This outlook provides a focused assessment of the state of public capital in the major European countries and identifies areas where public investment could contribute more to stable and sustainable growth.

The Outlook is structured into two parts: the chapters of Part I respectively explore public investment trends in France, Germany, Italy, Spain and Europe as a whole, and illuminate how the legacy of the 2008 Global Financial Crisis is one of insufficient public investment. Part II investigates some areas into which resources could be channelled to reverse the recent trend and provide European economies with an adequate public capital stock.

The essays in this outlook collectively foster a broad approach to and definition of public investment, that is today more relevant than ever. Offering up a timely and clear case for the elimination of bias against investment in European fiscal rules, this outlook is a welcome contribution to the European debate, aimed both at policy makers and general readers.

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6. In Search of a Strategy for Public Investment in Research and Innovation

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Introduction and Main Points at Issue

The role of research and innovation (R&I) as key drivers of economic growth has been gaining increasing importance and has now become an object of renewed concern in the European policy agenda. The intensity of research and development (R&D) expenditure on GDP in the European Union (EU) has grown over the past decade, but at decreasing rates, and it is still well below that recorded for Japan and the United States (US). Globally, however, the growth of R&D expenditure has been driven by massive investments in newly industrialized Asian countries, especially by China, whose share of world R&D expenditure has increased from 5% in 2000 to 21% in 2015 (European Commission 2018b). In line with this trend, China has recently outperformed the EU R&D investment in terms of both total amount and GDP percentage, and further growth is expected to continue, according to the current Five Year Plan (Figure 1).

However, the sluggish growth of R&D investment in the EU is also the result of large differences across the Member States. This calls not only for a closer assessment of major patterns of R&D expenditure at the country level but also for special attention to the role played by public funding with respect to the more-than-ever complex evolution of technological innovation and the need for the productive structure to be supported to continuously capture the potential of new technologies. It is, in fact, not by chance that such a perspective now appears at the core of the strategic guidelines devised by the next Research and Innovation Framework Programme Horizon Europe (European Commission 2018a). A major emphasis of the Programme has been put on the need to build new and stronger synergies between the public- and private-side stakeholders in
order to overcome the main barriers that still hold back industrial scale-up processes and competitiveness of the EU economy. Nonetheless, this should constitute only part of an advanced stage of the EU approach to research and innovation policies.

Looking at all of the EU strategies to support and boost research and innovation, we also have to consider direct and indirect funds used to create new research infrastructures or support existing ones (European Commission 2019a). These include scientific equipment and instruments, scientific data archives, communication networks, computing systems and any other research and innovation structure open to external users. With the actions on infrastructure, the EU aims to not only reduce fragmentation of the research and innovation ecosystem and avoid duplication of effort but also enhance public-private cooperation, by making industries more aware of opportunities to improve their products and by facilitating programs of co-development of advanced technologies. Bearing in mind that the infrastructure strategy is quite relevant, we nevertheless consider this funding as a part of the total EU R&D expenditure and will do so for this chapter.

Although it is clear that the EU as a whole still lags behind the US and major Asian countries in terms of R&D intensity and that in recent years the gap has widened further with regard to business R&D expenditure, the emergence of deeper divides across the Member States (notably between major northern and southern countries as well as between the western and eastern areas) may very well be the result of existing country-specific structural divergences that have developed on different grounds. This
requires a better understanding of differences in country patterns of R&D expenditure, with a more detailed look at the evolution of the various main sources of R&D funding and their relationship to major structural factors shaping the characteristics of national research and innovation ecosystems. The objective is to put into perspective the need for R&D investment across the Member States, trying to assess to what extent the role of public R&D funding is consistent with the development of national research and innovation ecosystems and in which terms the lack of sufficient R&D investment could be adequately restrained in the EU policy framework.

