• Commercialisation or internal utilisation of innovation developed through FP projects (product, service, process, organisational) by existing firms (Outcome)
	• Number of submitted and issued Patents and Licences (Output)
	• Innovation & Technology Management capabilities enhancement (Outcome)
	• Improving dimensions of economic performance (Outcome)
	    ○ Product, service, process quality
	    ○ Productivity enhancement
	    ○ Revenues increase
	    ○ New business models
	    ○ Employment increase
	    ○ Production cost reduction
	    ○ Market share increase
	    ○ Exports increase
	• Engagement of end-users in FP projects (either as partner of the consortium or as external stakeholder) (Output/Outcome)
		• Survey
		• Case Studies
		• Desk Research / Secondary Sources

Promoting knowledge-intensive entrepreneurship through the commercial exploitation of scientific knowledge	• Creation of spin-offs and other start-ups (Output/Outcome) For young firms: • Continuity of participation in FPs (Outcome) • Improving business R&D capabilities (Outcome) • Business R&D activity of higher risk (Output/Outcome)	• Survey • Case Studies • Desk Research / Secondary Sources • Social Network Analysis

	• Commercialisation or internal utilisation of innovation developed through FP projects (Outcome) • Number of submitted and issued Patents and Licences (Output) • Innovation & Technology Management capabilities enhancement (Outcome) • Improving dimensions of economic performance (Outcome) • Position in research networks (centrality degree) (Outcome) • Creation of new / Strengthening of existing cooperation relationships with Academia/Research entities, other Industry actors and Public organisations (Outcome)	
Shaping and improving public services	• Utilisation of innovation developed through FP projects (product, service, process, organisational) by public organisations / Degree of importance of innovation in public procurement (Outcome) • Engagement of end-users in FP projects (either as partner of the consortium or as external stakeholder) (Output/Outcome) • Changing organisational practices, organisation of work and even culture (Outcome)	• Survey • Case Studies • Desk Research / Secondary Sources
Attracting R&D investment from global businesses	• Additional funding for innovation exploitation and scaling-up (Output) • Increase of Foreign Direct Investment in R&I (Outcome)	• Survey • Case Studies • Desk Research / Secondary Sources
NETWORKING IMPACTS		
Types of Impacts	**Indicators**	**Research Methods to be used**
Strengthening collaboration between Industry, Public users of technology and Research organisations (Universities and Research Centres)	• Establishment of new cooperation relationships between Industry actors (manufacturing, service and other firms), Public organisations (technology users) and Research entities (Universities and Research Centres) (Outcome) • Sustaining existing cooperation relationships between	• Survey • Case Studies • Social Network Analysis • Desk Research / Secondary Sources

	Industry actors, Public organisations and Research entities (Outcome) • Intensity of knowledge flows and learning mechanisms within the projects (Output) • Intensity of communication/dissemination actions and interaction with external stakeholders (Output/Outcome) • Participation of firms, public organisations, Universities and Research Centres of the same country in common FP projects (Output) • Level of researchers' mobility to Industry and Public Organisations (Output/Outcome)	
Promoting scientific and research collaboration with partners from other European countries and the rest of the World	• Establishment of new cooperation relationships with Research, Industry and Public Sector partners from other countries (Outcome) • Sustaining existing cooperation relationships with Research, Industry and Public Sector partners from other countries (Outcome) • Intensity of knowledge flows and learning mechanisms within the projects (Output) • Participation intensity of the various organisations in the EU Framework Programmes (Output) • Degree of centrality regarding the position of the various organisations in the research networks formed by EU Framework Programmes (Outcome) • Level of researchers international mobility (Output/Outcome)	• Survey • Case Studies • Social Network Analysis
	SOCIETAL IMPACTS	
Types of Impacts	**Indicators**	**Research Methods to be used**
Tackling societal challenges (as set out in the Horizon 2020 objectives) ○ Health, demographic change and wellbeing,	In fields related to Societal Challenges: • Development and utilisation/diffusion of innovations (product, service, process, organisational) / Degree of importance of innovation in public procurement	• Survey • Case Studies

○ Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy, ○ Secure, clean and efficient energy, ○ Smart, green and integrated transport, ○ Climate action, environment, resource efficiency and raw materials, ○ Europe in a changing world - inclusive, innovative and reflective societies, ○ Secure societies - protecting freedom and security of Europe and its citizens.	(Output/Outcome) • Number of submitted and issued Patents and Licences (Output) • Engagement of end-users in FP projects (either as partner of the consortium or as external stakeholder) (Output/Outcome)	
Contributing to increasing public awareness and understanding of science, economic and societal issues	• Intensity of communication/dissemination actions and interaction with external stakeholders (Output/Outcome)	• Survey • Case Studies
Contributing to European cohesion as a result of the Realisation of the European Research Area	• Balance of participation intensity between Member States and European regions (Output) • Intensity of knowledge flows and learning mechanisms within the projects (Output)	• Social Network Analysis • Survey • Case Studies
POLICY IMPACTS		
Contributing towards evidence based policy-making and influencing public policies and legislation at a local, regional, national and EU/international level	• Intensity of communication/dissemination actions especially regarding policy makers and shapers (Output/Outcome) • Contribution to policy debates or documents in fields related to societal challenges, economic prosperity, employment creation and regional development / Contribution to the degree of importance of innovation in public procurement (Outcome)	• Survey • Case Studies

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