6.1. The EU in Depth

The EU vocation for public investment in R&D has been largely confirmed over the past decade, and only a slight decrease in public R&D intensity (on GDP) has emerged after 2012 (Figure 2). This contraction was smaller than that in the US and Japan, and the EU still holds the highest share of global public R&D investment (European Commission 2018b). As a matter of fact, an increase of total public R&D expenditure in the EU took place every year between 2007 and 2015, while a similar dynamic occurred in a more limited period between 2012 and 2015 with regard to the total of national government budgets for R&D (European Commission 2018b). This last trend is only partially reflected in the variations of national government budgets for R&D as a share of total general expenditure. The share of public budget allocated to R&D, which increased until the beginning of the international crisis up to nearly 1.5% and

![Fig. 2 Evolution of public R&D intensity, 2000–2016](image)

**Notes:** (1) KR: There is a break series between 2007 and the previous years. (2) US: (i) Public R&D expenditure does not include most or all capital expenditure; (ii) There is a break in series between 2003 and the previous years. (3) JP: There is a break in series between 2008 and the previous years and between 2013 and the previous years (4) CN: There is a break in series between 2009 and the previous years. *Source:* DG Research and Innovation — Unit for the Analysis and Monitoring of National Research and Innovation Policies — Science, Research and Innovation performance of the EU 2018. *Source of data:* Eurostat, OECD.
Fig. 3 R&D intensity, 2000, 2007, 2016 and 2020 target

Notes: (1) CZ, UK: R&D intensity targets are not available. (2) EL, SE: 2001, HR: 2002, MT: 2004. (3) BG, CZ, EE, FR, LV, LT, HU, PL, RO, SI, SK: 2015 (4) PT: The R&D intensity target is between 2.7% and 3.3% (3.0% was assumed). (5) LU: The R&D intensity target is between 2.3% and 2.6% (2.45% was assumed). (6) IE: The R&D intensity target is 2.5% of GPN, which is estimated to be equivalent to 2.0% of GDP. For DK, EL, FR, LU, HU, NL, PT, RO, SI, SE, UK: breaks in series occur between 2000 and 2016. Source: DG Research and Innovation — Unit for the Analysis and Monitoring of National Research and Innovation Policies — Science, Research and Innovation performance of the EU 2018. Source of data: Eurostat, Member States.

Source of data: Eurostat, Member States.

Fig. 4 Share of government budget appropriations or outlays on R&D — percentage of total general government expenditure

Source of data: Eurostat. Figure created by the authors.
declined between 2010 and 2012 up to 1.36%, shows a very slight increase after 2012, staying between 1.37% and 1.39% with an adjustment to 1.4% only in 2017. By and large, it is interesting to note that over the past decade (2007–2017) the EU’s total of national government budgets for R&D has increased by 16.5% and that the share of public budget allocated to R&D in 2017 is only -5% lower than the peak percentage of 1.48% in 2009.

The present dynamics of public R&D investment in the EU is the result of large divergences among the Member States in the pattern of change of the share of public budget allocated to R&D. A first divide with respect to the EU global trend can be observed between countries that increased their investment in R&D as a share of public budget and those that went in the opposite direction. But deeper insights into the behaviour of public R&D budgets in the EU can be gained by looking at the differences among the Member States with regard to the share of total R&D expenditure on GDP (GERD/GDP) (Figure 3), especially within the EU15 aggregate. Increasing shares of the public budget allocated to R&D are observed for most of the northern EU15 countries, characterized by the highest shares of total R&D expenditure on GDP (Figure 4), including Germany, Austria, Sweden, Denmark and Belgium; another two countries, Finland and the Netherlands, still rank well above the EU average in 2017 but show a contraction of the R&D share of the public budget. On the other side, EU15 Member States with the lowest share of total R&D expenditure on GDP, notably the southern countries (Greece, Italy, Portugal and Spain) and Ireland, show sharp contractions of the share of public budget allocated to R&D during the central years of the international crisis, with only partial adjustments to higher levels at the end of the period (2016–2017) in the case of Portugal and Greece. Compared to the other EU15 countries, and with the exception of Belgium and France, these countries still have the lowest shares of the public budget allocated to R&D, well below the EU average. This is clearly a point of concern as, among the core Member States, and unlike Belgium and France, southern European countries and Ireland still have the lowest shares of R&D intensity. A different case is that of the United Kingdom, where the R&D intensity on GDP is well above that of southern countries but slightly below the EU average and where the share of public budget allocated to R&D declined sharply over the past decade (although with some upward adjustments between 2013 and 2017). The dynamics of public R&D investment as a share of government spending is somewhat more erratic in the case of the Eastern EU countries; with the exception of Estonia and the Czech Republic, the use of public budgets to finance R&D expenditure is much more limited here than in the EU15 countries.
Fig. 5 GERD financed by sector (%), 2015

Notes: Sweden, Israel: 2013; France: 2014; Greece, Austria, Iceland, Serbia: 2016; United States: R&D expenditure does not include most, or all capital expenditure; Israel: Defence (all or mostly) is not included. Source: DG Research and Innovation — Unit for the Analysis and Monitoring of National Research and Innovation Policies — Science, Research and Innovation performance of the EU 2018. Source of data: Eurostat, OECD, UNESCO.
6.2. Public Investment

Looking at the extent to which R&D public funding contributes to the whole of R&D expenditure, another remarkable fact is that the share of total R&D (GERD) financed by government in the EU has declined all the time, although, at 31.1% it is still higher than comparable shares of the US, China, Japan and South Korea (Figure 5), while the share of government financed GERD on GDP is still below that of the US. This trend is reflected in all Member States, but large differences can be observed across countries. In the EU15 Member States, the share of R&D public funding is generally higher in southern countries (Italy, Greece, Portugal, Spain), mainly as a result of less research carried out by the business sector. This is true only in part for the eastern Member States; they show an even smaller share of total research expenditure financed by the business sector, but, as the result of the much higher incidence (largely well above the EU average) that contribution from abroad has on the smaller total R&D expenditure of these countries. At the same time, it should be observed that the decline of the share of GERD financed by government is also the effect of the fall of direct government contributions to business research, which have dropped sharply in all countries since the beginning of the financial crisis (OECD 2018). Instead, the decrease of public funding of R&D involved public research only to a more limited extent, both as a share of GDP and in terms of total government expenditure (OECD 2018). This latter trend is mostly in line with the dynamics already observed for the EU share of the public budget allocated to R&D and is well reflected in the higher education (HERD) and government (GOVERD) components of public R&D expenditure on GDP (Figure 6).

Thus, given the remarkable divergences among the Member States recorded for all public R&D spending, this suggests a more in-depth analysis of the main patterns of public R&D expenditure emerging at the country level. The attempt is also that of unveiling the possible main direction of public R&D spending (and hence the direction of public R&D investment) while accounting for the whole of the R&D funding structure. The aim is twofold: to overcome important drawbacks that characterize the allocation of R&D funds in the public budget with respect to specific socio-economic objectives, and to assess to what extent the need for public R&D investment is consistent with broad R&D country strategies that are supposed to be followed. In fact, given the still substantial lack of information necessary for analyzing the real content of governmental appropriations and the structure of public R&D outlays, crossing data on R&D spending with those on actual R&D expenditure would be of little help in understanding R&D investment strategy by government, especially from the perspective of a comparative analysis between countries. Looking then at the patterns of public R&D expenditure, it is first of all relevant to compare, in terms of GDP and at the EU level, the steep decline of GOVERD expenditures with the upward trend found for both HERD expenditures and BERD (business) expenditures (Figure 6).
This appears to indicate the increasing importance of research and innovation as a driver of economic activity, with the consequent need to adequately support the growth of human capital. However, the patterns of R&D expenditure at the country level are generally consistent with the EU trend only for the higher education and the business sectors, while both the dynamics and the intensity of the government expenditure are more country-specific. Furthermore, it should be noted that increasing intensities of R&D expenditure on GDP in the higher education’s sector are widely observed with the highest and/or increasing intensities of R&D expenditure in the business sector, although there are some remarkable exceptions in countries where the intensity of R&D expenditure in the business sector is still well below the EU average. Trend reversals to lower intensities of the higher education expenditure are common instead in countries still boasting the lowest business R&D intensities (such as southern countries among the EU15 members) and to countries with the highest business R&D intensities (such as the Netherlands and the UK), although, excepting the UK, the latter still stand well above the EU average of higher education expenditure intensity.

All in all, the growth of R&D in the business sector appears to be an important driver of the total R&D expenditure in the EU as a whole. This is a result of remarkable differences in the R&D business intensities among countries, which were in part reflected in the growth of the higher education expenditure. This is a point of concern...
especially for Member States with the lowest business R&D intensity, as, in most cases, they have very low growth rates for the higher education expenditure and still show a large gap with respect to the EU average. Moreover, and most importantly, it should be noted that, despite the increase in R&D business expenditure, the EU R&D business intensity still lags well behind that of the US, Japan, Korea and China. However, there does not seem to be enough evidence to conclude that this is a consequence of the decrease of direct government support for business R&D. As has been widely observed (OECD 2018; European Commission 2018b), this decrease has, in fact, been largely compensated for by an increase in indirect support through tax incentives, the growth of which has been much higher in the EU than in the US, Japan, Korea and China, and which are now higher than they have ever been. It has also been pointed out that, among the Member States with the highest business R&D intensities, Germany and Finland did not adopt tax incentives, while more generally it has been observed that the use of tax incentives can hardly turn into expenditure additionality unless it becomes part of a more comprehensive strategy involving direct investment activity by government within a more targeted “mission-oriented” investment view (Mazzucato 2013). Indeed, significant evidence has emerged about additionality effects on R&D business expenditure, pointing out that greater benefits arise for high-tech sectors that already boast a higher R&D orientation (Freitas et al. 2017). As the entire amount of the R&D business expenditure is consistent with the industry specialization (Moncada 2016), this should also call for a closer consideration of the structure of the economy where tax incentives are to be implemented.

Additional R&D financing from abroad has also played an increasing role in all EU countries (European Commission 2018b) and, as mentioned above, has become a key component of total R&D investment, especially in eastern countries. However, when looking at the main public sources of R&D financing as represented by the European Commission Structural Funds and the Horizon 2020 program, we cannot help but notice that they hide major infrastructural divergences among the Member States. With regard to the Structural Funds, also bearing in mind that in many more developed countries they cover a limited portion of the territory, it is quite clear that the share of funding explicitly allocated to R&I (research and innovation) projects is marginal among eastern countries (Figure 7), with only a few exceptions slightly above the EU average (16%).

Moreover, in these last countries, the extent to which R&I funds contribute to innovation in the business sector is well below the EU average in most cases, while shares well above the average are noticed mostly for countries that also hold the lowest shares of Structural Funds allocated to R&I projects. This could suggest that the initial development lag of these countries was such that funds were first used for the macroeconomic context as a whole, including support for the activity of research centres. The explicit contribution of R&I funds to innovation in the business sector is instead much higher among the EU15 Member states, although a remarkable variability
Fig. 7 Structural Funds: share of funding allocated to R&I (devoted to small and medium-sized enterprise (SME) and to research); total per country

Source of data: 2007–2013 database of the cumulative allocations (European Regional Development Fund (ERDF) and Cohesion Fund (CF)) to selected projects and expenditure at NUTS2 (https://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/expost2013/wp13_3_db_nuts2_ae.xlsx). Figure created by the authors.

Fig. 8 Horizon 2020: average of European contribution per project and per country

Source of data: Horizon 2020 country profiles, May 2019. Figure created by the authors.
is observed across countries. In particular, the share of research and innovation funds allocated to innovation projects is quite specific for each country and, most importantly, does not show any relationship with the R&D intensity in the business sector.

With regard to the Horizon 2020 program, the latest figures show (Figure 8) that the average EU contribution per project is higher, the higher the countries’ total R&D is as a share of GDP, although a further difference emerges between EU15 countries and the eastern Member States. Southern EU15 countries lag behind northern ones, but eastern countries lag almost always (excepting Portugal) behind southern EU15 countries, even when these are countries in which the total R&D expenditure makes up a similar share of GDP.

6.3. Final Remarks and Policy Considerations

The first paragraph of the Joint Statement on “New Economic Growth: The Role of Sciences, Technology, Innovation and Infrastructure” of the G7 of Academies of Science, which met in Rome in 2017, states:

Science, technology and innovation have long been important drivers of economic growth and human development. Growth relies on the integration of basic and applied research, at both public and private levels, on an international scale. The challenge is to ensure that, even during phases of economic slowdown, science and technology continue to support the objectives of sustainability and improved living standards in all countries. Institutional arrangements are needed to make sure that the potential of science and technology is aligned with the paths and strategies of economic development, social inclusion and environmental sustainability, as argued by the United Nations report “Transforming our world: the 2030 Agenda for Sustainable Development.” (G7 Academies of Science 2017)

This implies an increasing investment in infrastructures — both tangible and intangible — that contribute to inclusive development and to progress in science and technology, as mentioned in policy recommendations of the statement.

In this respect, the quantity (intensity of the R&D effort and the number of researchers) and the quality of the research produced, measured by the scientific impact and the ability to transfer it as innovation in the economy and society, determine measurable rankings that place the different scientific and innovative systems and their aggregations on a supranational scale, according to criteria and indicators that we have examined and compared in this chapter. All the most recent comparative analyses based on statistical data and their processing as quoted in the bibliography agree in registering a worldwide growth of these indicators (the effort in R&I), marked, however, by strong differentials between countries. The positioning of individual countries is confirmed, combining a strong economic dynamic with a corresponding commitment in R&D. Within this general framework, different groupings of countries are outlined on the basis of the industrial structure, the importance of the commitment
to research by companies, and the ability of the public actor not only to compensate for weaknesses and “market failure” but also to stimulate the propensity to research and innovation with planned and targeted initiatives and not simply contextual policies and interventions.

The existence of differentials between countries in research and innovation performance, and within them between areas and regions, cannot, however, be tackled simply by rebalancing the resources used and/or orienting them towards common initiatives. Likewise, higher efficiency cannot be derived from strategies based on a reduction of public funding or on forcing public/private interaction, without the corresponding guidelines, or delegating the motivation for public funding of companies to the tax incentives and the choice of contents and objectives to a generic “demand-pull force” (Mazzucato 2013, 2019). In fact, it is necessary to assess to what extent the resources dedicated to R&D, and the relative spending modes are able to turn into an effective development lever, starting from the structural characteristics of the entire research and innovation system (Wirkierman et al. 2018). Moving from this last consideration, the present chapter, therefore, aims to underscore the “system infrastructure” nature of the research activity. It does so by highlighting, through the main results of the analyses and the most recent data on the subject, that the investment in research cannot be separated from policies and/or strategies that take into account the strengths and weaknesses of the productive fabric of each country.

In this context, the public actor is committed to playing a key role in orienting processes, both with respect to triple or quadruple helix models and to the construction of a strategy that is able to face the challenges of new technologies as well as of the behaviour of companies at the global level. To this is added, in particular for Europe, the dimension of supranational cooperation and the supporting role exercised by Structural Funds, which, beyond the purpose of overcoming structural imbalances among countries, highlight different propensities with respect to their use in support of research and innovation. Partnership and subsidiarity are, therefore, two particular elements of the strategy in support of research and innovation that must be integrated into the evaluation of the public budget allocation for research spending.

The lines of analysis followed in our work focused in particular on public investment, both direct and in support of companies, including the infrastructural endowment. Some trends have emerged that have already been highlighted by the various institutional organizations, from the OECD to the European Commission. As far as Europe is concerned, there are clear distinctions in the country profiles that, with considerable simplification, can be characterized with respect to two “geographical” directions: from north to south and from west to east, where a strong correlation seems to emerge between a substantial and growing public intervention and the presence of a significant business system with a strong propensity for R&I. By contrast, in less developed countries (which are characterized by a poor effort in R&D in the business sector) it is difficult for the public actor to exercise a leverage function with respect
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to the role of the companies. This turns to “contextual” infrastructural interventions, both in the technological field and as related to the overall infrastructural country endowment, by means of a “targeted” use of Structural Funds. Also, in this regard, even the examination of technological infrastructures as such and those aimed at research, despite the specificity of individual cases, indicates the presence of country-specific models. It was therefore considered useful, as analogous to what the OECD already does, to examine the vertical relations between public financing to beneficiaries and the executors, i.e., subjects in charge of performing R&D (in most cases public bodies), by analyzing the relationship between direct funding and the role exercised by support through tax incentives. As an example, Germany and Finland, which are high-tech countries, have not implemented tax credit policies that means giving priority to direct financing.

With respect to the use of Structural Funds, the attractiveness of funds “from abroad,” or the propensity to participate and win on competitive funds, the differences among countries make it clear that we are not in the presence of a single “winning model” to follow. A careful analysis of the Community Scoreboard (European Commission 2019b) presents the double advantage of a reading over time and a spatial representation, according to the indicators used, of the positioning of individual countries. The report, while confirming the nature and characteristics of this positioning, points out that there are specific features of the countries that the indicators are hardly able to represent and that could offer the possibility of targeted interventions to be calibrated with respect to the desired objectives without requiring substantial resources. However, it seems clear that the confirmation of a polarization of “cases of excellence” does not help the realignment process called for by the cooperation, particularly with respect to the ability of weaker countries to use research results. This effect appears to be even more negative the more one considers the advance of newly industrialized countries and the potential reduction of interactions at the international level linked to new protectionist trade policies.

In the European context there is an attempt to tackle the above-mentioned polarization and the related growth of disparities between countries with, essentially, two instruments: (1) strengthening the infrastructural endowment, according to a logic of subsidiarity that uses different means such as Structural Funds and more generally other EU policies, and (2) promoting at the same time scientific excellence, cooperation and innovative capacity with the framework program instrument. In this regard, the choices made in Horizon Europe, both on method and merit of the “missions,” and in general the policy to promote innovation and to build up and use technological and research infrastructures, even with limited resources, seem to provide a response to the role of guidance and support of the public actor coordinated at a supranational level. It remains to be seen how this translates into concrete contextual actions, in a correct balance between direct intervention and fiscal incentives and in not confining research to a “subsidiary” and “ancillary” role with respect to the more explicit industrial and commercial policies.
Our analysis has made use of a harmonized system of data that, born in the OECD context almost sixty years ago, has developed and established itself as the dominant data system, and has given rise to “supporting tools” both in the form of the production of manuals and through the promotion of committees to settle and elaborate proposals. This is a precious reality that has directed not only the collection phase, but also the use of data by analysts, scholars and decision-makers. However, on the whole, analysis of the data underlines the need to overcome some deficiencies that make difficult a better use of available information. In fact, it is difficult to interpret the strategy that guides investment processes, also considering the logic of the so-called “black box” of research that links decisions to results and their use, through implementation. This is due to the inherent limits of the GBARD (Government Budget Allocation for R&D) set-up and its classification (OECD 2015) and to the difficulty of establishing a link with the decision-making processes exercised by the beneficiaries of the resources. Also, the ex-post reading on the expenses does not help with respect to additionality, directionality and, above all, determination of the mix of resources needed to guide choices. We respond today to a growing demand for measurability of the impact of public R&D investment (in particular to facilitate the choices and the optimal allocation of resources) in a way that is not fully coordinated and without a fully equipped “toolbox” at our disposal.

It follows that better knowledge tools are required, starting from a structured evaluation of the policies, the related information, and the knowledge baggage that enables the establishment of relationships between the different interventions and the promotion of an impact assessment that is not related to merely a single intervention. The experience gained concretely and in several exercises at the European level within the Framework Program, although not unique and always successful, constitutes an undoubted point of reference from which to start.

Given this framework, the implementation of a new course of public investment research policies should, therefore, envisage a renewed orientation of the strategies consistent with the new course of missions/objectives formulated at the European level and, at the same time, point to a coordination with policies aimed at increasing the innovative potential of the economic system, in relation to the characteristics of the productive specialization of each country.

References


